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Not only Nokia

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Has the spurt of IT-centered innovations of the 1990s resulted in sizably higher productivity growth? This question, first raised in the US and later on in Europe and the rest of the world, has not been given a firm answer yet. This paper adds to the evidence on Europe by looking at a seemingly ideal *new economy* laboratory, *i.e.* the sectors of Finland. We find three main results. First, Nokia was absolutely crucial in getting all started. Second, much the same as in the US, TFP productivity gains spilled over onto few other sectors and cyclical factors did play a role in boosting productivity in the second part of the 1990s. Third, nevertheless, the timing and the sector distribution of productivity gains are strongly and negatively related to the dynamics of the machinery and equipment sector price deflator. This is suggestive that productivity gains cannot simply be the side effect of fortunate cyclical circumstances.

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1. Introduction

Has the spurt of IT-centered innovations of the 1990s resulted in sizably higher productivity growth? This question, first raised in the US and later on in Europe and the rest of the world, has not been given a firm answer yet. This paper adds to the evidence on Europe by looking at a seemingly ideal *new economy* laboratory, *i.e.* the sectors of Finland. We find three main results. First, Nokia was absolutely crucial in getting all started. Second, much the same as in the US, TFP productivity gains spilled over onto few other sectors and cyclical factors did play an important role in boosting productivity in the second part of the 1990s. Nevertheless, and this is our third point, the timing and the sector distribution of productivity gains are strongly and negatively related to the dynamics of the machinery and equipment sector price deflator. This is suggestive that productivity gains cannot simply be the side effect of fortunate cyclical circumstances.

In the US, before the current slowdown, a sharp acceleration of about one percentage point in the growth rate of labor productivity marked a clear watershed between the second half of the 1990s and the productivity slowdown period (1972-1995). Investment in IT goods went up at unprecedented rates as well, contributing to both capital deepening and acceleration in TFP growth. This is why Oliner and Sichel (2000), Jorgenson and Stiroh (2000) and others conveyed the message that the resurgence of growth has been an information technology story. [1]

In Europe, the picture is quite different. In most countries, there was no acceleration in the rate of growth of productivity. This is partly consistent with the cross-country evidence of delayed diffusion of information technologies in European countries (see the survey in Daveri (2002)). Yet the overall availability and coverage of cross-country aggregate data on IT is seriously wanting. This leaves room for questioning how much can be learned about the essence and the extent of the IT revolution from cross-country data.

The same issues have been analyzed exploiting sector data. Our paper lies within this domain. Looking at sector data is particularly important to disentangle the relation between IT and growth, for the diffusion of the 'new economy' crucially hinges on the extent to which productivity gains in the innovating sectors extend to other sectors in the economy.

[1] Whether the rapid US growth in the second half of the 1990s was a manifestation of a brand new paradigm or simply the result of luck has been an object of heated discussion. Businessmen and journalists shared the same view as technology scholars that something radically new was around. Other economists, in particular those working with aggregate data, were less convinced. More effectively vocal than others, Gordon (2000) cast serious doubts on how long-lasting IT-related productivity gains would have been.

Gordon (2000, 2001) argued that such spillover effects are indeed fairly small in the U.S. economy. The Council of Economic Advisers (2001) and, more systematically, Stiroh (2001) found instead a significant confirmation of the existence of trend breaks in the US time series of productivity growth rates in IT-related sectors.

Van Ark (2001) and Pilat and Lee (2001) decomposed aggregate productivity growth into its sectoral determinants, grouping sectors in IT manufacturing producers and users, and IT services-providers, for many European and OECD countries. Van Ark found that IT-producing sectors are mainly responsible for Europe's lower productivity growth. Productivity growth differences between the IT *users* in Europe and the US are instead much smaller and their contribution to the productivity performance becomes visible only after the second half of the 1990s. Along the same lines, the contribution to productivity growth from the ICT *services* seems to be much smaller in all of the countries included in the sample, possibly because of the start-up costs entailed by IT infrastructure provision. Pilat and Lee obtained similar results. IT manufacturing sectors featured high rates of productivity gains in many European countries. Countries with large IT-producing sectors, such as Ireland, experienced above average growth rates. Yet the same applies to other OECD countries with much smaller IT sectors, such as Australia. This raises some doubts as to the asserted importance of developing domestic IT-producing sectors, as a prerequisite for productivity booms.

In general, the scope of cross-country studies remains severely constrained by data limitations, in the same fashion as in the aggregate studies mentioned above. The only country in Europe where labor productivity growth per man hour and TFP growth can be meaningfully and consistently calculated for 2-digit sectors over a fairly long period of time is Finland[2]. This is the first reason why we chose to concentrate our work on the Finnish manufacturing and services sectors.

There is another, more substantial, reason, though. Finland is both an IT producer and an IT user, which makes it an ideal laboratory to answer questions on the importance of IT capital accumulation and the role of IT producers and users in propelling growth.

In our study, we first start from basics, providing evidence on the fast spreading of IT-related activities in the Finnish economy, which was particularly evident in the second half of the 1990s. Then we continue asking whether the growth rates of labor productivity and TFP accelerated in parallel some time in the 1990s. As it turns out, this was not the case.

Available OECD-STAN data for 31 sectors in 1975-99 do not show a sustained rise in Finland's labor productivity growth after the sharp collapse of the early 1990s, but just an abnormally strong recovery followed by a return to 'normality', *i.e.* to the growth rates experienced before the 1990-91 recession. Our fixed-effects OLS and WLS regressions point, instead, to a sustained rise in TFP growth in the second half of the 1990s, although just for a few manufacturing and service sub-sectors.

The list of the sectors with productivity increases either in 1992-94 or in 1995-99 obviously starts from "Radio, TV and communication equipment", where Nokia's contribution is recorded. It also, and crucially, includes other service sectors, such as "Telecommunications" and "Renting of machinery and equipment". Based on Finland's input-output tables, these sectors can be classified among the technologically closest to Nokia. Altogether, they represent about 5% of value added and 3.5% of total hours worked in Finland in 2000.

When employing a similar sector classification as in previous studies, we find evidence of productivity and TFP accelerations, both for IT producers in 1992-94 and users in 1995-99. The bottom line is, however, that, when the sectors mentioned above are taken out of the OECD categories of IT *users* and *producers* however, no productivity acceleration is left for the other sectors in the Finnish economy.

Finally, documenting the presence of breaks in the observed productivity growth of few sectors is clearly not enough to argue that there was an IT-based *new economy* around in Finland in the 1990s. Absent sector data on the diffusion of IT, the crucial point is how incremental productivity gains can be unambiguously related to information technologies.

We address this point in two steps. First, we try several methods of correction for factor utilization. All of our experiments make it clear that favorable cyclical circumstances indeed concurred in triggering off the measured productivity enhancements. In spite of that, we also find a close association between the time and sector dynamics of the price deflators of machinery and equipment and productivity growth, however. At times when, and in sectors where, productivity growth accelerates, the price deflators of machinery and equipment undergo faster deflation (or reduced inflation) compared to previous years. This is evidence that the productivity recovery was not just driven by the bouncing back from the unfortunate downturn of the early 1990s. It may not

[2] At least when confining ourselves to the use of STAN, *experimental release*, in order to work on an internationally comparable dataset.

be enough to prove that there has been a 'new economy' in Finland in the late 1990s, but it is at least indicative of the occurrence of a favorable supply shock.

The structure of the paper is as follows. In Section 2 we document the size of the IT sector in Finland, both in terms of production and diffusion. In Section 3, the nitty-gritty of labor and total factor productivity is described as a preview of the systematic fixed-effects regression analysis conducted in Section 4, where a closer look at sector productivity developments is taken. In Section 5, the role of cyclical factors and the dynamics of investment price deflators are studied. Section 6 concludes.

2. Production and diffusion of information technologies in Finland

International comparisons of business and technology environments invariably rank Finland at the top. "Finland boasts best growth prospects. Report says thriving tech sector puts country ahead of global rivals" (*Wall Street Journal Europe*, October 18, 2001, p.3). The Report mentioned in the WSJE headline is the Global Competitiveness Report (GCR) 2001 based on a broad survey conducted by the World Economic Forum and the Harvard Center for International Development with 4600 chief executives in 75 countries. Its main conclusions are that, boosted by ICT world leader Nokia and other high-tech companies, Finland would have supplanted the United States as the country with the brightest growth prospects over the next five years. This remarkable outcome improves upon the findings in GCR 2000, where Finland ranked fifth. This is just an example. Approximately in parallel, the Economist Intelligence Unit (2001) and the International Institute for Development Management (2000) came to very similar conclusions.

Although these opinions may, to an extent, be endogenous to the latest developments in a country (rather than being genuine and independent forecasts of what the next future is going to be), the consensus fits well with available data on IT trade balances – a rough indicator of the international competitiveness of a country.[3] As reported in the OECD Communications Outlook 2001, in 1998 Finland featured the largest per-capita surplus in the foreign trade of communication equipment

[3] It is well known that trade surpluses and deficits are misleading indicators of international competitiveness in a global economy, where sales of foreign affiliates to domestic multinationals may be bigger than domestic exports. As nicely exemplified in Department of Commerce (2002), although US IT companies are often seen as world market leaders, the United States featured a negative IT trade balance of 88 billion US$ in 2000.

(about 1000 US$) in the world.[4] This stems from a communication equipment trade surplus in absolute terms of about 4.3 billion US$, which subtracts out 1 billion dollars of imports from a hefty 5.3 billion dollars of exports. The surplus mostly originates from 'transmission equipment' (which makes about 70% of the total surplus), with 'telephone and switching equipment' and 'parts' contributing for another half a billion US$ each.

All in all, Finland is indeed one of the most innovative countries in the world, with its innovation pace tightly linked to its ability to master information technologies. To better understand where this advantage comes from and, at the same time, set the ground for the discussion in the next sections, we now dig a little deeper and document the growth of IT production and diffusion in Finland.

2.1 IT Production

Production of IT goods and services stems from production of IT goods (such as hardware, software and telecommunications equipment) in the manufacturing sector and from the provision of IT services in the service sector[5]. In 1998, OECD countries reached an agreement on an industry-based definition of the 'ICT sector' based on ISIC Rev.3. [6] Based on this definition, *IT manufacturing* includes the following sub-sectors:

- "Office, accounting and computers machinery and equipment" (NACE Code: 3000),
- "Insulated wire and cable"(3130),
- "Electric valves, tubes and other electric components" (3210),
- "TV/Radio transmitters; line telephone and telegraph apparatus" (3220),
- "TV/Radio receivers; sound and video apparatus, associated goods" (3230)
- "Instruments and appliances for measuring, checking, testing, navigating and other purposes" (3312 and 3313)

Production of *IT services* originates from such sub-sectors as:

[4] The two most proximate followers, Sweden and Ireland, present per-capita communication equipment trade surpluses for about 800 and 200 US$.

[5] Software is only partly included in the manufacturing sector. Indeed, the largest part of software production is included in Business Services, more specifically in Computer and Related Activities.

[6] As reported in OECD (2001, p.84)), "for a manufacturing industry to belong to the ICT sector, its products (a) must be intended to fulfil the function of information processing and communication including transmission and display, and (b) must use electronic processing to detect, measure and/or record physical phenomena or control a physical process. For services industries, their products must be intended to enable the function of information processing and communication by electronic means".

- “Wholesaling of machinery, equipment and supplies” (5150; only wholesaling of ICT goods should be included)
- “Telecommunications” (6420; inclusive of fixed and mobile telephone communication, other telecommunications and data transmission services),
- “Renting of office, machinery and equipment (including computers)” (7123)
- “Computer and related services”(72; inclusive of hardware and software consulting, data processing, and maintenance of office machinery).

Adding up the various items implied by this definition, Jalava and Pohjola (2001) and Jalava (2001) calculated that, in 1999, the Finnish ICT sector accounted for 13% of the value added of ‘market production’[7] – roughly 8.9% of Finland's GDP in that year (see data in **Table 1**). In turn, production of IT manufactures and services counts for, respectively, 60% and 40% of the total IT contribution to GDP. [8]

Table 1: The IT share in the value added of market production (in %)

1975	1980	1985	1990	1995	1999
3.7	4.2	5.3	5.8	8.0	13.0

Table 1 also shows that the GDP share of IT goods and services has been rapidly growing over the last few years (from 8% of market GDP in 1995 to 13% in 1999). About two thirds of this rise stems from the value added originating in the production of telecommunications equipment. The remaining one third is from the increased contribution of IT services. As documented by Koski, Rouvinen and Yla-Anttila (2001), not only is Finland one of the EU leading producers of IT (together with Ireland and Sweden), but is also the most prominent “leapfrogger” vis-a-vis the rest of Europe, the US and Japan. In common parlance, Finland is the country which climbed up the ranking of IT producers most rapidly since the mid 1990s.

[7] Market production is total production minus production of the public sector and production of non-profit institutions servicing households. ‘Community, social and personal services’, included in the US definition of the NFBS (non-farm business sector) is excluded from the market sector. Statistics Finland publishes a breakdown of market and non-market activities for each sector, including ‘Community, social and personal services’, for the 1990s only; moreover, the sectoral breakdown is not particularly detailed. This distinction is thus useless for our purposes in this paper.

[8] We computed ourselves the IT share of total GDP and the share of IT manufactures over gross output. Figures are even bigger than for GDP. IT production is more than 10% of gross output, and production of manufactures makes about 70% of the IT contribution to gross output. This is because the fraction of output devoted to intermediates is higher for IT than for the other goods and services in the economy.

Nokia, in particular, has crucially contributed to the rapid increase in the GDP share of the IT sector. Cellular phone production (and thus Nokia) is included in the “TV/Radio transmitters, etc.” item in a two.digit sector classification, such as in STAN. The increased share of this sub-sector alone makes almost 100% of the increased share of the IT sector over GDP. In 1999, it was about 50% of IT contribution to total value added, with Nokia’s value added alone reportedly close to 3.3% of GDP (Ali-Yrkko (2001)). In turn, Nokia’s exports are 20-25% of total exports - bigger than the total output of the paper industry, the former leading industry in Finland. Moreover, Nokia undertakes 35% of total business R&D and employs 5% of manufacturing employment.

Is there anything else but Nokia in the Finnish IT industries? As reported by Ali-Yrkko, Paija, Reilly and Yla-Anttila (2000) and IMF (2001), about 4000 firms (mostly small and medium-sized) and 200 electronics manufacturing services companies make up the so called ‘ICT cluster’. Some 350 of them are first-tier suppliers to Nokia, and represent the ‘Nokia network’.

The extent of this network, and in particular of the sub-sectors where this network exerts its effects, can be evaluated by looking at the 1995 input-output tables recently produced by the OECD/Stats Finland. Though in nominal terms[9], they provide some indications as to the inter-industry structure of the Finnish economy. After a slight re-classification of sectors in order to match as closely as possible the sector breakdown in the next Sections, we looked at inter-industry connections in the Finnish market production sectors (see our re-classified I-O Table reported in Appendix 3). We find that the “TV etc.” sector as classified in the I-O Tables is tightly connected, first of all and expectedly, to itself (with an I-O coefficient of 0.21 as to domestic use). Other sub-sectors showing relatively high I-O coefficients are the manufacturing sectors producing electrical goods (with a coefficient of 0.02) and the service sectors classified among “Other Business Activities”, which include “Renting of Machinery and equipment” as well as R&D activities (with a coefficient of 0.05). The I-O coefficients of “Post and Telecommunications” and “production of computer and other accounting office equipment” in the “TV etc. “ column are instead close to zero.

To see what this means in practice, suppose Nokia’s products face an exogenous demand shift. This translates into an impact increase in the intermediate demands for the goods produced by the

[9]At the present, the fixed base year used in Finnish National Account is set in 1995. So the constant price tables and current price would in principle be identical. In practice, however, they differ since the annual supply-use tables from

sectors technologically connected to Nokia. Hence, by this channel, the output of "TV, etc.", "Other business activities" and "electrical goods" would go up by respectively about 21%, 5% and 2% of the initial shift. The other sectors would also enjoy some boost in their output, but to a much smaller extent.

2.2 IT diffusion

'New economy' activities are hardly confined to the production of IT goods and services. The production of information and communication technologies is much more internationally concentrated than their extent of adoption. In most countries, the 'new economy' is essentially about the diffusion of information technologies. Hence, in order to understand whether information technologies play an important role in the economy, one should also look at spending data (see **Table 2**).

Table 2: IT spending and investment in Finland

IT spending, million US$, 2001	10002 million US $
IT spending, % GDP, 2001	8.0 %
IT spending, % GDP, 1995	5.5%
IT spending, per capita terms, 2001	1938.2 US $
IT investment, % GDP, 1999	4.0%
IT investment, % GDP, 1995	2.9%

Data on nominal spending in IT, as well as on other dimensions of the diffusion of IT, are reported in WITSA (2002)'s *Digital Planet* [10] for 50 countries – about 98% of the world IT market. WITSA data provides a clear and consistent picture of size and composition of spending and of the diffusion of information technologies in the Internet decade (1992-2001), at specific points in time and over time. It does so for Finland too.

1995 onwards are being compiled presently and Stats Finland is currently switching to chain-linked indexes.

[10] WITSA is the World Information Technology and Services Alliance, a consortium of 48 associations of information technology industries around the world. IDC (International Data Corporation) is a leading consulting company specialized in research on high-tech industries. WITSA spending data includes concern sales of hardware,

According to WITSA, IT spending in Finland reached 10 billion US$ in 2001. This is 8% of the Finnish GDP and corresponds to per-capita spending of about 2000 US$ per year. By way of comparison, Finland's GDP share of IT spending is slightly bigger than the US share and slightly smaller than the EU share. Within Europe, Sweden, Denmark, the UK and the Netherlands devote 2-3 percentage points of their GDPs more than Finland to IT spending. As to per-capita spending, Finland ranks 14th in the world and higher than the EU average of 1700 US$. Switzerland ranks first (with per-capita spending of 3600 US$ per year) and the US and Denmark second (about 3000 US$). In many other EU countries, IT spending per capita is higher than in Finland.

Hence, according to the spending data as portrayed in WITSA's Digital Planet, Finns are not among the world top spenders in IT goods and services. Drawing the implication that IT diffusion is still limited would grossly miss the point, though.

Lending exclusive attention to nominal spending data is misleading for two reasons. First, IT spending is measured by WITSA in value terms. Suppose that IT prices (such as computer prices, but also and crucially Internet access prices) are systematically smaller in Finland than in other OECD countries. Then, it would be the case that the fewer resources sunk into the IT sector in Finland do not necessarily imply smaller extent of adoption, but just smaller costs in the access to (and possibly higher efficiency in) the usage of information technologies.

No solid facts can be brought to bear to support this view. **Figure 1** (taken from OECD (2000) and included at the end of this paper) contrasts data on Internet penetration (measured on the y-axis of **Figure 1** as the number of Internet hosts) as of September 1999 with data on average prices for twenty-hours Internet access in 1995-2000 in PPP-US$ (reported on the x-axis in the same Figure). The scatter diagram in **Figure 1** is clearly suggestive of a significantly negative correlation between the cost of Internet access and its penetration. The evidence in **Figure 1** is relevant here, for Finland features in the North-West part of the panel. In 1995-2000, the Finns enjoyed the second lowest Internet access price in the OECD (and hence possibly in the world), right after Canada and very similar to the United States. Correspondingly, Internet penetration was higher in Finland than in any other OECD countries (except for the United States). In particular, Internet access price was two to three times lower and Internet penetration five to ten times higher in Finland than in Italy, France, Germany and Spain.

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software and related external and internal services, plus telecommunications. For a longer discussion of the imperfect matching between WITSA items and national accounting items, see Daveri (2002).

Moreover, if one cares about the growth effects of IT, investment, rather than spending, should be looked at. When the attention is turned to IT investment, the picture changes radically. Colecchia and Schreyer (2001) reports national accounting figures for IT investment for a sample of nine OECD countries (the G-7, Australia and Finland). Finland and the United States exhibit the highest investment shares in the sample. In 1999 – the latest year for which data are available - Finland invested about 4% of its GDP in IT machinery and equipment, hence more than 50% of total IT spending and 28% of total non-residential investment. Moreover, the 1999 figure is a full percentage point higher than Finland's GDP share of IT investment in 1995, which represents a remarkable increase compared to the previous five years: the GDP share of IT investment was 2.7% of GDP in 1990 already.

2.3 Conclusions on IT production and diffusion

Our short survey of the available indicators drives us to conclude that Finland deserves the title of 'land of the IT revolution' in many ways and dimensions. Nokia is indeed a big company in a small country, for it represents a disproportionate share of Finland's GDP. Anyway, Nokia is not the only player on the productivity recovery scene. Some other manufacturing sectors as well as some conventionally defined *IT using* service sectors are connected to the Nokia-centered revival. This may imply that productivity spillovers out of durable manufacturing are important. Although spending data do not place Finland on top, both investment and Internet penetration data clearly suggest that information technologies are indeed part of everyday life in Finland to a much greater extent than in most other OECD countries. Furthermore, this has increasingly been the case in the second part of the 1990s.

Still, this does not imply that Finland has enjoyed higher productivity growth *as a result of* the IT revolution. To gain a better understanding of this crucial point, we turn to analyze productivity data at various levels of disaggregation, *i.e.* aggregate and broad sub-sectors in Section 3 and thirty-one manufacturing and service sectors in Section 4.

3. Productivity growth: a first pass at the data

Finland cannot but be regarded as a fast-growing country within the OECD skyline. Productivity per hour worked in the non-farm market sector [11] - the closest possible counterpart of the non-farm business sector monitored by the BLS in the US - grew by 3.6% per year in 1976-2000 (see **Figure 2**).

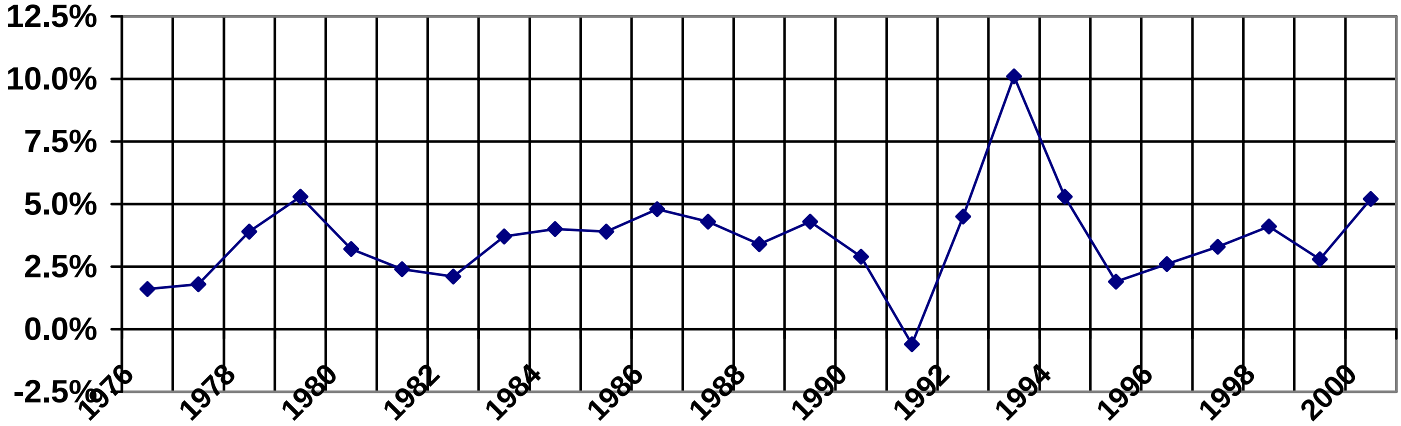


Figure 2: Value added per hour worked, annual growth rates, %

This is much higher than the productivity growth rates experienced in the US and the large countries in Europe over the same period of time. In particular, labor productivity growth rates such as those observed in the US in the second part of the 1990s would not be regarded as exceptional in Finland.

There are obviously many reasons for why growth rates are high or low at different periods of time. The question here is not so much whether Finland grew *permanently* faster than the US, but rather what happened to productivity growth *over time*. Given that IT materialized in Finland some time in the early 1990s, has this brought about higher productivity growth than in the past?

Over the last twenty-five years, the Finnish economy has gone through three main periods: the 'socialist' period, the deep recession of the early 1990s, and the recovery through the 1990s. In this period, the structure of the Finnish economy has changed radically, in particular over the past two decades, in two crucial respects: markets took over the State in allocating resources, the stock market took over banks in the allocation of credit.

[11] Here we follow the OECD definition. Unlike the OECD practice, we leave the real estate sector out. See the Appendix for a precise description of sector classification.

Still at the beginning of the 1980s, though, paper and metal made the bulk of industrial output. Nokia counted no less than twelve production lines, including soft tissue, tires and heavy-duty cables, with some side production of computers and telecommunications equipment. Finance was tightly controlled by Finnish banks and insurance groups, with little role for the stock market. Altogether banks and insurance groups held a tight grip on nearly all of the country's large companies. This bank-firm relation was similar to the one observed in other countries in the world, such as Germany, Japan and South Korea (and possibly others). Cross-ownership, lack of transparency, and collusion between industry, finance and Government was the rule to preserve a consensus built and maintained at the expense of small shareholders and domestic savers.

As capital movements were freed worldwide and financial markets were opened up to foreign competition in the 1980s, Finland went through a lending boom-and-bust cycle (as exhaustively documented by Honkapohija and Koskela, 1995). Initially, cheap foreign borrowing resulted in sudden construction and stock market booms. Then as a major recession set in the early 1990s, the country was precipitated in the bust part of the credit cycle. This process was magnified by the sharp devaluation of the early 1990s, which triggered a wave of bankruptcies. Still, the credit and banking crisis led to a successful rationalization of the public sector and taught companies the importance of respecting balance sheets without counting on ex-post bail-outs.

Dating the start of the recession is relatively uncontroversial. Both GDP and employment started falling in the first quarter of 1990, right after the collapse of the socialist regimes. At about the same time, unemployment began its fast sky-rocketing rise (from 2.7% in 1990:Q1 to 17.5% in 1994:Q1). Dating the trough of the downturn is less obvious. Yearly GDP data reached its minimum in 1992, while business sector GDP at quarterly frequencies bottomed down in the first quarter of 1993, with labor market data lagging behind and reaching a minimum in the first quarter of 1994.

Such swings - in particular the recession of the early 1990s - are instead much less apparent when productivity data are looked at.

On average, labor productivity grew fast and steadily in Finland. Productivity per hour worked in the Finnish non-farm market sector rose by an average 3.6% per year in 1976-1999, very high indeed by any standard in the Industrial Countries. This rapid growth has also been particularly steady. The coefficient of variation of the value added per hour worked is 0.5, clearly smaller than the coefficient of variation for value added itself (about 1.3), the difference being essentially due to a much higher standard deviation of value added (4.4% *vs.* 1.9%).

Table 3a: Productivity growth and its decomposition in Finland (1976-99), non-farm market sector

	Labor productivity growth	Capital contribution	TFP growth
1976-99	3.6	0.9	2.6
1976-89	3.5	1.0	2.5
1990-91	1.2	2.6	-1.5
1992-99	4.3	0.4	3.9

Three distinct sub-periods – roughly paralleling those marked by GDP developments - can be traced anyway (see **Table 3a**). In 1976-89 (the 'socialist' period), labor productivity grew at roughly the same rate (3.5% per year; 3.6% if the1976-77 slowdown is left out) as its 1976-99 average. It then sharply fell to 1.2% in 1990-91 (the recession period), before the sudden recovery to 4.3% in 1992-1999.

The dynamics of aggregate TFP growth matched quite closely that of labor productivity. The TFP growth rate averaged 2.6% in 1976-99. This averaged out 2.5% per year in the socialist period (hence about the same as its long-run average), -1.5% in 1990-91 and 3.9% in 1992-99. The growth rate in 1992-99 was about 1.5 percentage points higher than the one recorded in the socialist period.

At first sight, then, the claim that (labor and multi-factor) productivity growth accelerated over the 1990s is not misplaced for Finland. Whether this acceleration is to relate to IT production and diffusion remains to be seen, however. In particular, since we do not control for quality improvement in factor accumulation, a fraction of our TFP measure should be assigned to quality improvements if technological progress is at least partly embodied in the accumulation of newly installed capital goods. [12] Using US data for 1949-1983, Hulten (1992) shows that, once we take into account quality improvements for capital goods, as much as 20 percent of U.S. multi-factor productivity growth is due to embodied technological progress. The results are even more striking once attention is restricted to the productivity slowdown period only.

[12] Quality adjusted data for capital stocks are not available. For a detailed discussion on the measurement of TFP, see **Appendix 1** and **2**.

Our statement about TFP performances must then be more carefully scrutinized both along the time and sector dimensions. We start splitting 1992-99 into a “bouncing back” (1992-94) and a “sustained growth” (1995-99) periods. We also consider whether labor productivity and TFP growth were different in three broad sectors such as durable manufacturing, non-durable manufacturing, and services & construction.

These are important questions to ask. To evaluate whether there is a ‘new economy’ around in Finland, we care about long-term growth. Hence, the growth acceleration should be ‘permanent’, *i.e.* not constrained to a short time period and/or to a narrow set of sectors. If it does not last, it may be simply the ‘bouncing back’ effect of the end of the deep recession of 1990-91. If it affects too few sectors, it may be hampered by congestion effects related to diminishing marginal returns to capital. In both cases, it would be temporary.

Data in **Table 3b** shows that labor productivity and TFP evolved dissimilarly across broad sectors and over time.

Table 3b: Productivity growth and its decomposition in Finland (1992-99), broad sectors

	Labor productivity growth	**Capital contribution**	**TFP growth**
1992-94			
Non-farm market sector	6.6	2.5	4.1
Durable manufacturing	11.4	1.0	10.4
Non-durable manufact.	10.2	3.4	6.8
Services & construction	4.2	2.6	1.6
1995-99			
Non-farm market sector	3.0	-0.8	3.8
Durable manufacturing	7.7	-0.6	8.2
Non-durable manufact.	2.7	0.1	2.6
Services & construction	2.0	-1.0	2.9

After taking the ‘bouncing back’ years away, no labor productivity acceleration compared to pre-recession years is left for the non-farm market sector as a whole. Hourly productivity growth popped up to a yearly 6.6% in 1992-94, then dropping to 3% in 1995-99 - half a percentage point lower than in the socialist period. The growth slowdown is particularly pronounced for the non-durable sector, where labor productivity growth fell short of pre-recession growth by 2.5

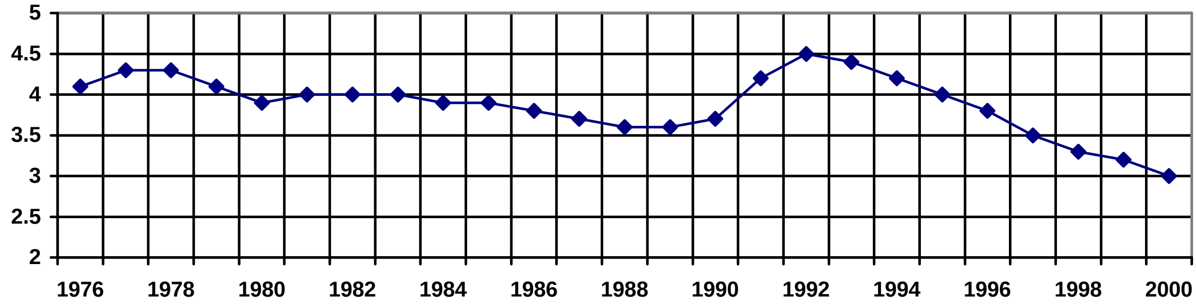
percentage points (2.7% in 1995-99, as opposed to 5.4% in 1976-89). A similar, but less pronounced, trend holds for services and construction too. Durable manufacturing is the exception to this pattern. Likewise in the US, labor productivity growth in producer durables accelerated to an astonishing 11.4% per year in 1992-94, before dropping to 7.7% in 1995-99. This latter figure is three percentage points higher than the average pre-recession growth rate in the same sectors in 1976-89.

The acceleration of TFP growth is, instead, more uniformly distributed over time and clearly survives even outside the 'bouncing back' period and not just in durable manufacturing. In fact, TFP growth in the non-farm market sector stayed at 3.8% per year in 1995-99, still 1.3 percentage points higher than in 1976-89. Once again, this is mostly due to durable manufacturing, whose average TFP growth was still 8.2% per year in 1995-99 – almost five percentage points higher than in 1976-89! Yet, unlike for labor productivity, TFP growth in the service sectors reached 2.9% in 1995-99. This is not too high a figure across sectors, but is a full percentage point higher than TFP growth in the same sectors during the socialist period. This is worth mentioning for, if confirmed, it would interestingly contradict Baumol's (1967) cost disease theory.

These same points can also be appreciated by looking at the ratios between TFP and labor productivity growth rates and how they evolved over time. This ratio is comparatively high (about 0.75) in Finland with respect to other countries. It also clearly rose over time, from 71% in 1976-89 to 91% in 1992-99 for the non-farm market sector. The low (or negative) contribution from capital and the crucial importance of TFP is particularly evident when 1976-89 is contrasted with 1995-99. Relatively to 1976-89, the growth rate of labor productivity in the non-farm market sector fell by half a percentage point, the net effect of the decrease in the contribution of capital of about two percentage points and the increase in the TFP contribution of about 1.5 percentage points. In a nutshell, it is regularly the case that total factor productivity represents more than 100% of the observed acceleration in labor productivity growth rates.

Figure 3 makes it clear why this has been the case by showing the gradual, but continuous, decline in the capital-value added ratio in the Finnish economy throughout the 1990s. This may only be the case if labor productivity goes up by more than the capital-labor ratio. In other words, there is clear evidence that the process of restoring growth in Finland involved quite a bit of capital shedding, of old capital in particular (see Maliranta (2001) for a rendition of how restructuring involved a process of substitution away of obsolete capital). This is partially at odds with the growth experience of some other countries. A polar case would be Singapore, whose very high growth rates have been found by Young (1995) to be almost entirely driven by capital deepening. Instead, Finnish firms have seemingly welcomed the chance offered by information technologies to get rid of old capital. This resulted into higher TFP growth and little or no new capital accumulation.

Figure 3: Capital – value added ratio in the non-farm market sector



To sum up, Finland exhibits similarities and differences with the US. Likewise Gordon's results, durable manufacturing appears to make the bulk of productivity gains in the 1990s in Finland. There is also evidence of productivity gains even outside durable manufacturing, notably in the total factor productivity of the service sector. This is enough to invite more careful consideration of the time series dynamics of the Finnish manufacturing and service sectors. This is done in the next section.

4. Breaks in sector productivity growth in Finland: when, in what sectors and for how long?

In this section we want to test whether deterministic trend breaks can be traced in the series of labor productivity and TFP growth rates of 31 sectors in the Finnish economy. We rely on the newly released STAN data base of the OECD-STI Department (see **Data Appendix 1** for a full-fledged description of the OECD Stan Database and a list of the sectors and sector groups).

The breaks are estimated in a fixed-effects model, as follows:

$$G_{it} = \alpha_i + \beta_t + \gamma D_{i't'} + error_{it}$$

where G_{it} is the growth rate of productivity per hour worked or total factor productivity in sector i at time t ($i=1,2,..,31$; $t=1, 2, .., 24$, with $t=1$ for 1976, $t=2$ for 1977, .., and $t=24$ for 1999). The sector fixed effects capture time-invariant differences in growth rates due to unexplained factors that differ across sectors. Examples may include the traditionally lower productivity of sectors like those involved in food production with respect to those focusing on chemistry or communication devices. The period fixed effects capture sector-invariant differences in growth rates due to unexplained factors that differ over time. They are aimed at canceling out the two serious downturns faced by the Finnish economy in the mid 1970s and early 1990s, whose explanation goes beyond the scope of our work. The suffice *i'* and *t'* identifies specific dates and sectors, which, based on the first pass at the data in the previous section, we identify as the most likely candidates for experiencing a break.

We run both labor productivity and TFP regressions. In the labor productivity regressions, we use two measures of sector activity, value added and gross output[13]. In TFP regressions we also employ two measures of total factor productivity, which differ in the way cyclical utilization of capital is netted out: TFP1 embodies a correction for electricity consumption, as suggested in Burnside, Eichenbaum and Rebelo (BER; 1995, 1996) and recently in Baxter and Farr (BF; 2001), while TFP2 identifies the working week of capital by correcting for the average number of effective hours worked as in Shapiro (1993)[14].

In both cases, we make an effort to correct for the potential problem, first emphasized by Hall (1990), of business-cycle driven improvements in total factor productivity. BER computes capital-utilization-corrected measures of US productivity growth under the assumption that capital services can be directly proxied by electricity consumption at the appropriate level of disaggregation. The adjusted time series exhibit a sharp decrease in the correlation between productivity growth rates and output fluctuations, a fall in the ratios of the TFP to GDP volatility and a drop in the probability of technological regress, compared to the unadjusted measures of the Solow residual, both in the aggregate and at the sector level. [15]

[13] In the Finnish National Accounts the volume of value added is assumed to change at the same rate with the volume of gross output at a detailed industry level. So, we expect results not to differ much. However, as shown later, they are not identical, which is due to the fact that a more detailed industy-classification is being used in the Finnish NA. Moreover, attention should be paid in interpreting our results since the double-deflation method is not used in Finnish manufacturing sectors. As a consequence, changes in the relative prices of final output and intermediate input may distort results sometimes.

[14] Neither for TFP, nor for Labor Productivity, quality adjusted labor input can be used; this may bias upwards our estimates of the rates of growth of the Finnish productivity. The use of total hours worked instead of total number of employed should partly reduce the problem.

[15] This is measured as the proportion of times that the technological residual exhibits a decline in their sample.

Along the same line of reasoning, BF explores how accounting for various measures of factor utilization alters the statistical properties of the measured productivity residuals for Canada and the US. They use three different proxies, namely the standard capital stock, but also energy inputs and material inputs. Although according to the authors, none of the three does a fully convincing job in correctly measuring TFP, the overall message of their study does not substantially differ from BER.

We first focus on electricity use. Notice anyway that our correction is somehow different from the one implemented in BER and BF. Whereas they simply replace the growth of the capital stock by electricity consumption, we instead super-impose de-trended electricity consumption on physical capital growth rates (labeled TFP1 in **Table A**). [16] This seems to fit better the Finnish experience, where the BER-BF assumption of fixed energy-capital coefficients looks untenable at times when scrapping of old capital is documented to have occurred (see Maliranta, 2001). In **Table A**, we also report results from TFP growth computed *à la* BER (TFP-BER in **Table A**).

Table A : Total factor Productivity measures: comparative properties

	TFP1	TFP2	TFP	TFP BER
All sectors				
Output Growth Corr.	0.418	0.458	0.482	0.498
Volatility Ratio	0.441	0.369	0.447	0.749
Prob. Of Regress	0.17	0.12	0.17	0.56
Manufacturing				
Output Growth Corr.	0.459	0.504	0.548	0.455
Volatility Ratio	0.412	0.394	0.546	0.542
Prob. Of Regress	0.09	0.04	0.17	0.39
Durable Goods				
Output Growth Corr.	0.611	0.582	0.673	0.714
Volatility Ratio	0.510	0.501	0.620	0.702
Prob. Of Regress	0.17	0.12	0.17	0.35
Non Durable Goods				
Output Growth Corr.	0.384	0.507	0.488	0.361

[16] See **Appendix 2** for a more detailed discussion of this statement.

Volatility Ratio	0.376	0.392	0.521	0.352
Prob. Of Regress	0.13	0.08	0.17	0.70
Services				
Output Growth Corr.	0.375	0.458	0.462	0.513
Volatility Ratio	0.445	0.390	0.405	0.990
Prob. Of Regress	0.26	0.17	0.21	0.61

To check the plausibility of our results, we build a second measure of TFP correcting for the number of hours worked (see Shapiro (1993)). The underlying assumption is that capital needs to be operated by human beings and therefore its effective use can be proxied by the number of average hours effectively worked (TFP2 in **Table A**). [17]

As in previous studies, we find that adjusting for either electricity consumption or hours worked alters the statistical features of our measures of total factor productivity with respect to an unadjusted measure of TFP (labeled 'TFP'). The results in **Table A** show that both our corrections reduce the pro-cyclicality of the displayed behavior of TFP, as measured by its correlation with the relevant growth rate of gross output, as well as the volatility ratios and the probability of technological regress in our series. [18] Moreover, our procedure is not dominated by the BER strategy in delivering the desired correction. Finally, none of the two measures unambiguously outperforms the other along all of the analyzed dimensions. Consequently, in what follows we report the results obtained for both indicators.

Before moving to the discussion of our results, we need to stress another important methodological issue, recently raised by Stiroh (2001). According to the standard growth accounting framework, we expect to observe a zero correlation between the Solow residual and the extent of capital deepening, being TFP residually defined. Any departure from this condition should be modelled to obtain theoretically consistent estimates of TFP growth rates. [19] Using sector data for the U.S. economy, Stiroh (2001) reports IV estimates showing that the statistical relation between capital and TFP is either not significant or significantly negative. Though

[17] See **Appendix 2** for an analytical explanation to this point.

[18] We only report results for broad aggregates. We replicated the same results for the two-digit level of disaggregation.

[19] Stiroh (2001) suggests that at least one of the following possibilities could be taken into account as responsible for departures from the neoclassical theory of growth: spillovers and network effects; measurement errors; omitted variables; imperfect competition; reverse causality.

surprising at first sight, this result may be given a cost-of-adjustment rationale. Consistent with learning-driven theory of growth, one may think of factors temporarily depressing the productivity of the newly introduced capital. This piece of evidence may fit well the Finnish case where much of the 'socialist' period was characterized by over-accumulation of unproductive capital, scrapped, with the specific knowledge attached to it, during the 1990-1991 crisis. Hence, to further investigate the relevance of Stiroh's ideas for Finland, we estimate the following equation over the period 1975-1999:

$$G_{it} = \alpha_i + \beta_t + \gamma G(k_t) + \delta G(het_{it}) + error_{it}$$

where G_{it} is the growth rate of total factor productivity in sector *i* at time *t* (*i=1,2,..,31; t=1, 2, .., 24,* with *t=1* for 1976, *t=2* for 1977, .., and *t=24* for 1999), α and β are specific time and sector dummies, $G(k_{it})$ is the growth rate of capital (corrected according to one of the two described procedures) and $G(het_{it})$ is the growth rate of total hours worked. Again following Stiroh, we estimate the equation, both for TFP1 and TFP2, using time and sector dummies as well as lagged values of the regressors as instruments. We find that, when only one lag (either t-1 or t-2) is included in the set of instruments, the term $G(k_{it})$ is never significant. When both lags are included though, a significantly negative effect of capital on both measures of TFP is detected over the entire sample. These results are however not robust to the exclusion of 1990-1991 from the sample. When two separate equations are estimated for the periods before and after the crisis, no evidence of significant correlation between TFP and capital deepening survives. We conclude that there is no strong evidence in favor of the hypothesis that cleansing effects during the recession were at work.

Empirical strategy

We estimate the model in (1) in two ways. In the simplest version we use OLS, but we also estimated it using WLS (Weighted Least Squares), with weights proportional to the size of the economy in 1975 – the beginning of the period under consideration. The size of the economy is measured in terms of total gross output in the non-farm market sector (we also tried total employment, and it does not appear to make a difference). Checking the robustness of OLS results by also looking at WLS results serves the purpose of evaluating the extent to which measurement error – a potentially more serious problem with smaller sectors – may bias our results. In all cases, we report White heteroskedasticity consistent standard errors.

First, we want to test whether *all* sectors in Finland experienced increases in productivity growth rates after 1992. This is done by constraining period fixed effects to take on just four values: *t=1* for 1976 and 1977, *t=2* for all years between 1978 and 1989, *t=3* for 1990 and 1991, and *t=4* for 1992-99. OLS and WLS results taking the 1978-89 period as benchmark are shown in **Table 4**. Results show evidence of the 1976-77 and 1990-91 slowdowns, with no evidence whatsoever of a trend break in labor productivity in 1992-99. Some evidence of a positive change in the growth rate of TFP is there, instead.

Table 4: Was there a trend growth break in all sectors since 1992?

Dep. Variable	**Value added per hour worked**	**Gross output per hour worked**	**TFP 1**	**TFP 2**
Benchmark: 1978-89				
OLS 1976-77	-.025*** (.009)	-.022** (.009)	-.031*** (.009)	-.027*** (.009)
WLS 1976-77	-.021*** (.007)	-.016** (.007)	-.032*** (.007)	-.028*** (.007)
OLS 1990-91	-.030*** (.010)	-.030*** (.009)	-.046*** (.010)	-.044*** (.010)
WLS 1990-91	-.023*** (.009)	-.021*** (.008)	-.043*** (.009)	-.039*** (.009)
OLS 1992-99	.006 (.006)	.006 (.006)	.019*** (.007)	.012* (.006)
WLS 1992-99	.002 (.006)	.004 (.005)	.012* (.006)	.005 (.006)
OLS R-squared	.18	.19	.21	.19
WLS R-squared	.14	.16	.17	.15
# observations	744	744	713	744
Sector fixed effects	Yes	Yes	Yes	Yes

Yet our preliminary exploration of the data suggests us to slightly change our working hypothesis to account for potential heterogeneity of period fixed effects, both over time and across sectors. The break may have not been permanent, but just limited to the 'bouncing back' years (question #1). Moreover, only *some* sectors in the Finnish economy may have experienced such growth windfall (question #2).

We start with question #1. The results in **Table 5** are indicative of the presence of substantial heterogeneity over time. Once the 'bouncing back' period is netted out, there is a reduction in labor productivity growth in 1995-99, and no evidence of acceleration in the growth rate of total factor productivity. WLS estimates show very little or no evidence of TFP acceleration even in 1992-94.

Next we go on examining growth heterogeneity across sectors. **Table 6** reports evidence concerning the breakdown in broad sectors (durable manufacturing, non-durable manufacturing, services & construction). The results in **Table 6** show that the 1992-94 growth acceleration relatively to 1978-89 is there for the manufacturing sector as a whole, hence including both the durable and the non-durable sectors. This acceleration is short-lived, however, for growth rates in the durable manufacturing sector go back to their 1978-89 benchmark in 1995-99. The growth shortfall suffered by non-durable producers is almost equal in magnitude to their growth gain in 1992-94. The service sector shows instead no marked acceleration upwards or downwards in either period, except for one of the TFP measures in 1995-99. This finding is no longer there, though, when WLS rather than OLS is employed instead.

Table 5: Was the growth windfall temporary?

Dep. variable	Value added per hour worked	Gross output per hour worked	TFP 1	TFP 2
Benchmark: 1978-89	Dummy variables for 1976-77 and 1990-91 not reported			
OLS 1992-94	.034*** (.011)	.037*** (.010)	.030*** (.007)	.031*** (.012)
WLS 1992-94	.027*** (.010)	.030*** (.008)	.012* (.006)	.016 (.011)
OLS 1995-99	-.011 (.007)	-.012** (.006)	.011 (.007)	.000 (.007)
WLS 1995-99	-.013** (.006)	-.012*** (.005)	.019* (.011)	-.001 (.007)
OLS R-squared	.20	.23	.21	.21
WLS R-squared	.18	.22	.18	.15
# observations	744	744	713	744
Sector fixed effects	Yes	Yes	Yes	Yes

It might be the case, however, that the three broad sectors are too heterogeneous themselves as well. “Services & construction”, *e.g.*, lumps together “Construction” and “Electricity, Gas and Water” with “Post and Telecommunications” and “Computer and Related Activities”, where productivity developments may have been quite far apart from each other. Likewise, it may be desirable splitting the non-durable manufacturing group to separate relatively advanced sectors (such as “Chemicals and Chemical Products”) from traditional ones (such as “Food, Beverages and Tobacco” or “Textile, Textile Products, Leather and Footwear”).

The evidence in Section 2 is suggestive that productivity growth may be related to either IT production or diffusion. Hence, we want to explore sector heterogeneity along this other dimension. To do that, we rely on the OECD sector classification of IT producers and users reported in Section 2, although with some degree of approximation. STAN provides us with a 2-digit NACE classification, which only imperfectly captures the definitions of ICT producers and users reported in Section 2.

Table 6: Durable and non-durable manufacturing, services & construction

Dep. Variable	Value added per hour worked	Gross output per hour worked	TFP 1	TFP 2
Benchmark: 1978-89	Dummy variables for 1976-77 and 1990-91 not reported			
# observations	744	744	713	744
Sector fixed effects	Yes	Yes	Yes	Yes
OLS estimates				
Durables 1992-94	.054** (.022)	.053*** (.023)	.062*** (.024)	.060*** (.023)
Durables 1995-99	-.008 (.016)	-.006 (.016)	.008 (.016)	.004 (.014)
Non-durables 1992-94	.039*** (.012)	.042*** (.012)	.037*** (.011)	.032*** (.011)
Non-durables 1995-99	-.037*** (.009)	-.034*** (.009)	-.014 (.010)	-.022** (.009)
Services 1992-94	.015 (.022)	.022 (.015)	-.000 (.020)	.008 (.022)
Services 1995-99	.008 (.009)	-.002 (.006)	.034*** (.011)	.017 (.011)
R-squared	.22	.24	.24	.22
WLS estimates				
Durables 1992-94	.048*** (.012)	.048*** (.013)	.050*** (.013)	.047*** (.013)
Durables 1995-99	-.014 (.011)	-.013 (.012)	.001 (.014)	-.003 (.012)
Non-durables 1992-94	.047*** (.008)	.050*** (.008)	.040*** (.008)	.035*** (.008)
Non-durables 1995-99	-.023*** (.009)	-.021*** (.009)	-.007 (.009)	-.012 (.009)
Services 1992-94	.011 (.017)	.014 (.012)	-.001 (.018)	-.003 (.018)
Services 1995-99	-.007 (.010)	-.007 (.006)	.016 (.012)	.006 (.010)
R-squared	.20	.24	.21	.18

We consider our approximate classification a useful breakdown, anyway. **Table 7** shows the coefficients estimated when sectors are grouped in USER and NON-USER groups. **Table 8** shows the coefficients of the sectors classified among the IT producers (PROD) and NON-IT producers (non-PROD).

The results in **Tables 7** and **8** show that:

(a) Non-IT users and non-IT producers enjoyed a temporary boom in 1992-94, but then suffered from a severe growth shortfall in 1995-99, particularly as to labor productivity growth. This holds both for OLS and WLS estimates;

(b) Productivity growth in IT-using sectors did not accelerate in 1992-94 (except when gross output is considered). IT users enjoyed a 2-3 percentage points increase in TFP growth, although not in labor productivity growth, in 1995-99.

(c) IT producers experienced sizably higher productivity growth in 1992-94 (+5-6 percentage points), but this was short-lived, except for the WLS estimates of one TFP measure.

Table 7: IT users

Dep. Variable	Value added per hour worked	Gross output per hour worked	TFP 1	TFP 2
Benchmark: 1978-89	Dummy variables for 1976-77 and 1990-91 not reported			
# observations	744	744	713	744
Sector fixed effects	Yes	Yes	Yes	Yes
OLS estimates				
User 1992-94	.036 (.025)	.044** (.020)	.030 (.025)	.041 (.025)
User 1995-99	.015 (.013)	.006 (.012)	.035*** (.014)	.023* (.013)
Non-User 1992-94	.032*** (.009)	.033*** (.009)	.030*** (.008)	.024*** (.008)
Non-User 1995-99	-.029*** (.007)	-.028*** (.006)	-.006 (.007)	-.016** (.007)
R-squared	.22	.24	.22	.22
WLS estimates				
User 1992-94	.015 (.029)	.026 (.022)	-.002 (.030)	.006 (.033)
User 1995-99	.010 (.009)	.005 (.007)	.028*** (.009)	.019** (.009)
Non-User 1992-94	.032*** (.008)	.032*** (.007)	.027*** (.008)	.020** (.008)
Non-User 1995-99	-.022*** (.008)	-.019*** (.006)	-.002 (.009)	-.009 (.008)
R-squared	.20	.23	.20	.16

These findings, as well as the summary of productivity developments presented in Section 3, are suggestive that productivity gains may be more localized than implied by the OECD classifications. In particular, one would like to know how much Nokia counts in determining the statistical significance of the coefficients of IT users and producers in **Table 7** and **8**. Hence, to conclude this section, we estimated individual growth breaks for each of the IT-using and producing sectors, both with OLS and WLS.

Table 8: IT producers

Dep. Variable	Value added per hour worked	Gross output per hour worked	TFP 1	TFP 2
Benchmark: 1978-89	Dummy variables for 1976-77 and 1990-91 not reported			
# observations	744	744	713	744
Sector fixed effects	Yes	Yes	Yes	Yes
OLS estimates				
Producer 1992-94	.052* (.031)	.059** (.030)	.063* (.033)	.063** (.032)
Producer 1995-99	.009 (.023)	.006 (.023)	.019 (.023)	.016 (.019)
Non-Prod'er 1992-94	.030*** (.012)	.032*** (.010)	.022* (.012)	.023* (.012)
Non-Prod'er 1995-99	-.016*** (.006)	-.018*** (.005)	.009 (.007)	-.003 (.007)
R-squared	.21	.23	.22	.21
WLS estimates				
Producer 1992-94	.050** (.023)	.055** (.023)	.052** (.024)	.049** (.024)
Producer 1995-99	.019 (.016)	.020 (.016)	.032** (.015)	.026 (.015)
Non-Prod'er 1992-94	.026** (.011)	.029*** (.008)	.018 (.011)	.014 (.012)
Non-Prod'er 1995-99	-.014** (.007)	-.013*** (.005)	.006 (.008)	-.002 (.007)
R-squared	.18	.22	.18	.16

In **Table 9**, the OLS estimates relative to those sectors with at least one significant coefficient either in 1992-94 or 1995-99 are singled out. They are “Radio, TV and communications” (labeled “Nokia” in **Table 9**), “Post and Telecommunications” (“TLC”), “Renting of machinery and equipment” (“RentMach”), and “Research and Development” (“R&D”).

The results in **Table 9** add important details to the broad picture of the post-1992 growth acceleration. Regression results shown previously have detailed clear evidence of a strong bouncing back of the economy in 1992-94. The estimates in **Table 9** show that the 1992-94 growth acceleration was indeed extraordinarily high for Nokia, whose estimated acceleration coefficient reaches .272 in the labor productivity equation and .311 in the TFP equation. This roughly means that, with respect to its own average growth performance over the benchmark period 1978-1989, the various productivity growth rates of Nokia sector were between 27 and 31 percentage points higher. As average growth was roughly 6% in 1978-1989, this implies that Nokia experimented tremendous productivity improvements of about 33-37%. The descriptive statistics taken over 1992-1994 for "Nokia" confirm this jump.

Table 9: Nokia and the others – Ordinary least squares

Dep. Variable	Value added per hour worked	Gross output per hour worked	TFP 1	TFP 2
Benchmark: 1978-89	Dummy variables for 1976-77 and 1990-91 not reported			
# observations	744	744	713	744
Sector fixed effects	Yes	Yes	Yes	Yes
OLS estimates				
Nokia 1992-94	.272*** (.070)	.272*** (.070)	.311*** (.066)	.308*** (.061)
Nokia 1995-99	.105* (.057)	.104* (.058)	.106* (.058)	.116** (.052)
TLC 1992-94	.014 (.012)	.014 (.013)	-.000 (.011)	-.002 (.012)
TLC 1995-99	.041* (.023)	.045* (.024)	.055** (.024)	.040* (.024)
RentMach 1992-94	.088*** (.023)	.050*** (.017)	.103*** (.032)	.128*** (.044)
RentMach 1995-99	.015 (.020)	.012 (.018)	.129*** (.026)	.105*** (.026)
R&D 1992-94	-.028*** (.010)	.004 (.013)	-.034*** (.012)	-.036*** (.011)
R&D 1995-99	-.032*** (.007)	-.052*** (.013)	-.023** (.011)	-.029*** (.011)
Oth. IT-user 1992-94	.014 (.032)	.026 (.024)	-.001 (.030)	.015 (.032)
Oth. IT-user 1995-99	.007 (.017)	-.001 (.014)	.020 (.018)	.007 (.016)
Other 1992-94	.032*** (.009)	.033*** (.009)	.030*** (.009)	.024*** (.008)
Other 1995-99	-.029*** (.007)	-.028*** (.006)	-.006 (.007)	-.016** (.007)
R-squared	.26	.28	.29	.28

Another IT-related sector enjoying substantial acceleration (+5 to 10 p.p. compared to the 1978-89 benchmark) in the growth rates of both labor productivity and TFP was "Renting of Machinery and equipment”. This is to be contrasted with the lower acceleration of non-IT related in the economy, ranging around 3 p.p.. Importantly, a handful of IT-using sectors did not enjoy any growth acceleration in this period. The R&D producing sector appears to have suffered a growth shortfall (in Section 5, we will show that this result is not always there, though).

Table 9 also provides useful information to understand where the 1995-99 growth acceleration did originate. Nokia and “Renting of machinery” still exhibit a TFP growth acceleration (compared to the 'socialist' period benchmark) of some 10-12 percentage points. This same thing applies to labor productivity growth as well, at least for Nokia. Unlike in 1992-94, during 1995-1999 “Post and telecommunications” joins the group of the fast-growing sectors by showing an increase of 4-5 p.p. in its growth rate of labor productivity and TFP. Productivity growth in the non-IT-related sectors shows instead definite signs of a slowdown of some 2-3 percentage points compared to the benchmark.

We interpret these findings as implying that productivity gains may be more localized than implied by the OECD classifications extensively exploited in previous work. Partly at variance with Gordon’s findings for the United States, we also find that productivity spillovers out of durable manufacturing are significant. “Renting of machinery” and “Post and Telecommunications” sizably benefited from the productivity revival in the Nokia-driven sector. More importantly, their overall importance in the Finnish economy has risen. In fact, their value added share over the non-farm market sector rose from 3% in 1978-1989 to about 4.5% in 1992-1999. In parallel, their employment share (in terms of hours worked) went up from 2.9% to 3.6%. The productivity gains are particularly evident for “Renting of machinery”, whose average TFP growth before 1990 was –8% per year and trending downwards.

Similarly, the three sectors’ contribution has crucially driven the aggregate performance of both total factor productivity and labor productivity. Following Domar (1961) and OECD (2001), we are able to aggregate value added-based sectoral labor productivity and TFP and compute each sector’s contribution to aggregate productivity. The accounting relation for TFP is given by:

$$grwoth_{TFP-Aggregate} = \sum_{j} \left(\frac{P_{VA}^{J} VA^{j}}{P_{VA} VA} \right)^{average} growth_{TFP\_j}$$

where the $growth_{TFP\text{-}Aggergate}$ is aggregate TFP, and $growth_{TFP\_j}$ is sectoral productivity. Sectoral weights are obtained as the average over two periods[20] of the ratio of the sectoral nominal value added to the aggregate nominal value added.

The aggregating relation for labor productivity is given by:

$$growth_{Lab\,\Pr od} = \sum_j \left\{ \left(\frac{P_{VA}^J VA^j}{P_{VA} VA} \right)^{average} growth_{ValueAdded\_j} - \left(\frac{LabComp_j}{LabComp} \right)^{average} growth_{TotHours\_j} \right\}$$

where the aggregate measure of labor productivity ($grwoth_{LabProd}$) is shown to be equal to a weighted difference between the growth of the sectoral vale added and the growth of the total number of hours worked in that sectors. Domar's weights are now expressed as the ratio between sectoral and aggregate nominal value added and by the ration between sectoral and aggregate total labor compensation.

Figures 4 and **5** show that, during the period 1992-1999[21], taken all together the three sectors accounted on average for 42.5% of the aggregate TFP performance and 30.5% of aggregate labor productivity performance, with Nokia being in both cases the *absolute* leader[22]. Although part of this result is induced by the large share of value added imputed to Nokia, most of the it is driven by a spiky acceleration of the sectoral productivity as documented above. The role of Renting Of Machinery, which only amounts to 0.5% in both cases, is limited by the extremely small, although growing, size of this sector. Its average contribution to TFP, however, has moved from negative values during the 'Socialist' Period to positive ones (as documented by **Figure 6**[23]); similarly, its average contribution to Labor Productivity has moved from 0.00% during the 78-89 period to 0.5% after the 90-91 crisis (**Figure 7**). The dynamics of Nokia's and Post&Telecom's contributions are even more striking; Post&Telecom doubles its average contribution to TFP starting in 92 with a subsequent partial decline, and rises its average contribution to Labor Productivity by 4% in 95-99. Nokia's contribution sky rockets in both cases from figures around 2% to some 28-33% amazing results. It is easy to attach to these results a *revolutionary* message.

[20] In both this and the following equation weights are averaged over two subsequent periods to achieve a Tornqvist Index.

[21] The two graphs plot the average yearly contribution of each sector to TFP and Labor Productivity over the 92-99 time span.

[22] Only estimates for TFP2 are reported; results for TFP1 do not differ in the overall message one can learn. Moreover, results for gy95het are not reproduced because of space constraints; the methodology used to aggregate gross output-based labor productivity measures is however slightly different.

The OLS results in **Table 9** are fully confirmed when WLS techniques are employed instead, and the same set of regressions estimated (see the results in **Table 10**). No substantial change arises in the pattern of partial correlation, significance and sign of the estimated coefficients. We conclude that our results are not driven by the potentially high measurement error induced by the inclusion of some small sector.

Table 10: Nokia and the others – Weighted least squares

Dep. Variable	Value added per hour worked	Gross output per hour worked	TFP 1	TFP 2
Benchmark: 1978-89	Dummy variables for 1976-77 and 1990-91 not reported			
# observations	744	744	713	744
Sector fixed effects	Yes	Yes	Yes	Yes
WLS estimates				
Nokia 1992-94	.273*** (.070)	.274*** (.070)	.312*** (.066)	.309*** (.061)
Nokia 1995-99	.107* (.057)	.106* (.058)	.106* (.058)	.116** (.052)
TLC 1992-94	.016 (.013)	.015 (.013)	.000 (.011)	-.001 (.012)
TLC 1995-99	.043* (.023)	.046* (.024)	.053** (.024)	.040* (.024)
RentMach 1992-94	.089*** (.024)	.052*** (.019)	.102*** (.032)	.127*** (.044)
RentMach 1995-99	.016 (.020)	.014 (.018)	.129*** (.026)	.104*** (.026)
R&D 1992-94	-.026*** (.010)	.006 (.012)	-.036*** (.012)	-.036*** (.011)
R&D 1995-99	-.030*** (.010)	-.050*** (.020)	-.023** (.011)	-.029*** (.011)
Oth. IT-user 1992-94	.010 (.031)	.022 (.024)	-.010 (.033)	-.001 (.036)
Oth. IT-user 1995-99	.007 (.009)	.002 (.008)	.025** (.009)	.016 (.010)
Other 1992-94	.032*** (.009)	.032*** (.007)	.025*** (.008)	.020*** (.008)
Other 1995-99	-.022*** (.008)	-.019*** (.006)	-.004 (.009)	-.010 (.008)
R-squared	.20	.24	.28	.23

[23] Figure 6 and Figure 7 display the average yearly contribution to, respectively, TFP and Labor Productivity over three different time periods, namely 1978-1989 (the 'Socialist' Period), 1992-1994 (the Bouncing Back) and 1995-1999.

5. How do we know that it was IT and not something else?

In Section 3 and 4, we have documented the productivity growth acceleration in the Finnish economy, providing evidence that such acceleration has been particularly strong in 1992-94 during the "bouncing back" period. During this period of time, productivity growth has accelerated in the economy at large and particularly in some (but not all) IT-producing sectors. In 1995-99, there was no such a thing as a labor productivity acceleration compared to the benchmark years. Something was there instead for TFP growth, particularly in some IT-using sectors, although once again the TFP growth acceleration cannot be said to have concerned the whole of the IT sectors in the economy.

This helps make the point that the production of some IT goods (notably cellular phones) has had a strong impact on productivity growth in Finland. This is in line with the findings in most of the Finnish literature on this topic and with the cross-country studies surveyed in Section 1. Previous work has left unanswered a crucial question, however: can we safely relate these productivity developments to what happened to information technology adoption? We can't, honestly. In this Section, however, we present two pieces of evidence bearing on this issue.

First, we show that our results survive after partialling out the effects of cyclical fluctuations from labor productivity and TFP growth series. Second, we provide evidence in support of the presence of a favorable supply shock.

In the first part of this Section, we show that our measures of TFP growth capture something related to technology and not (or not completely) to business-cycle fluctuations. This problem was first emphasized by Hall (1990) and since then discussed in many other papers (such as Burnside, Eichenbaum, Rebelo (1995, 1996) and Baxter and Farr (2001)).

5.1 Was it just good luck?

The main concern with the robustness of our growth results is that they may be driven by business-cycle fluctuations. To investigate this possibility, we perform two experiments.

In the first experiment, we append the dependent variable lagged once or twice or three times to our preferred regressions in **Table 9** and **10**. As the growth rate of output displays an auto-regressive behaviour[24], if the correlation between cycles and various measures of productivity is the only driving force of our results, the inclusion of the lagged values of the dependent variable among the regressors should make the productivity jumps no longer significant. Note that, in running this test, we drop the time dummies, for the lagged values of our various measures of productivity already embody the negative effects of the two 1976-77 and 1990-91 downturns, and there is no need for additional controls.

Table 11: Nokia and the others, robustness test, lagged dependent variables

Dep. Variable	Value added per hour worked	Gross output per hour worked	TFP 1	TFP 2
Benchmark: 1978-89	Dummy variables for 1976-77 and 1990-91 not reported			
# observations	651	651	620	651
Sector fixed effects	Yes	Yes	Yes	Yes
OLS estimates				
Nokia 1992-94	.305*** (.040)	.300*** (.054)	.329*** (.049)	.326*** (.041)
Nokia 1995-99	.140*** (.053)	.136* (.053)	.150*** (.055)	.157*** (.052)
TLC 1992-94	.017* (.010)	.015 (.010)	-.000 (.008)	-.001 (.009)
TLC 1995-99	.044* (.023)	.046** (.023)	.055** (.025)	.044* (.023)
RentMach 1992-94	.097*** (.036)	.048** (.022)	.125*** (.041)	.148*** (.056)
RentMach 1995-99	.045** (.028)	.034* (.018)	.196*** (.034)	.179*** (.033)
R&D 1992-94	-.017*** (.010)	.016 (.013)	-.020* (.011)	-.024* (.011)
R&D 1995-99	-.024*** (.007)	-.047** (.022)	-.011 (.010)	-.018* (.010)
Oth. IT-user 1992-94	.005 (.032)	.026 (.025)	-.012 (.032)	.006 (.032)
Oth. IT-user 1995-99	.009 (.018)	.000 (.016)	.021 (.018)	.017 (.017)
Other 1992-94	.037*** (.009)	.037*** (.008)	.033*** (.009)	.025*** (.008)
Other 1995-99	-.024 (.007)	-.021*** (.006)	-.007 (.008)	-.006 (.007)
Dep.var. (t-1)	-.079*** (.071)	-.044(.057)	-.045 (.079)	-.056 (.074)
Dep.var. (t-2)	-0.21*** (.070)	-.17*** (.065)	-.180*** (.067)	-.214*** (.073)
Dep.var. (t-3)	-.039 (.068)	-.058 (.064)	-.079 (.067)	-.059 (.070)
R-squared	.31	.32	.32	.32

[24] Our regressions (not reported here) suggest that the process is an AR of at most order three. Consequently we include three lags of the dependent variables in our regressions.

The results in **Table 11** are suggestive that our previous results withstand this experiment. In fact, our coefficients of interest do not loose their statistical significance, and their size is unaffected or even slightly increased[25]. Furthermore, the slowdown of the R&D sector is dampened for all productivity measures and it turns out to be less significant.

Notice, moreover, that, among the three included regressors, only the twice-lagged productivity measure exhibits a significantly negative and quite large effect. Importantly, as mentioned above, this does not affect our results.

Table 12: Nokia and the others, robustness test, economy wide output fluctuations

Dep. Variable	Value added per hour worked	Gross output per hour worked	TFP 1	TFP 2
Benchmark: 1978-89	Dummy variables for 1976-77 and 1990-91 not reported			
# observations	744	744	713	744
Sector fixed effects	Yes	Yes	Yes	Yes
OLS estimates				
Nokia 1992-94	.283*** (.072)	.283*** (.072)	.331*** (.069)	.330*** (.066)
Nokia 1995-99	.113** (.057)	.111** (.057)	.117*** (.057)	.127*** (.052)
TLC 1992-94	.026* (.015)	.025* (.015)	.019 (.015)	.020 (.016)
TLC 1995-99	.049** (.023)	.052** (.024)	.065** (.025)	.051** (.024)
RentMach 1992-94	.099*** (.023)	.060*** (.020)	.123*** (.029)	.149*** (.038)
RentMach 1995-99	.022 (.020)	.019 (.018)	.139*** (.025)	.116*** (.025)
R&D 1992-94	-.016 (.009)	.015 (.014)	-.014 (.011)	-.014 (.012)
R&D 1995-99	-.024** (.008)	-.044** (.019)	-.012 (.008)	-.017* (.009)
Oth. IT-user 1992-94	.025 (.035)	.037 (.026)	.018 (.034)	.037 (.037)
Oth. IT-user 1995-99	.015 (.018)	.005 (.016)	.029 (.019)	.020 (.017)
Other 1992-94	.043*** (.009)	.043*** (.009)	.050*** (.009)	.045*** (.009)
Other 1995-99	-.021*** (.006)	-.020*** (.006)	.004 (.007)	-.004 (.007)
GY	-.067 (.045)	-.066 (.042)	.154*** (.046)	.197*** (.045)
R-squared	.25	.27	.27	.27

[25] OLS produce inconsistent estimates of coefficients in dynamic panel models. However, as suggested by Hsiao (1986), the asymptotic bias is likely to be small since: a) the time dimension of the panel (T=25) is large relative to the cross-section (I=31); b) the size of the autoregressive coefficient is likely to be smaller, in absolute value, than 0.7.

To check more directly the robustness of our results, we also include the growth rate of the whole-economy gross output (*GY*) in our regression. Again, if the cyclical behaviour of this variable is the sole engine of the burst productivity, we expect to accept the null that our interaction dummy coefficients are zeroes. As in the previous robustness test, the new specification does not include the time dummies. Results in **Table 12** show that our findings are robust to business cycle considerations. Once more, all relevant coefficients are significant and their size is sometimes increased.

A possible objection to this testing procedure is that, by estimating just one coefficient for the sensitivity of sector productivity growth to economy-wide gross output fluctuations, we are unduly restricting all sectors to identically react to such fluctuations. A natural candidate to test for the robustness of our result against the possibilities of sector-specific business-cycles would be to replace aggregate by sector output growth (*gy*). Anyway, some cautions need to be adopted when interpreting the results of this last experiment. We expect in fact the results of this test to be partially affected since, by construction, the various productivity measures rely partly on different measures of *real* performance.[26]

Table 13 confirms our presumptions. The most striking results concern the "Nokia" sector. When controlling for sector fluctuations, the 1995-1999 positive performance vanishes. Although this may appear worrisome, we are not too surprised by this result, since our estimates for this coefficient are in fact not the most robust and significant in our previous Tables. More surprisingly, the 1992-94 coefficient is lower than before by up to 8 p.p. Anyway, the estimated coefficients for the rise in TFP growth is still around 0.25 and the one for labour productivity about 0.22. Even when subjected to the most stringent test we can think of, productivity gains are hardly explained *via* business-cycle arguments only.

Two other results are worth mentioning. First, we find that the slowdown of the R&D sector is more driven by cyclical forces than by supply-sided productivity decline. More importantly, when adding the sector growth controls, we find that the recovery in the TLC sector had already begun in 1992. [27]

The three experiments just described have also been performed using WLS estimators to account for possible measurement errors. We do not report the results here because of space reasons.

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[26] For example, our second measure of labour productivity is nothing but real term gross output divided by total worked hours.

[27] And this result partly showed up in the previous two tables as well.

Anyway, no differences have shown up when using the alternative estimation procedure. This reinforces our idea that our fixed-effects breaks do not simply capture cyclical circumstances. As emphasised in the next Section, a positive technological shock can help understand the productivity gains experienced by the Finnish sectors between 1992 and 1999.

Table 13: Nokia and the others, robustness test, sectoral level output fluctuations

Dep. Variable	Value added per hour worked	Gross output per hour worked	TFP – measure 1	TFP – measure 2
Benchmark: 1978-89	Dummy variables for 1976-77 and 1990-91 not reported			
# observations	744	744	713	744
Sector fixed effects	Yes	Yes	Yes	Yes
OLS estimates				
Nokia 1992-94	.219*** (.072)	.214*** (.072)	.241*** (.066)	.235*** (.062)
Nokia 1995-99	.067 (.056)	.062 (.057)	.056 (.054)	.064 (.048)
TLC 1992-94	.039*** (.015)	.040*** (.015)	.034** (.015)	.032** (.015)
TLC 1995-99	.048** (.023)	.050** (.023)	.062*** (.023)	.048*** (.022)
RentMach 1992-94	.123*** (.021)	.087*** (.016)	.150*** (.029)	.174*** (.041)
RentMach 1995-99	.021 (.016)	.018 (.016)	.139*** (.023)	.113*** (.024)
R&D 1992-94	-.000 (.009)	-.032*** (.012)	.002 (.009)	.000 (.009)
R&D 1995-99	-.011 (.009)	-.030 (.017)	.003 (.018)	-.002 (.009)
Oth. IT-user 1992-94	.025 (.035)	.037 (.025)	.014 (.032)	.030 (.034)
Oth. IT-user 1995-99	.020 (.018)	.011 (.015)	.032* (.019)	.025 (.018)
Other 1992-94	.049*** (.009)	.049*** (.009)	.052*** (.008)	.045*** (.008)
Other 1995-99	-.018*** (.006)	-.017*** (.006)	.006 (.007)	.001 (.005)
Gy	.165*** (.035)	.180*** (.029)	.223*** (.036)	.227*** (.036)
R-squared	.31	.35	.37	.37

5.2 The dynamics of the price deflators of machinery and equipment

We are after providing evidence in favor of the occurrence of a favorable supply shock in the Finnish economy after 1992, and possibly between 1995 and 1999. Here we look at the dynamics of the price deflators of investment goods. Our point is simple: if something related to the embodiment of technical change took place on the supply side of the economy, the price of machinery and equipment should go down (or their rate of inflation decrease) compared to previous years. If instead nothing occurred on the supply side, and growth is demand-driven, we expect machinery and equipment price inflation to go up compared to the past.

Then we run the same type of fixed effects regressions as in (1), albeit with the price of machinery and equipment on the left-hand side and with a smaller set of sectors (24 rather than 31; see the list in the **Data Appendix**). In particular, we do not have data for "Radio, TV and communications", but together with "Office, Accounting, and computers", "Electrical machinery not elsewhere classified" and "Medial and optical instruments". Moreover, "Renting of machinery and equipment", "Computer and related activities", "R&D" and "Other business services" are not separately measured. In short, our sector disaggregation for investment deflator dynamics is less fine than in the rest of the paper and this disaggregation is unfortunately less fine just in the sectors we mostly care about.

Table 14: The dynamics of the sector prices of machinery and equipment

	OLS	WLS
Benchmark: 1978-89		
# observations	552	552
Sector fixed effects	Yes	Yes
1976-77	.038*** (.007)	.042*** (0.07)
1990-91	-.016*** (.005)	-.017** (.007)
Nokia et al. 1992-94	-.001 (.019)	-.001 (.019)
Nokia et al. 1995-99	-.078*** (.012)	-.078*** (.012)
TLC 1992-94	-.041* (.024)	-.041* (.020)
TLC 1995-99	-.114*** (.014)	-.114*** (.013)
Business 1992-94	-.031 (.030)	-.030 (.030)
Business 1995-99	-.095*** (.022)	-.094*** (.021)
Oth. IT-user 1992-94	-.013 (.015)	-.035 (.027)
Oth. IT-user 1995-99	-.071*** (.007)	-.078*** (.008)
Other 1992-94	-.009 (.007)	-.012 (.010)
Other 1995-99	-.041*** (.005)	-.050*** (.006)
R-squared	.38	.41

We can anyway construct an approximation to the ideal test we would have liked to run and thus go ahead with it. We try and test whether the trend breaks in the series of the sector prices of machinery and equipment correspond to the same sectors and periods detected when looking at labor productivity and TFP growth. The price of machinery and equipment tends to decrease mostly in 1992-99, in the sectors related to IT use (such as the aggregate item that we label 'business services'), and more clearly so in 1995-99. In **Table 14**, we find that this is largely the case. OLS and WLS estimates produce very similar numerical and statistical results.

Note that we are employing the absolute level of price deflators, and not the relative price of investment. We do it because we need time dummies (in particular: the interaction between time and sector dummies) to test our preferred hypothesis. Yet, period time dummies, when inserted as regressors, do most of the job of taking cyclical influences away. Hence, normalizing prices of machinery and equipment by the sector price deflator and adding period dummies altogether implies over-fitting, which we want to avoid. Hence we prefer to keep the absolute level of investment price deflators on the left-hand side and control for period-specific influences (including cyclical influences) by having time dummies on the right-hand side.

6. Conclusions

In this paper we exploited Finnish sector data over the last twenty five years. Our main results, extensively discussed in previous sections, are that the Finnish economy is crucially driven by Nokia and the IT cluster. Anyway, productivity spillovers out of durable manufacturing are fairly important. Other IT-using sub-sectors, namely "Renting of machinery" and "Post and Telecommunications", largely benefited from productivity improvements. More importantly, their overall importance in the Finnish economy is becoming more evident as the shares of these sectors in value added and employment grow. We also made a specific effort to show that this has not simply been the result of fortunate cyclical circumstances.

Our results do not obviously imply that cyclical fluctuations have become unimportant. Now Finland, in parallel with its high-tech sector and with the world economy at large, is indeed facing a tough cyclical downturn. Its GDP per employed person fell by 0.7% in 2001 - a dramatic slowdown compared to the previous decade. However, this only makes it even more urgent than in the past to try and understand whether and how much the underlying long-run growth rate of the economy has gone up thanks to the diffusion of information technologies. This is why we thought of writing this paper in the first instance.

In the end, should we expect a permanently higher productivity growth rate in the future of Finland? This remains to be seen, particularly in the midst of a recession. Based on our findings, two conclusions can be ventured, however.

First, the sizable differences in the growth rates of TFP and labor productivity of the second part of the 1990s will likely narrow down, as the process of getting rid of old capital reaches completion.

Second, the extent to which the Finnish economy becomes less Nokia-dependent crucially hinges on whether TFP growth spillovers go beyond those sectors already affected in the 1990s, to other service sub-sectors, such as wholesale and retail trade, and finance. Using detailed financial statement and payment transactions data, Mortinen (2002) finds that TFP growth in the Finnish banking sector was substantial, and already much bigger than in other countries in the second half of the 1990s. This is once again suggestive that measurement issues will continue to play an important role in evaluating productivity developments, particularly in the service sectors.

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Data appendix

1. Data source and variables

The main data source for this paper is the OECD STAN database. Electricity consumption data are from the OECD Statistics Web Site. What they are for is detailed in Appendix 2.

We have conducted our sectoral analysis at a two-digit level of sector disaggregation. This is as follows:

1. Mining and Quarrying
2. Food Products, Beverages and Tobacco
3. Textile, Textile Products, Leather and Footwear
4. Wood and Products of Wood and Cork
5. Pulp, Paper, Paper Products, Printing and Publishing
6. Coke, Refined Petroleum Products and Nuclear Fuel
7. Chemical and Chemical Products
8. Rubber and Plastic Products
9. Other Non-Metallic Mineral Products
10. Basic Metal
11. Fabricated Metal Products
12. Machinery and Equipment, NEC
13. Office, Accounting and Computer Machinery
14. Electrical Machinery and Apparatus
15. Radio, TV and Communication Equipment
16. Medical, Precision and Optical Instruments
17. Motor Vehicles, Trailers and Semi-Trailers
18. Other Transport Equipment
19. Manufacturing NEC, recycling
20. Electricity, Gas and Water Supply
21. Construction
22. Wholesale and Retail Trade, Repairs
23. Hotels and Restaurants
24. Transport and Storage
25. Post and Telecom

26. Financial Intermediation *except* for *insurance and pension funds*

27. Insurance and Pension Funding *except for compulsory social security*

28. Renting of Machinery and Equipment

29. Computer and Related Activities

30. Research and Development

31. Other Business Activities

We define moreover:

- Non-Durable Goods as the sum of sectors from 1 to 11 plus sector 19.
- Durable Goods as the sum of the sectors from 12 to 18.
- Services as the sum of all remaining sectors.

We employed the following variables from the OECD STAN database:

- *Value.added.95*, Value Added, Volumes, Quantity Index, at basic prices; notice that the series is a Fixed-weight Laspeyres Index, base year 1995.
- *Y.95*, Gross Output, Volumes, Volumes, Quantity Index, at basic prices; notice that the series is a Fixed-weight Laspeyres Index, base year 1995.
- *Y*, Gross Output, at current prices.
- *Kapital*, Gross Capital Stock, Volumes, defined as Tangible Fixed Assets excluding cultivated assets.
- *Lab.compensation*, summing wages and salaries paid by producers as well as all supplements such as contributions to social security, private pensions, health insurance, life insurance and similar schemes.
- *Depreciation*, Consumption of Fixed Capital.
- *Op.sur*, operating surplus.
- *Total Hours*, Total Hours worked by Employees. These are actual hours worked, not just paid for, and do not include only employees, but total number of engaged.
- *Total.Employment*, Headcounts, number of total engaged.
- *Price of Machinary and Equipment*, Sector price deflator of investment goods

Notice that "all" refers to the Non-farm market sector. So, we do not include agriculture and we also exclude from our analysis all the so called Community Social and Personal Services. In this regard, we are moving away from the analysis usually applied to USA productivity analysis. The main reason for our choice is driven by the fact that for Finland most of services included in this last category are Government provided. They are indeed part of the non-market economy. Therefore for accounting reasons, they do not incorporate productivity gains.

Finally, we leave out two other sectors. One is Real Estate Activities. As suggested by OECD Productivity Manual, this sector tends to incorporate no productivity gains for its own peculiar structure. Second, we also drop Activities Related to Financial Activities. Although it may be interesting and important to evaluate how ICT is influencing the productivity of activities collateral to financial markets, this sector displays for Finland a too volatile behavior because of the 1990-1991 financial crisis. Fortunately, its particularly small size suggests that we are not dropping an extremely relevant part of the economy.

2. Productivity measurement and TFP construction methodology

Throughout the paper we make use of the productivity measurement method introduced by Solow (1957). This growth accounting method consists in identifying technical change by calculating the TFP. This is turn computed netting out of output growth the changes in factor inputs, including intermediates. Here we do it by employing value added for we don't have intermediates. We do it in two ways in order to try and account for cyclical utilization of factor inputs.

The first one, TFP-measure 1, account for cyclicality of factor use correcting capital services for actual electricity consumption. We do it in the following way.

As a first step regress, sector by sector, the (log) of the electricity consumption on a deterministic linear trend:

$$log(electricity\ consumption)_{it} = a + b^*\ Trend + error\ term_{it}$$

The implied residuals are then saved and used to build the cyclical utilization of capital. This should be reasonable under the following two assumptions:

1. Effective capital utilization is a function of final consumption of electricity divided by the total potential electricity potential. This holds for each sector.
2. A linear time trend is able to represent the total potential electricity potential for each sector[28].

[28] In this regard, we've also tried higher order polynomials or HP filters without any different result.

We build therefore for each sector a measure of *effective capital services* as:

$$K^{eff}_{s,t} = K_{s,t} * exp(e_{s,t})$$

where e is the residual from the previous regression, s is the sector index and t is a time index. Following this strategy, we are able to measure capital services taking both into account the use of existing machines, proxied by the electricity consumption, and the introduction of new capital goods.

Data on electricity consumption have been downloaded from OECD Statistics, for the period 1975-1998. The implied TFP series will then be one period shorter than our full sample.

Unfortunately, a two digit sector analysis for electrical consumption is not fully provided by OECD and not always the sector that we consider and those surveyed by OECD coincides. We built the following mapping, by proxying sectors without a specific time series for electricity use by the immediately closer sector whose data are available:

- Mining and Quarrying has its own electricity consumption data
- Food Products, Beverages and Tobacco is proxied by Tobacco Sector electrical consumption
- Textile, Textile Products, Leather and Footwear is proxied by Textile
- Wood and Products of Wood and Cork is proxied by Wood
- Pulp, Paper, Paper Products, Printing and Publishing is proxied by Paper
- Coke, Refined Petroleum Products and Nuclear Fuel is proxied by Chemical
- Chemical and Chemical Products is proxied by Chemicals
- Rubber and Plastic Products is proxied by Chemical
- Other Non-Metallic Mineral Products has its own data
- Basic Metal is proxied by Iron and Steel Production
- Fabricated Metal Products is proxied by a general category Non Specified Manufacturing
- Machinery and Equipment, NEC is proxied by Machinery
- Office, Accounting and Computer Machinery is proxied by Machinery
- Electrical Machinery and Apparatus is proxied by Machinery
- Radio, TV and Communication Equipment is proxied by Machinery
- Medical, Precision and Optical Instruments is proxied by Machinery

- Motor Vehicles, Trailers and Semi-Trailers are proxied by Transport[29]
- Other Transport Equipment is proxied with Transport [30]
- Manufacturing NEC, recycling is proxied by Non Specified Manufacturing
- Electricity, Gas and Water Supply is proxied by a general category Other Non Specified Sectors minus Agriculture
- Construction has its own data
- Wholesale and Retail Trade, Repairs is proxied by Other Non Specified Sectors minus Agriculture
- Hotels and Restaurants is proxied by Other Non Specified Sectors minus Agriculture
- Transport and Storage has its own data
- Post and Telecom is proxied by Transport since STAN data classify the former sector as a subset of the previous
- Financial Intermediation, *except* for *insurance and pension funds*, is proxied by Other Non Specified Sectors minus Agriculture
- Insurance and Pension Funding, *except for compulsory social security*, is proxied by Other Non Specified Sectors minus Agriculture
- Renting of Machinery and Equipment is proxied by Other Non Specified Sectors minus Agriculture
- Computer and Related Activities is proxied by Other Non Specified Sectors minus Agriculture
- Research and Development is proxied by Other Non Specified Sectors minus Agriculture
- Other Business Activities is proxied by Other Non Specified Sectors minus Agriculture

The implied TFP is derived following standard Solow techniques. So first we derive labor share and its two periods average value[31], and then compute TFP residually. In analytical terms, our TFP 1 is given by:

$$lab.share = \frac{lab.compensation}{lab.compensation + op.sur + depreciation}$$

[29] We also tried Machinery, but it is a less successful proxy of output and hours worked.
[30] See the previous footnote.

$$lab.share.average = \frac{lab.share_t + lab.share_{t-1}}{2}$$

$$growth_{valu.added95/tot.hours} = (1 - lab.share.average) * growth_{Kap.Effective/tot.hours} + growth_{TFP}$$

Since our procedure to correct for electricity may possibly induce distortions in our measure of TFP, we also propose a second correction strategy. In this case we proxy effective capital services taking into account the variation of total worked hours. Following Shapiro (1993), we compute TFP as:

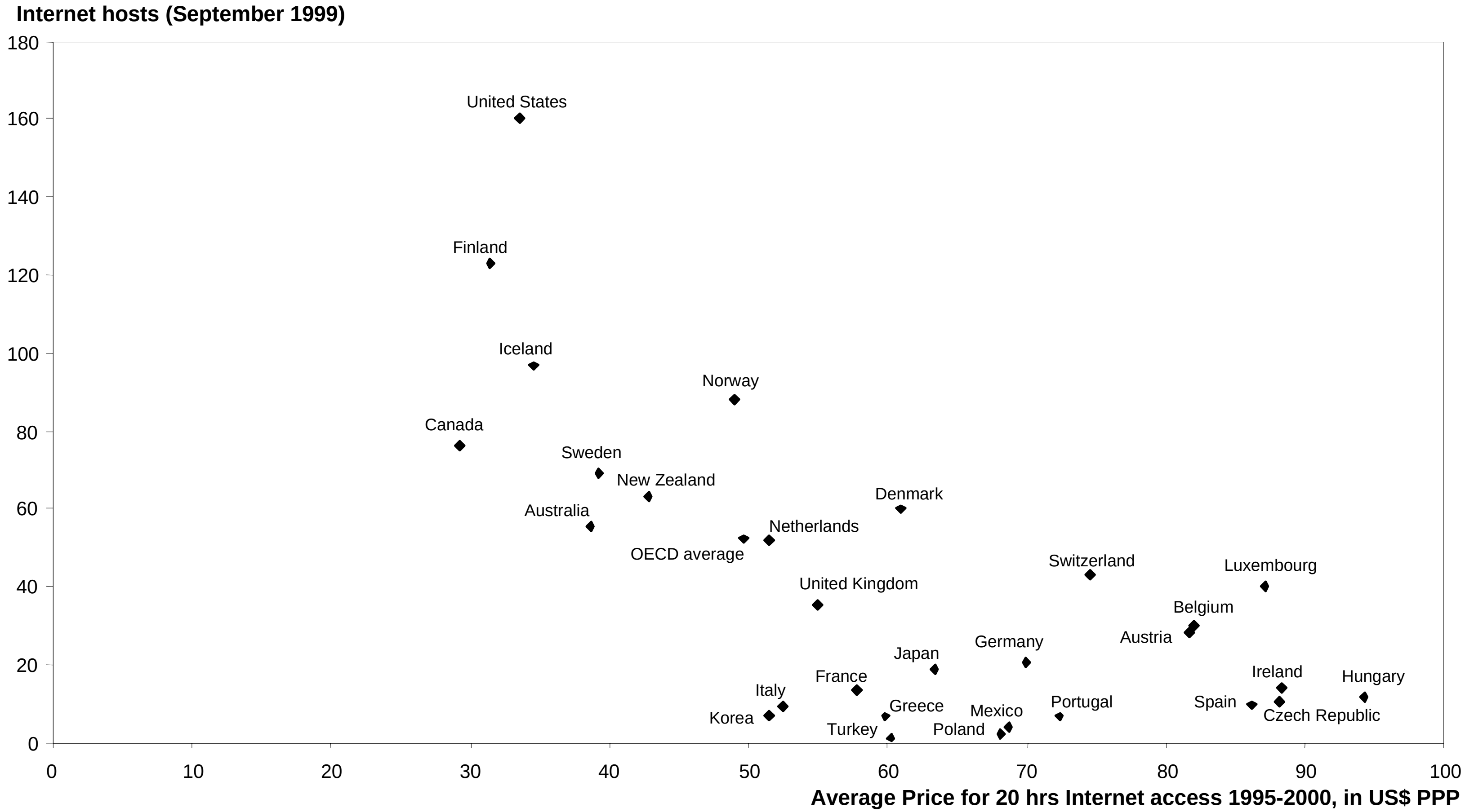
$$growth_{TFP} = growth_{value.added95/tot.hours} - (1 - lab.share.average) * growth_{Kapital/Total.Employment}$$

This is the indicator to which we refer as TFP 2 in the text

As a final remark, it is important to underline that, as pointed out by Hulten (1992), it is important to distinguish between embodied or disembodied technological change. If technical change is embodied, standard growth accounting methods are flawed for TFP growth embodies component essentially due to quality change in factor inputs (see also Jorgenson, 1966). Actual TFP growth is thus smaller than TFP measured without accounting for factor quality changes.

[31] This is to achieve a Tornqvist Index.

Figure 1 - Average price of 20 hours of Internet access (1995-2000) and Internet host penetration



Note: Data on hosts for Luxembourg is from mid-1999. Internet access costs include VAT.
Source: OECD (www.oecd.org/dsti/sti/it/cm) and Telcordia Technologies (www.netsizer.com)

APPENDIX 3

Finland - Industry by Industry Input-Output coefficients – Domestic Use

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
ISIC Rev. 3			mining	food	Text	wood	pulp	coke	chem	rubber	othnm	basic	fabri	meqnec	office	elctr	TV	medinstr	motveh	othtrsp	man nec	EGW	cst	trade	hotels	trs	ptc	finance	Re&bus
			10-14	15-16	17-19	20	21-22	23	24	25	26	27	28	29	30	31	32	33	34	35	36-37	40-41	45	50-52	55	60-63	64	65-67	
1	mining	10-14	0.019	0.001	0.001	0.001	0.005	0.000	0.012	0.000	0.032	0.012	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.028	0.019	0.000	0.000	0.000	0.000	0.000	0.000
2	food	15-16	0.007	0.212	0.004	0.003	0.007	0.002	0.009	0.004	0.003	0.002	0.003	0.004	0.001	0.003	0.002	0.004	0.002	0.003	0.003	0.003	0.001	0.011	0.232	0.005	0.003	0.002	0.002
3	text	17-19	0.004	0.000	0.106	0.001	0.001	0.000	0.001	0.002	0.005	0.001	0.003	0.002	0.000	0.001	0.001	0.001	0.001	0.004	0.001	0.001	0.005	0.001	0.001	0.001	0.000	0.000	0.000
4	wood	20	0.002	0.001	0.001	0.095	0.021	0.001	0.002	0.003	0.009	0.002	0.003	0.003	0.000	0.004	0.000	0.001	0.001	0.001	0.116	0.006	0.066	0.001	0.000	0.000	0.000	0.000	0.001
5	pulp	21-22	0.020	0.044	0.020	0.020	0.205	0.011	0.035	0.032	0.027	0.009	0.013	0.013	0.011	0.014	0.011	0.018	0.008	0.010	0.027	0.044	0.003	0.031	0.013	0.014	0.014	0.018	0.024
6	coke	23	0.011	0.002	0.002	0.002	0.003	0.069	0.018	0.003	0.008	0.019	0.001	0.002	0.001	0.002	0.002	0.002	0.003	0.002	0.003	0.006	0.003	0.004	0.001	0.022	0.003	0.002	0.004
7	chem	24	0.023	0.003	0.023	0.016	0.027	0.007	0.114	0.090	0.016	0.006	0.018	0.003	0.001	0.011	0.002	0.005	0.008	0.008	0.021	0.003	0.015	0.004	0.001	0.001	0.001	0.001	0.002
8	rubber	25	0.003	0.010	0.014	0.002	0.002	0.003	0.009	0.026	0.010	0.001	0.002	0.005	0.003	0.006	0.006	0.009	0.013	0.006	0.013	0.008	0.016	0.014	0.001	0.004	0.001	0.000	0.001
9	othnm	26	0.004	0.003	0.002	0.005	0.001	0.000	0.003	0.003	0.085	0.001	0.002	0.001	0.000	0.001	0.000	0.001	0.011	0.006	0.004	0.001	0.068	0.002	0.000	0.001	0.001	0.000	0.001
10	basic	27	0.004	0.002	0.001	0.003	0.003	0.002	0.004	0.006	0.011	0.327	0.123	0.051	0.004	0.038	0.004	0.007	0.034	0.039	0.012	0.008	0.008	0.001	0.001	0.000	0.001	0.001	0.001
11	fabri	28	0.009	0.005	0.003	0.008	0.002	0.004	0.005	0.004	0.016	0.003	0.099	0.020	0.001	0.012	0.004	0.005	0.021	0.046	0.023	0.009	0.066	0.001	0.000	0.002	0.000	0.000	0.001
12	meqnec	29	0.046	0.004	0.003	0.006	0.007	0.003	0.006	0.006	0.018	0.003	0.013	0.130	0.001	0.010	0.002	0.006	0.047	0.061	0.004	0.008	0.012	0.001	0.001	0.007	0.001	0.001	0.001
13	office	30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.001	0.002
14	elctr	31	0.001	0.000	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.000	0.004	0.015	0.013	0.060	0.021	0.020	0.006	0.008	0.004	0.005	0.009	0.001	0.000	0.001	0.001	0.000	0.001
15	TV	32	0.005	0.002	0.002	0.001	0.002	0.002	0.002	0.003	0.002	0.002	0.003	0.004	0.036	0.035	0.212	0.014	0.004	0.005	0.003	0.002	0.001	0.005	0.002	0.004	0.022	0.003	0.006
16	medical	33	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.039	0.000	0.116	0.001	0.002	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000
17	motveh	34	0.007	0.000	0.002	0.001	0.000	0.000	0.000	0.001	0.001	0.000	0.004	0.009	0.001	0.001	0.001	0.001	0.032	0.007	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	oth trsp	35	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.002	0.001	0.000	0.001	0.000	0.000	0.002	0.058	0.001	0.000	0.012	0.000	0.000	0.014	0.000	0.000	0.000
19	man nec	36-37	0.000	0.000	0.004	0.001	0.000	0.000	0.000	0.001	0.001	0.011	0.001	0.001	0.000	0.002	0.000	0.001	0.003	0.006	0.056	0.000	0.009	0.002	0.000	0.001	0.000	0.005	0.002
20	EGW	40-41	0.028	0.011	0.011	0.022	0.057	0.029	0.038	0.018	0.022	0.023	0.010	0.008	0.002	0.008	0.003	0.006	0.008	0.010	0.012	0.250	0.006	0.011	0.002	0.005	0.006	0.009	0.033
21	cst	45	0.019	0.005	0.002	0.006	0.008	0.003	0.006	0.005	0.010	0.002	0.005	0.006	0.001	0.005	0.001	0.002	0.004	0.008	0.003	0.009	0.020	0.001	0.015	0.082	0.039	0.008	0.056
22	trade	50-52	0.007	0.003	0.004	0.003	0.002	0.026	0.008	0.006	0.004	0.014	0.006	0.009	0.010	0.005	0.008	0.014	0.021	0.004	0.013	0.002	0.090	0.060	0.047	0.038	0.036	0.020	0.035
23	hotels	55	0.005	0.003	0.004	0.003	0.007	0.002	0.003	0.007	0.003	0.003	0.004	0.006	0.001	0.005	0.004	0.006	0.003	0.004	0.004	0.003	0.001	0.004	0.003	0.009	0.004	0.004	0.002
24	trs	60-63	0.148	0.060	0.031	0.079	0.049	0.024	0.046	0.037	0.079	0.044	0.031	0.025	0.011	0.022	0.012	0.018	0.018	0.020	0.033	0.017	0.023	0.053	0.001	0.072	0.027	0.007	0.002
25	ptc	64	0.002	0.003	0.005	0.002	0.015	0.001	0.002	0.003	0.004	0.001	0.003	0.004	0.002	0.004	0.003	0.005	0.003	0.002	0.005	0.002	0.003	0.027	0.002	0.004	0.049	0.019	0.022
26	finance	65-67	0.013	0.010	0.016	0.011	0.011	0.005	0.012	0.014	0.014	0.008	0.013	0.013	0.006	0.014	0.012	0.016	0.012	0.012	0.016	0.013	0.013	0.034	0.032	0.024	0.025	0.079	0.028
27	Re&bus	70, 71, 74	0.128	0.039	0.063	0.025	0.029	0.024	0.030	0.042	0.037	0.024	0.091	0.063	0.036	0.042	0.050	0.063	0.030	0.109	0.045	0.020	0.007	0.060	0.137	0.020	0.046	0.086	0.112
total NFBS intermediates			0.517	0.423	0.327	0.312	0.466	0.219	0.369	0.317	0.419	0.522	0.458	0.398	0.145	0.344	0.363	0.346	0.295	0.441	0.423	0.450	0.479	0.330	0.493	0.332	0.280	0.266	0.336

Figure 4: Sectoral Contriburtion, MFP2, 92/99

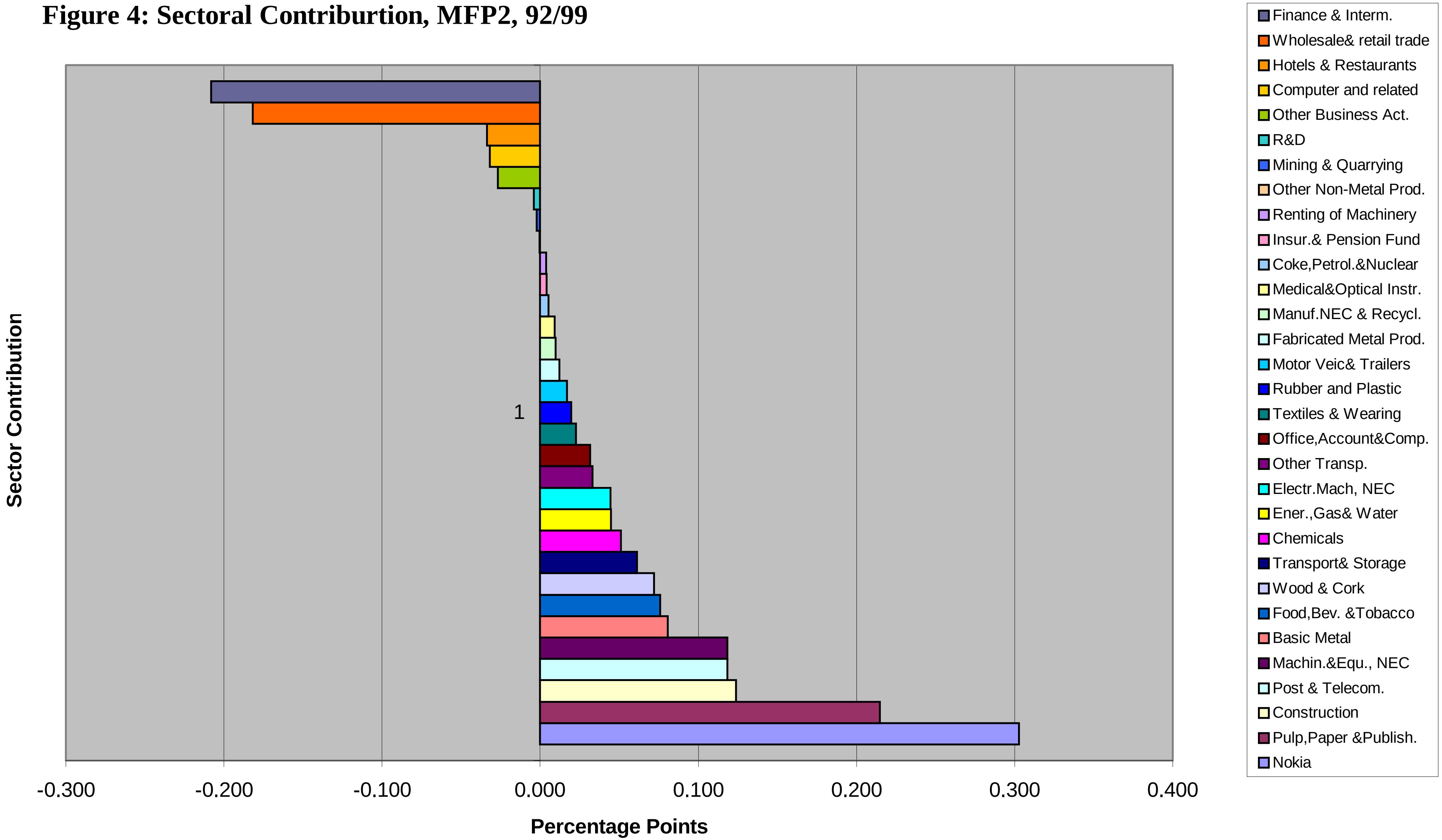


Figure 5: Sectoral Contribution, LP, 92/99

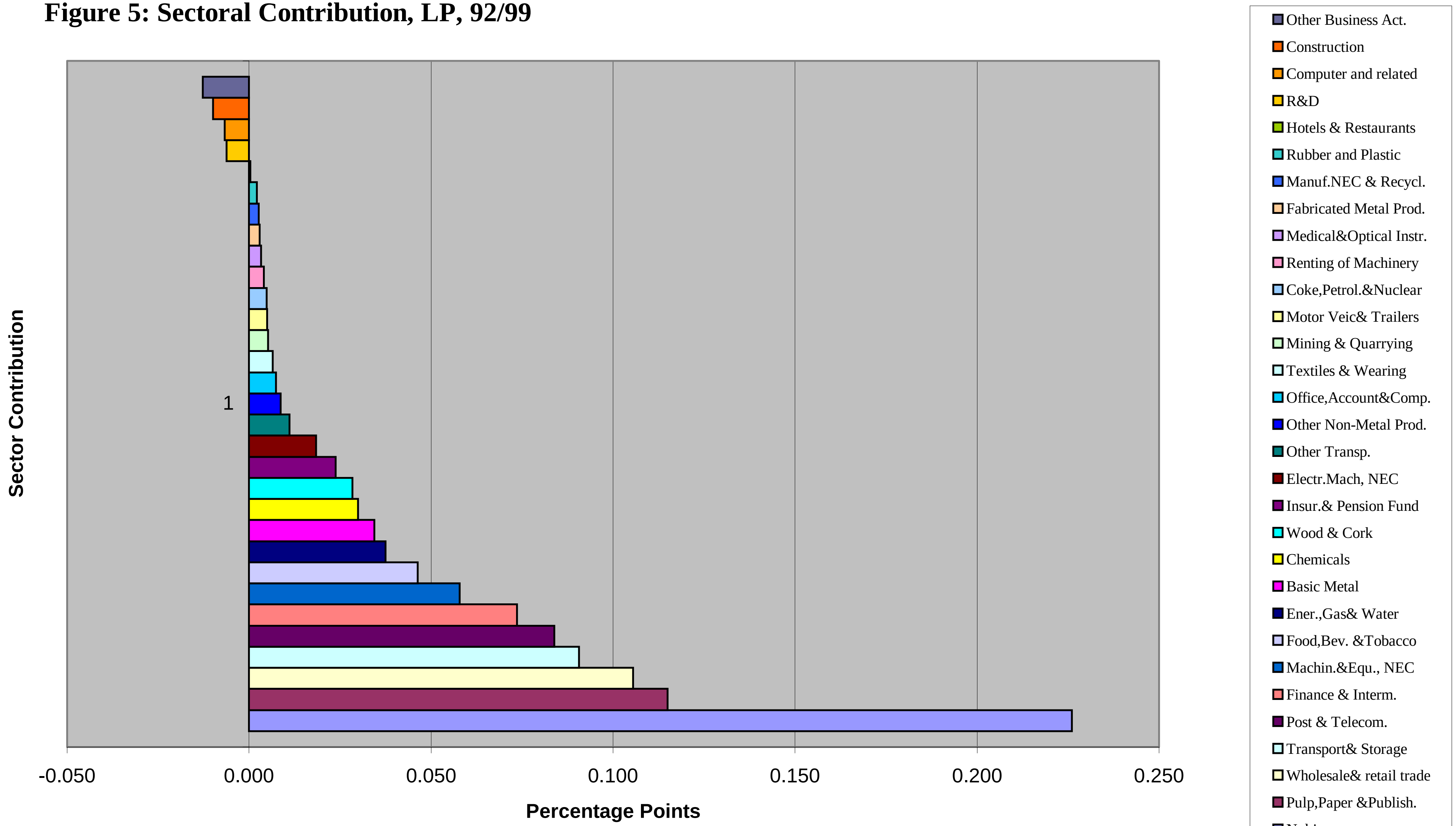


Figure 6 : Sectoral Contribution to MFP2

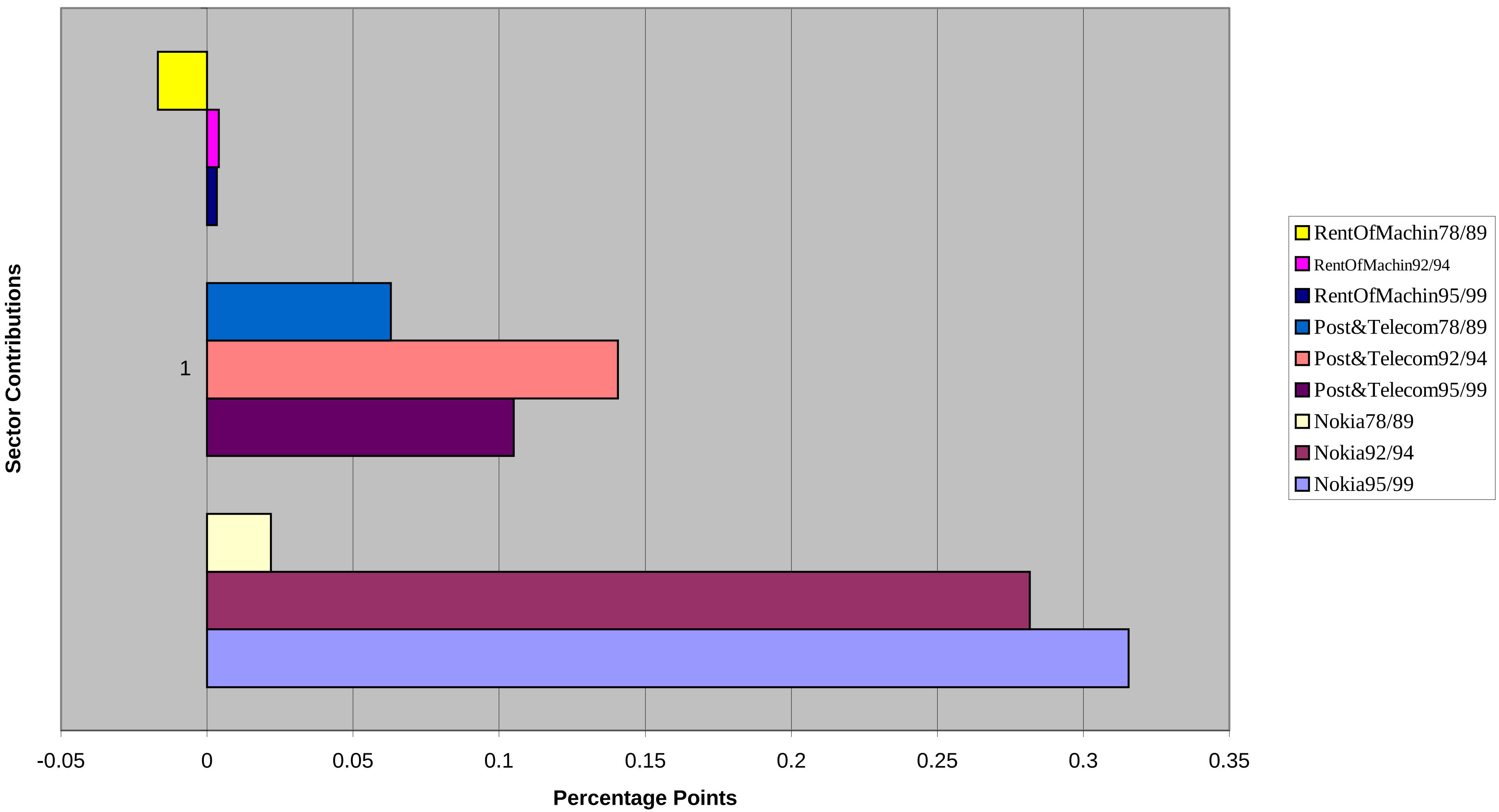


Figure 7: Sector Contribution to LabProd