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Jukka Jalava

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PRODUCTIVITY IN THE FINNISH MANUFACTURING INDUSTRY, 1975–2003*

Jukka Jalava**

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ABSTRACT

Labour productivity grew on average at the rapid 5 per cent annual rate in the Finnish manufacturing industry from 1975 to 2003. The labour productivity growth was broad-based in the 1970s and 1980s with contributions from multi-factor productivity gains in the paper and metal industries dominating. In the 1990s productivity growth was much more concentrated to the electronic industry. The level of labour productivity in Finnish manufacturing matched that of the US by the end of the second millennium. Labour costs and unit labour costs remained at only three quarters of the US level, although real hourly compensation increased steadily. After 1995 the manufacturing industry constituted a quarter of the Finnish economy but contributed a third of overall economic growth.

JEL classification: E22, E23, E24

Key words: growth, productivity, manufacturing

TIIVISTELMÄ

Suomen tehdasteollisuuden tuottavuus vuosina 1975-2003

Suomen tehdasteollisuuden työn tuottavuus kasvoi keskimäärin 5 prosenttia vuodessa vuosina 1975-2003. Työn tuottavuuden kasvu oli laaja-alaista 1970- ja 1980-luvuilla joskin merkittävin kontribuutio tuli paperi- ja metalliteollisuuden kokonaistuottavuudesta. 1990-luvulla tuottavuuden kasvu oli huomattavasti keskittyneempää sähkötekniseen teollisuuteen. Suomen tehdasteollisuus saavutti vuosituhannen loppuun mennessä Yhdysvaltojen työn tuottavuuden tason. Työvoimakustannukset ja yksikkötyökustannukset jäivät kuitenkin kolmeen neljäsosaan Yhdysvaltain tasosta vaikka reaaliset työvoimakustannukset kasvoivat tasaisesti. Vuoden 1995 jälkeen tehdasteollisuuden nimellinen osuus Suomen taloudesta oli neljäsosa mutta kontribuutio kasvuun oli kolmannes.

Asiasanat: kasvu, tuottavuus, tehdasteollisuus

1. INTRODUCTION

During the 20th century Finland transformed from a backward agrarian country into a modern high-tech economy at the forefront of the production of information and communications technology.[1] How was this transformation achieved? As Finland was a late industrializing country the importing of foreign machinery and skilled workers, combined with study trips abroad were crucial. The first boost to manufacturing productivity came when the country was electrified (Jalava, 2004). After WWII capital fundamentalism, the view that growth can be generated through investments in physical capital, was strongly advocated in an influential monograph named 'Has Our Country the Patience Needed to Become Wealthy?' (Kekkonen, 1952). The author Urho Kekkonen, was then Prime Minister and later long time President (1956-82). The era of high investments started in 1948 when the investment ratio exceeded the 20 per cent level and continued until 1992. During that time on average a quarter of GDP was invested in fixed capital. Pohjola (1996) showed that although the massive investments contributed to growth, eventually capital inefficiency ensued.[2] Important manufacturing sectors were the wood and paper industries as well as metal and engineering industries which having reached the technology frontier could not simply rely on copying technology developed elsewhere but had to think outside the box. That is, strive to attain genuine product and process innovations by substantial research and development (R&D) efforts. This resulted in Finland breaking free from its dependence on its natural endowments and transformed Finnish growth from the investment driven sort to the innovation driven kind.

The international comparisons of O'Mahony and van Ark (2003) indicate that by the end of the second millennium Finnish manufacturing had managed to leap-frog to a level of labour productivity (LP) equal to the US. Two decades earlier Finland performed three quarters of the US level. Labour costs and unit labour costs remained at only three quarters of the US level, although real hourly compensation increased steadily. The aim of this paper is to examine this Finnish growth miracle. As we ex post know that the catching-up process was successful we utilize standard neoclassical growth accounting in the tradition of Solow (1957) and Jorgenson and Griliches (1967). It would be too heroic a claim for us state that we are able to explain the Finnish growth puzzle. However, we do believe that we can delineate the facts and pinpoint the main proximate sources of the Finnish manufacturing growth experience.

The outline of the paper is the following. In the next Section we take stock of the international bench-mark. In Section 3 we review the theoretical aspects of growth accounting and in Section

[1] See Hjerppe (1996) for the historical view of the Finnish economic transformation. Jalava and Pohjola (2002) outline the impact of the production and use of ICT on Finnish economic growth.

[2] Aulin-Ahmavaara and Jalava (2003) corroborate Pohjola's point of Finnish capital productivity growth being low until the late 1990s.

4 the empirical results are presented. The penultimate Section relates the manufacturing sector to the rest of the economy and the ultimate Section concludes.

2. CATCHING-UP WITH THE TECHNOLOGY FRONTIER

In 1950 the level of Finnish manufacturing labour productivity was only 38 per cent of the US LP level.[3] Finnish foreign trade was freed in the late 1950s, which led to a need to adapt to international competition as former home-market industries were not protected by customs barriers and import control any longer. Not surprisingly in a country that boasts vast forests: products of the wood and paper industry constituted the lion's share of Finnish exports until the late 1970s. But also products of the metal and engineering industries increased their importance from the mid-1950s onwards (Hjerppe, 1996). The competitiveness of the wood and paper industries were increased by large scale investment programs in the 1950s and 1960s (Hjerppe, 1982). Consistent investments into secondary production paid off and by 1980 Finnish LP had leap-frogged to three quarters of the US level and nine tenths of the EU-14 level (Table 1a). By then Finland had broken free from its dependence on its natural resources and began to increase its research and development (R&D) efforts. In the beginning of the 1980s R&D-expenditure in relation to GDP exceeded the one per cent mark. In the decade from 1985 to 1995 Finnish manufacturing successfully leap-frogged to the US level and left behind EU-14, Sweden and Denmark. Maliranta (2003) showed that the increased R&D intensity combined with larger exports to Western markets boosted manufacturing multi-factor productivity. In 1995 R&D per GDP was 2.3 per cent but at the end of our observation period the relation was as much as 3.5 per cent. Of all research and development expenditure business enterprises accounted for approximately 70 per cent. Manufacturing R&D was four fifths of the business enterprises total and of manufacturing research expenditure more than half was generated in the electronic industry.[4]

Remarkably Finland managed to keep abreast of the US growth also during the post-1995 US economic upswing when EU-14 fell behind. This increase in effectiveness was not combined with increased labour costs in Finnish manufacturing as labour compensation per hour was both in 1980 and 2001 approximately three quarters of the US level (Table 1b). EU-14 even managed to cut back on its labour costs relative to the US. Unit labour cost (ULC)[5], or the labour cost per hour worked not compensated for by labour productivity, was both in Finland and in EU-14 in

[3] See: Groningen Growth and Development Centre, ICOP Database 1987 Benchmark, http://www.ggdc.net

[4] See: http://www.stat.fi/til/tkke/index.html

[5] ULC is often defined as total current price labour compensation per unit of constant price value added.

1980 at the same level as in the US (Table 1c). By the year 2001 Finland managed to decrease its ULC to three quarters of the US level thanks to improvements in LP.[6] EU-14 also improved its ULC comparing with the US due to the aforementioned decrease in labour compensation relative to the US.

Maliranta (2003) accredits the efficiency improvements in Finnish manufacturing in the mid-1980 to mid-1990 period to micro-level productivity enhancing restructuring, i.e. "creative destruction". This restructuring also resulted in a reallocation of the functional income share in favour of capital as has been widely noted e.g. by Kyyrä (2002) and Sauramo (2004) and as can also implicitly be deduced from Table 1. Interestingly real hourly compensation is, nevertheless, growing as strongly as ever (Table 2 and Figure 3).

Table 1a. Relative levels of labour productivity in manufacturing, 1980–2001 (real value added per hour, US=100).

	1980	*1985*	*1990*	*1995*	*2000*	*2001*
Denmark	117	108	100	97	89	91
EU-14	85	86	88	88	79	81
Finland	74	78	90	102	103	101
Sweden	95	97	95	98	86	82
United States	100	100	100	100	100	100

Source: O'Mahony and van Ark (2003) CD-ROM

Table 1b. Relative levels of labour cost in manufacturing, 1980–2001 (labour compensation per hour, US=100).

	1980	*1985*	*1990*	*1995*	*2000*	*2001*
Denmark	96	58	111	121	85	86
EU-14	84	52	96	103	72	71
Finland	75	56	119	112	73	74
Sweden	131	72	129	106	79	72
United States	100	100	100	100	100	100

Source: O'Mahony and van Ark (2003) CD-ROM

[6] In the year 2001 Finnish LP was 101 and labour cost 74, hence ULC was 73 (=74/101) relative to the US.

Table 1c. Relative levels of unit labour cost in manufacturing, 1980–2001 (US=100).

	1980	*1985*	*1990*	*1995*	*2000*	*2001*
Denmark	83	53	111	125	96	95
EU-14	99	60	109	117	91	88
Finland	101	72	132	109	71	73
Sweden	138	75	136	108	92	88
United States	100	100	100	100	100	100

Source: O'Mahony and van Ark (2003) CD-ROM

3. THE PROXIMATE SOURCES OF AGGREGATE GROWTH

The classic aggregate production function of Solow (1957) can be presented in the form:

(1) $$Y_t = A_t f(K_t, H_t)$$

where, t denotes time, aggregate gross value added Y is produced from aggregate inputs consisting of capital K and labour H. The level of technology or multi-factor productivity is here represented in the Hicks neutral or output augmenting form by parameter A. Assuming that constant returns to scale prevail in production and that markets are competitive, growth accounting gives the share weighted growth of outputs as the sum of share weighted inputs and growth in multi-factor productivity:

(2) $$\hat{Y} = (1-\alpha)\hat{K} + \alpha\hat{H} + \hat{A},$$

where the ^-symbol indicates the rate of change, α is the income share of labour and (1-α) is the income share of capital. Neoclassical growth accounting basically divides output growth into the contributions of input growth with multi-factor productivity growth being the residual. The aggregate production function was further developed by Jorgenson and Griliches (1967) who broadened the concept of substitution in Solow's growth accounting framework and showed that it is also important to account for substitution between different kinds of capital and labour. The inputs are corrected for changes in quality and weighted with their marginal products, that is, their market prices. Since MFP catches all unmeasured factors such as disembodied technical change, organizational improvements, economies of scale and measurement errors, it is often called a ‘measure of our ignorance’.

If we deduct the change in hours worked from both sides of Equation 2 we have:

(3) $\hat{Y} - \hat{H} = (1-a)(\hat{K} - \hat{H}) + \hat{A}$,

where the change in labour productivity is explained by the share weighted change in capital deepening (capital per hour worked) and the change in MFP.

In order to construct our capital measure we started by computing capital stocks. The capital stocks were calculated using the perpetual inventory method with the assumption of geometric age-efficiency profiles:

(4) $K_t = K_{t-1}(1-d) + I_t = \sum_{t=0}^{\infty} (1-d)^t I_{t-t}$,

where K denotes year-end real capital stock, I is investment in constant prices and d is the rate of depreciation. The rates of depreciation used were: 0.03 for non-residential structures (Hulten and Wyckoff, 1996), 0.0152 for civil engineering and other structures (Fraumeni, 1997), 0.3 for transportation equipment (Hulten and Wyckoff, 1996), 0.12 for other machinery and equipment (Hulten and Wyckoff, 1996), and 0.315 for computer software (Jorgenson and Stiroh, 2001).

To aggregate the different capital asset types into a measure of capital services we first computed their user costs. The Hall-Jorgenson (1967) user cost or rental price of capital is defined as the net rate of return plus depreciation minus capital gain/loss:

(5) $r_t = p_{(t-1)} q_t + p_t d_t - (p_t - p_{(t-1)})$,

where r is the rental price, p is the price index for new capital goods and q is the net rate of return. The ex post approach was used to estimate the internal rate of return.[7] Defining capital income to equal nominal value added less labour compensation, and given information about depreciation, holding gains and capital stock, the net rate of return was estimated residually as:

(6) $q_t = \dfrac{capital\ income - \{p_t d_t - (p_t - p_{t-1})\} K_{t-1}}{p_{t-1} K_{t-1}}$,

where K is the real capital stock and pK the nominal capital stock. The aggregate volume index of capital services is:

[7] See Schreyer, Bignon and Dupont (2003) for an extensive discussion of the ex ante vs. ex post approaches. We chose to use the realized rate of return rather than the expected one as we opted to stay as close as possible to official national accounts data. There are admittedly also arguments favouring the use of the expected, i.e. ex ante, rate of return. However, the use of an ex ante rate of return would imply that capital was fully flexible and not quasi-fixed. Furthermore, Aulin-Ahmavaara and Jalava (2003) found for the total Finnish non-residential economy only minor differences between the ex post and ex ante methods' impacts on MFP growth in 1975-2001.

(7) $$c_{it} = \frac{K_{it}}{K_{i(t-1)}} = \prod_j \left(\frac{K_{ijt}}{K_{ij(t-1)}} \right)^{v_{ijt}},$$

where the weights v are defined as:

(8) $$v_{ijt} = \left(\frac{r_{ijt} K_{ijt}}{\sum_i r_{ijt} K_{ijt}} + \frac{r_{ij(t-1)} K_{ij(t-1)}}{\sum_i r_{ij(t-1)} K_{ij(t-1)}} \right) / 2 \; .$$

Here c is the volume index of capital services, i is industry and j is asset type.

4. WHAT THE NUMBERS TELL US

4.1. Aggregate manufacturing growth[8]

The volume of manufacturing gross value added at year 2000 prices increased during our observation period by an annual average of 3.7 per cent.[9] See Figure 1 for the growth rates of the quantity of value added, hours worked and labour productivity graphically. The Hodrick-Prescott filter was used with the smoothing parameter λ=100 to detrend the series in Figures 1, 2 and 3 (Hodrick and Prescott, 1997). As labour input, which we measure with the amount of hours worked, decreased by 1.3 per cent labour productivity grew by 5.0 per cent. The hourly compensation, including wages, salaries and employers' social contributions plus an imputed income for the self-employed[10] per hour worked, increased by 7.5 per cent and hence ULC by 2.6 per cent from 1975-2003. Real hourly compensation, hourly compensation deflated with the implicit value added deflator, increased on average by 4.5 per cent every year during our observation period. Using Equations 3 to 8 we found in our growth accounting exercise that of the 5.0 per cent LP growth one fifth or 1.0 percentage points came from capital deepening and 4.0 percentage points from MFP. See Figure 2 for the graphs of the annual changes in capital deepening, capital productivity and MFP. The Finnish growth experience differs from the US growth picture, where capital deepening has been the most significant contributor to LP growth in domestic private output 1959–98 as shown by Jorgenson and Stiroh (2001).

[8] The data is from Statistics Finland's national accounts published 8.7.2004. Data for years 2002 and 2003 are preliminary.

[9] In this paper the growth rates are expressed logarithmically. Thus growth is defined as: $100*[\ln(x_t/x_{t-1})]$.

[10] Calculated by multiplying the employees' hourly wages (including salaries but not employer's social contributions) by the amount of hours worked by the self-employed. The labour income's GDP share was constrained to a maximum of one.

Looking at the sub-periods we find that value added grew in 1975-90 by 3.7 per cent, experienced a slowing down in the early 1990s to 2.1 per cent (which is still far better than the -0.9 per cent plunge of GDP at market prices in 1990-95) and increased its growth rate in the post-1995 period to 4.8 per cent (Table 2). The labour input declined from 1975 to 1990 by 1.3 per cent annually, which meant that LP change was 5.0 per cent. During the economic recession manufacturing employment decreased by 90,000 persons from 1990-95. It ended up at 410,000 in 1995. Therefore also the hours worked declined at the brisk average rate of 4.1 per cent per year. The aftermath of this large scale labour shedding was a peak LP growth of 6.2 per cent in 1990-95. After 1995 the hours worked began to increase by 0.6 per cent per year and since the step-up in value added was not enough to offset the increase in labour input LP growth declined to 4.2 per cent.

The hourly compensation grew by as much as 10.5 per cent in 1975-90, but as the value added deflator was nearly 6 per cent real hourly compensation increased by 4.6 per cent. See Figure 3 for the graphs of hourly compensation, real hourly compensation and ULC. In the early 1990s hourly compensation halved its growth rate to 5.1 per cent and with the deflator at 1.7 per cent real compensation increased by 3.4 per cent. In the 1995 to 2003 period the change in hourly compensation became even more modest, 3.6 per cent, and because the value added deflator turned negative (-1.2 per cent per year) the change in real hourly compensation peaked at 4.8 per cent. The strongest average performance we observed. In the 1990s LP grew faster than the hourly remuneration which means that ULC change was negative. LP growth also outpaced real hourly remuneration in 1975-95 but fell behind after that implying that a shift in the manufacturing sub-industries' LP growth or real compensation has taken place.

Table 2. Average growth of value added, hours worked and related variables in the manufacturing industry, 1975–2003*, ln per cent.

	1975–1990	*1990–1995*	*1995–2003**
Nominal value added	9.5	3.8	3.5
Price of value added	5.8	1.7	-1.2
Volume of value added	3.7	2.1	4.8
Hours worked	-1.3	-4.1	0.6
Hourly compensation	10.5	5.1	3.6
Real hourly compensation	4.6	3.4	4.8
Unit labour cost	5.5	-1.1	-0.6
Labour productivity	5.0	6.2	4.2
Contributions from[a]			
Capital deepening	1.5	0.8	0.1
Multi-factor productivity	3.5	5.4	4.1

[a] Percentage points.

Figure 1. Gross value added (Y), hours worked (H) and labour productivity (Y/H) growth in manufacturing, 1976–2003*, ln per cent.

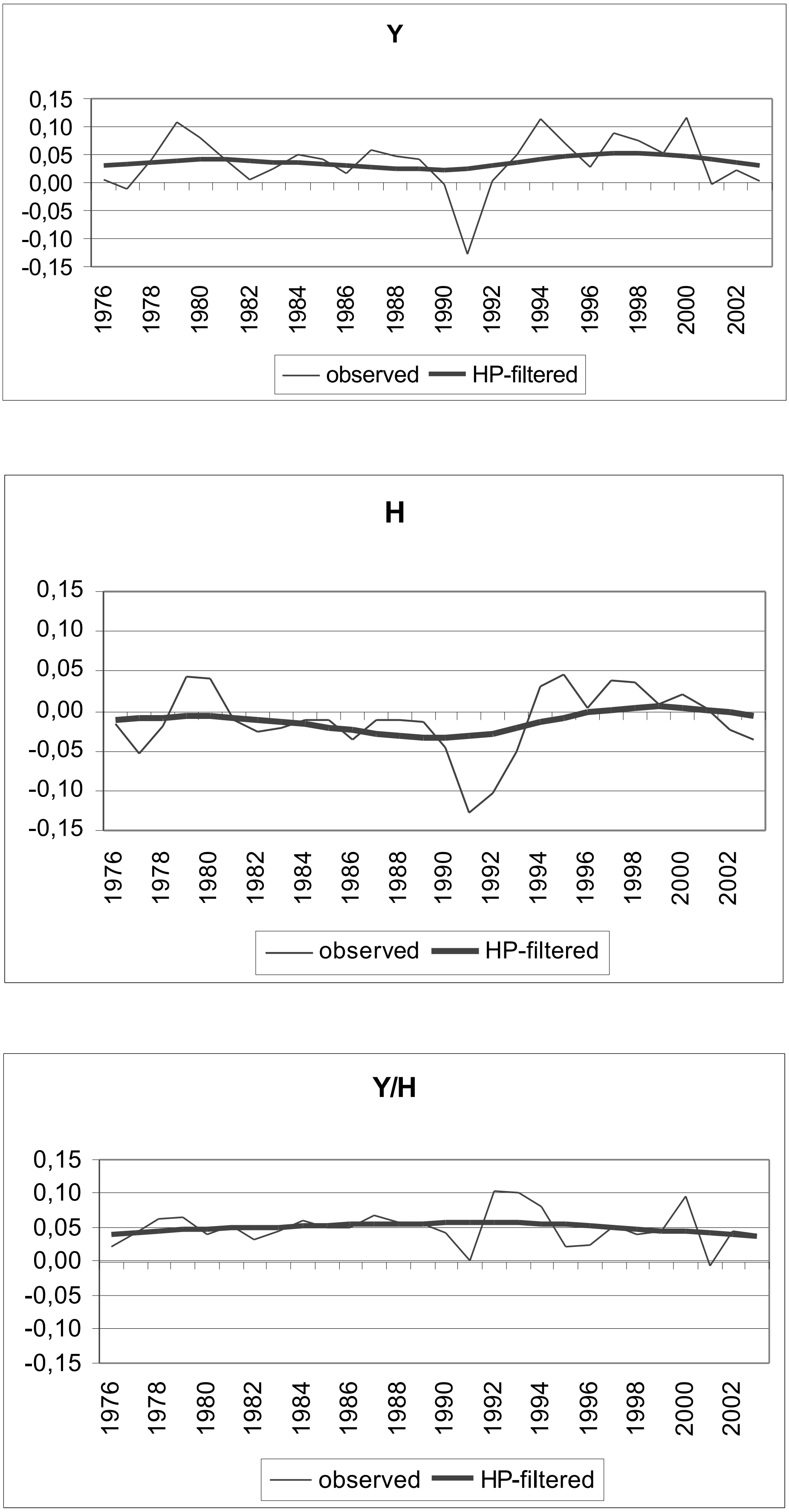
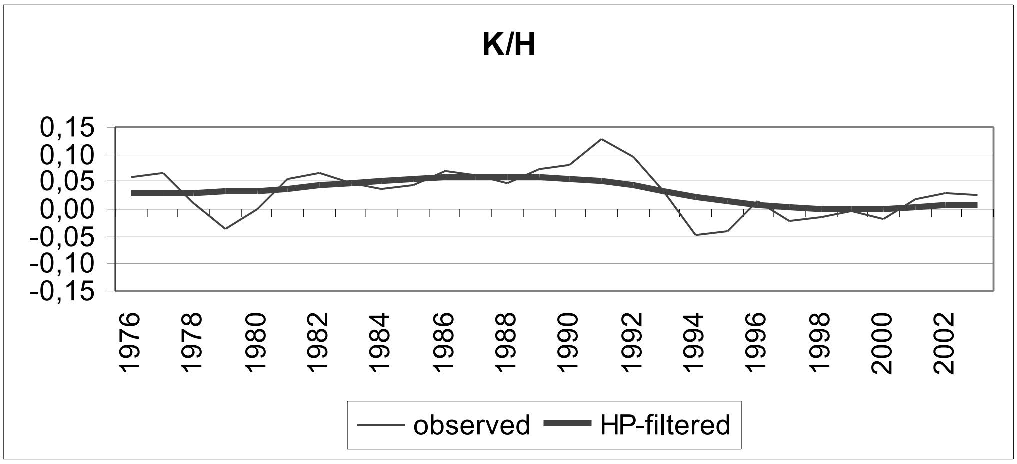
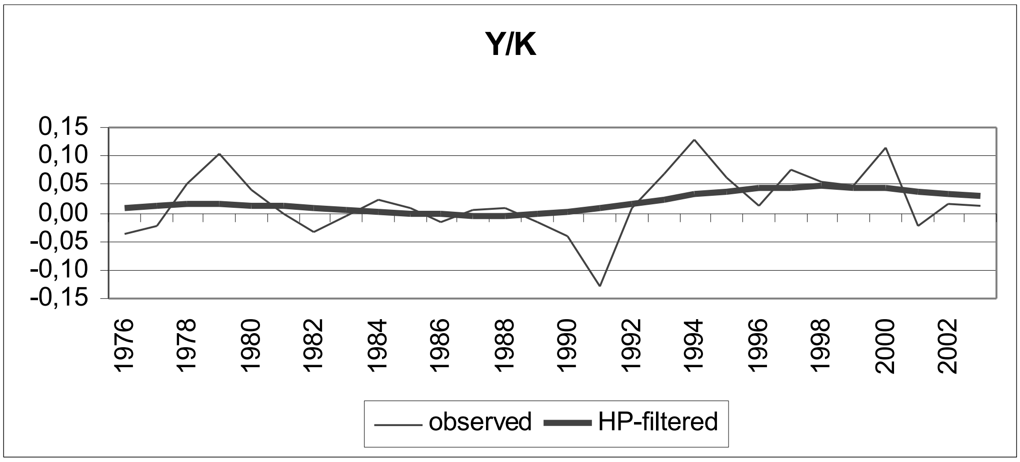


Figure 2. Capital deepening (K/H), capital productivity (Y/K) and multi-factor productivity (MFP) growth in manufacturing, 1976–2003*, ln per cent.





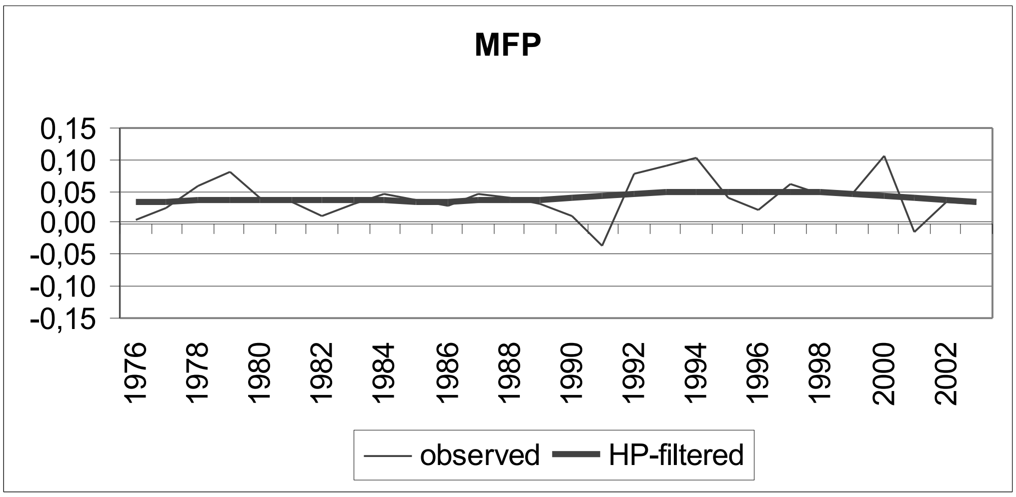
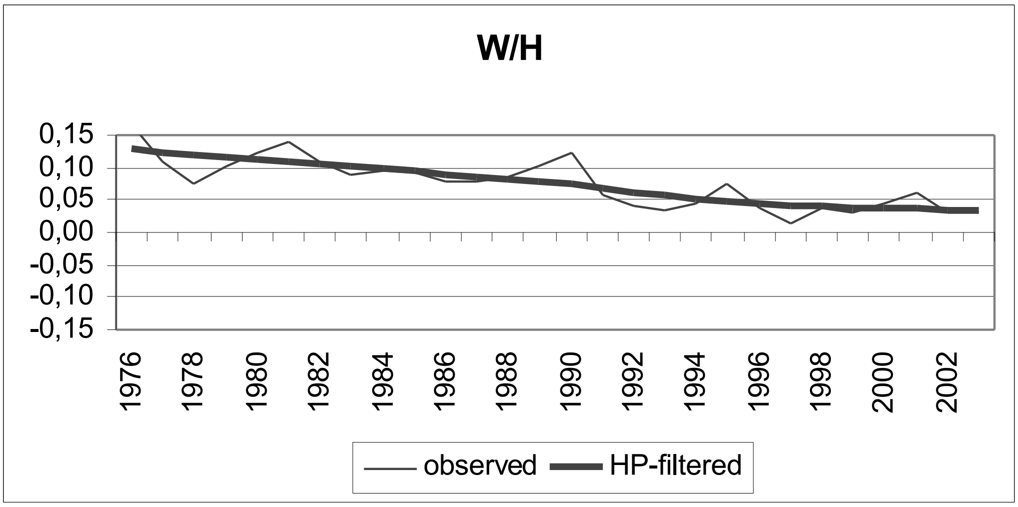
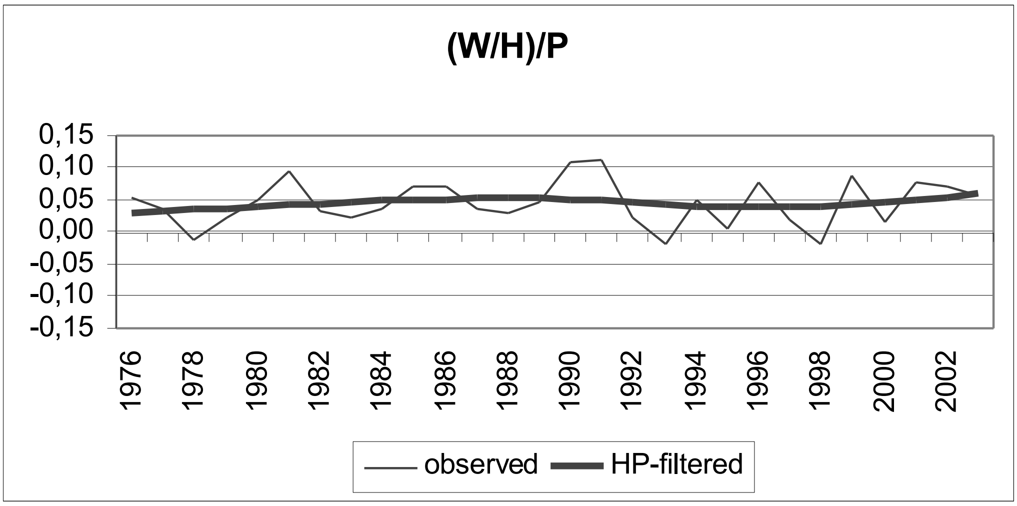
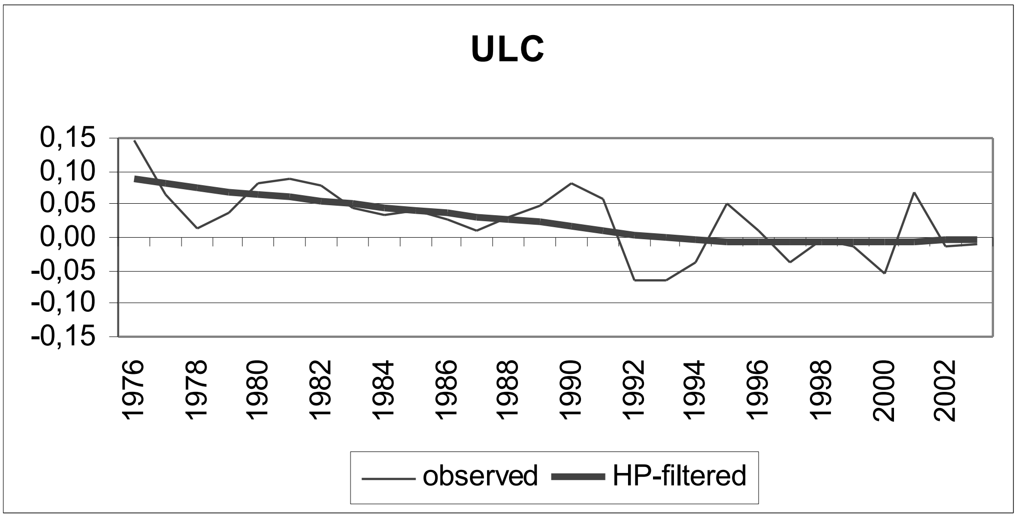


Figure 3. Hourly compensation (W/H), real hourly compensation ((W/H)/P) and unit labour cost (ULC) growth in manufacturing, 1976–2003*, ln per cent.







4.2. Yeast or mushroom?

Having laid out the broad outlines of the development in the Finnish manufacturing industry on an aggregate level we turn in this section to manufacturing sub-industries.[11] In the terminology of Harberger (1998) we want to ascertain whether the growth was across the board, yeast-like, or whether growth was polarized, mushroom-like. The obvious place to start is to look at the sub-industries' shares of value added. In the less than three decades we are observing significant structural changes took place. The spectacular success of the manufacture of electrical and optical equipment, the Nokia-effect, is of course self-evident. A quarter of the current price value added was generated in that industry in 2003 as compared to six per cent in 1975 (Table 3). Other gainers were the manufacture of basic metals and fabricated metal products that gained more than one percentage point and the manufacture of rubber and plastic products that gained four tenths of a percentage point. Industries that more or less kept their shares intact were: the chemical industry, the wood industry and the oil refining industry. Branches that lost approximately one percentage point were: the paper industry, the manufacture of machinery, the manufacture of non-metallic mineral products, other manufacturing including recycling and the leather industry. Big losers were the manufacture of transport equipment (-3 percentage points), the food and tobacco industry (-5 percentage points) and the textile industry that shedded more than six percentage points.

Table 3. Share of current price manufacturing value added by sub-industry, 1975, 1990, 1995 and 2003*, per cent.

	Industry	*1975*	*1990*	*1995*	*2003**
DA	Man. of food prod., bever. and tobacco	12.8	10.9	9.8	7.6
DB	Man. of textiles and textile products	8.1	3.4	2.2	1.6
DC	Man. of leather and leather products	1.1	0.6	0.4	0.3
DD	Man. of wood and wood products	4.3	6.3	5.2	4.3
DE	Man. of pulp, paper, etc., publ. and print.	20.0	21.1	26.4	18.8
DF	Man. of ref. petr. prod., coke and nuclear fuel	1.3	1.9	1.2	1.5
DG	Man. of chemicals and chemical products	6.0	6.3	6.5	5.8
DH	Man. of rubber and plastic products	3.1	3.2	3.0	3.5
DI	Man. of other non-metallic mineral products	4.3	4.7	2.7	3.3
DJ	Man. of basic metals and fabricated metal prod.	9.8	10.4	11.6	11.1
DK	Manufacture of machinery and equipment n.e.c.	12.2	13.0	11.6	10.7
DL	Manufacture of electrical and optical equipment	6.2	9.6	12.8	25.4
DM	Manufacture of transport equipment	7.1	5.0	4.1	3.9
DN	Manufacturing n.e.c. and recycling	3.6	3.5	2.5	2.2

[11] See the Appendix for the industry classification.

Five of the fourteen sub-industries managed to sustain faster than average LP growth in 1975-90 (Table 4). The industries were: the manufacture of rubber and plastic products, the manufacture of basic metals and fabricated metal products, the wood industry, the paper and printing industry and the electronic industry. During the 1990s recession when aggregate LP growth increased five industries still performed better than average. The wood and rubber industries fell behind and were replaced by the food and tobacco and oil refining industries. Overall LP growth slowed down in the post-1995 period to 4.2 per cent. Only two industries, the electronic industry and the wood industry were above average. The LP growth in 1995 to 2003 was very mushroom-like indeed, as the electronic industry performed double-digit numbers and none of the other thirteen sub-industries could match their pre-1990s performance let alone improve upon it. On the other hand it is more difficult to sustain rapid growth rates when you are on the technology frontier and cannot simply copy state-of-the-art technology that someone else has developed. O'Mahony and van Ark (2003) found that four Finnish manufacturing industries, i.e. the paper industry, the wood industry, the basic metals industry and the telecommunications industry both surpassed the US level of value added per hour worked and were the EU-14 top performers in 2001. To increase efficiency these industries must undertake costly research and development efforts themselves.

Table 4. Average growth of labour productivity by manufacturing sub-industry (in brackets the growths of quantity of value added and of hours worked), 1975-2003*, ln per cent.

	Industry	*1975-1990*	*1990-1995*	*1995-2003**
DA	Man. of food prod., bever. and tobacco	3.6 (2.1 -1.5)	6.4 (1.4 -5.0)	3.0 (1.4 -1.6)
DB	Man. of textiles and textile products	3.9 (-1.7 -5.6)	5.2 (-7.7 -12.9)	1.7 (-1.1 -2.8)
DC	Man. of leather and leather products	3.9 (0.3 -3.6)	4.1 (-6.8 -10.9)	2.2 (-3.0 -5.2)
DD	Man. of wood and wood products	5.8 (4.1 -1.7)	5.5 (0.0 -5.5)	4.7 (4.6 -0.1)
DE	Man. of pulp, paper, etc., publ. and print.	5.4 (4.3 -1.0)	7.0 (2.7 -4.3)	3.1 (2.1 -0.9)
DF	Man. of ref. petr. prod., coke and nuclear fuel	3.7 (3.7 0.0)	6.3 (5.9 -0.4)	1.1 (1.1 0.0)
DG	Man. of chemicals and chemical products	4.7 (4.9 0.2)	4.3 (2.4 -1.9)	3.1 (2.5 -0.6)
DH	Man. of rubber and plastic products	7.0 (5.7 -1.4)	3.7 (0.6 -3.1)	0.4 (3.1 2.7)
DI	Man. of other non-metallic mineral products	4.0 (2.9 -1.1)	4.3 (-5.9 -10.2)	1.4 (3.8 2.5)
DJ	Man. of basic metals and fabricated metal prod.	6.1 (6.1 0.0)	6.4 (2.8 -3.6)	0.7 (3.7 3.0)
DK	Manufacture of machinery and equipment n.e.c.	4.7 (4.3 -0.4)	4.4 (1.1 -3.3)	0.8 (1.7 0.9)
DL	Manufacture of electrical and optical equipment	5.4 (5.8 0.4)	8.6 (12.3 3.8)	12.7 (15.6 2.9)
DM	Manufacture of transport equipment	1.6 (-0.3 -1.9)	4.2 (-0.1 -4.3)	1.1 (0.0 -1.1)
DN	Manufacturing n.e.c. and recycling	3.8 (2.7 -1.2)	3.6 (-2.5 -6.0)	0.6 (1.9 1.3)

Turning our attention to the sub-industries MFP growth - which we calculated from their share weighted capital stocks and hours worked using equations 2 and 4 - we found that half of the sub-industries managed above average MFP increases in 1975-90 (Table 5). The top performers were the metal industry with 5.4 per cent, rubber and plastics with 5.1 per cent and the wood industry with 4.9 per cent. The other good performers were the oil refining industry, the paper industry, the electronic industry and machinery and equipment. In 1990-95 the rate of aggregate MFP change increased by almost two percentage points to 5.4 per cent. Now the rank of top performer was taken by the electronic industry that achieved an impressive 8.6 per cent growth rate. Also the paper industry, the oil refining industry and the metal industry performed more than the mean. The MFP growth in 1995 to 2003 was polarized as the electronic industry performed a 9.1 per cent average and the wood industry was its only companion above the average 4.1 per cent rate. Most of the other twelve sub-industries could not match their pre-1990s performance.

Table 5. Average growth of multi-factor productivity by manufacturing sub-industry, 1975-2003*, ln per cent.

	Industry	*1975-1990*	*1990-1995*	*1995-2003**
DA	Man. of food prod., bever. and tobacco	2.1	4.4	2.6
DB	Man. of textiles and textile products	2.6	4.5	1.9
DC	Man. of leather and leather products	3.4	3.6	1.7
DD	Man. of wood and wood products	4.9	4.8	4.2
DE	Man. of pulp, paper, etc., publ. and print.	3.7	6.3	3.1
DF	Man. of ref. petr. prod., coke and nuclear fuel	3.9	6.0	0.3
DG	Man. of chemicals and chemical products	3.3	2.9	2.1
DH	Man. of rubber and plastic products	5.1	2.7	0.7
DI	Man. of other non-metallic mineral products	2.3	2.2	2.7
DJ	Man. of basic metals and fabricated metal prod.	5.4	5.8	1.0
DK	Manufacture of machinery and equipment n.e.c.	3.6	4.1	1.1
DL	Manufacture of electrical and optical equipment	3.7	8.6	9.1
DM	Manufacture of transport equipment	0.7	3.7	0.9
DN	Manufacturing n.e.c. and recycling	2.8	2.4	0.8

Combining the information from Tables 3 and 5 we computed the sub-industries contributions to aggregate manufacturing MFP growth.[12] Table 6 shows the contributions of the sub-industries and the impact of the reallocation of outputs and inputs. In 1975-90 the largest contributions came from the paper and metal industries that contributed 0.8 and 0.5 percentage points, respectively. Machinery and equipment contributed 0.4 percentage, and the wood and electronic industries 0.3 percentage points each. In the early 1990s the paper industry was still the top performer with 1.5 percentage points. The electronic industry's contribution was 0.9 percentage points. The metal industry contributed 0.6 and the food and tobacco industry 0.5

[12] In practice we calculated the contributions annually by multiplying the average t and t-1 value added share with the sub-industry's MFP growth $\ln(x_t/x_{t-1})$.

percentage points. After 1995 almost half, or 1.9 percentage points of the aggregate MFP growth of 4.1 per cent stemmed from the electronic industry alone. The other major player was the paper industry with 0.7 percentage points and the reallocation effect contributed 0.6 percentage points. Table 6 confirms the message of Table 5 that MFP growth has become much more mushroom-like than before.

Table 6. Contributions to manufacturing multi-factor productivity growth by sub-industry, 1975-2003*, ln percentage points.

	Industry	*1975-1990*	*1990-1995*	*1995-2003**
DA	Man. of food prod., bever. and tobacco	0.2	0.5	0.2
DB	Man. of textiles and textile products	0.2	0.1	0.0
DC	Man. of leather and leather products	0.0	0.0	0.0
DD	Man. of wood and wood products	0.3	0.3	0.2
DE	Man. of pulp, paper, etc., publ. and print.	0.8	1.5	0.7
DF	Man. of ref. petr. prod., coke and nuclear fuel	0.1	0.1	0.0
DG	Man. of chemicals and chemical products	0.2	0.2	0.1
DH	Man. of rubber and plastic products	0.1	0.1	0.0
DI	Man. of other non-metallic mineral products	0.1	0.1	0.1
DJ	Man. of basic metals and fabricated metal prod.	0.5	0.6	0.1
DK	Manufacture of machinery and equipment n.e.c.	0.4	0.4	0.1
DL	Manufacture of electrical and optical equipment	0.3	0.9	1.9
DM	Manufacture of transport equipment	0.0	0.2	0.0
DN	Manufacturing n.e.c. and recycling	0.1	0.1	0.0
	Reallocation	0.1	0.3	0.6

May not sum to totals due to rounding and averages.

The average growth of hourly compensation was on a par with or more rapid than the average rate in only three industries in 1975-90 (Table 7). Compensation grew, however, evenly as the cost of labour input in most industries increased by 10.0-10.5 per cent on average. Real hourly compensation, hourly compensation deflated with the sub-industries own deflators, grew in half of the industries at the average 4.6 per cent rate or more (Table 8). In the early 1990s both nominal and real hourly compensation slowed down. Now five industries' nominal increases and as many as eight industries' real increases were at or above mean. In 1995-2003 the aggregate nominal wage increases were the smallest in our observation period. In real terms they were the most rapid. Six sub-industries distinguished themselves as generous in current prices but when deflating the nominal hourly labour cost to constant prices only three were above average.

Table 7. Average growth of hourly compensation by manufacturing sub-industry, 1975-2003*, ln per cent.

	Industry	*1975-1990*	*1990-1995*	*1995-2003**
DA	Man. of food prod., bever. and tobacco	10.8	4.9	3.3
DB	Man. of textiles and textile products	10.1	5.1	3.7
DC	Man. of leather and leather products	10.0	4.9	3.1
DD	Man. of wood and wood products	10.3	4.9	3.4
DE	Man. of pulp, paper, etc., publ. and print.	10.5	4.6	3.9
DF	Man. of ref. petr. prod., coke and nuclear fuel	10.6	3.0	4.0
DG	Man. of chemicals and chemical products	10.1	4.5	4.2
DH	Man. of rubber and plastic products	10.0	5.0	3.7
DI	Man. of other non-metallic mineral products	10.4	4.2	3.1
DJ	Man. of basic metals and fabricated metal prod.	10.2	4.8	2.8
DK	Manufacture of machinery and equipment n.e.c.	10.2	5.1	3.1
DL	Manufacture of electrical and optical equipment	10.3	5.3	4.8
DM	Manufacture of transport equipment	9.9	5.5	2.6
DN	Manufacturing n.e.c. and recycling	10.1	4.7	3.0

Table 8. Average growth of real hourly compensation by manufacturing sub-industry, 1975-2003*, ln per cent.

	Industry	*1975-1990*	*1990-1995*	*1995-2003**
DA	Man. of food prod., bever. and tobacco	4.5	4.5	4.3
DB	Man. of textiles and textile products	4.8	2.0	3.3
DC	Man. of leather and leather products	4.9	2.0	2.3
DD	Man. of wood and wood products	2.3	5.0	6.7
DE	Man. of pulp, paper, etc., publ. and print.	5.0	-1.0	6.7
DF	Man. of ref. petr. prod., coke and nuclear fuel	2.3	14.8	-1.2
DG	Man. of chemicals and chemical products	5.2	2.5	4.7
DH	Man. of rubber and plastic products	6.0	2.7	1.5
DI	Man. of other non-metallic mineral products	3.3	5.5	1.0
DJ	Man. of basic metals and fabricated metal prod.	6.4	1.7	3.5
DK	Manufacture of machinery and equipment n.e.c.	4.6	4.7	2.2
DL	Manufacture of electrical and optical equipment	3.7	8.0	8.2
DM	Manufacture of transport equipment	2.5	5.6	-0.3
DN	Manufacturing n.e.c. and recycling	3.5	5.4	2.9

Unit labour cost increased by a rate less than average in six industries in 1975-90 (Table 9). The best performer was the rubber and plastics industry which with its 3.0 per cent was in a league of its own. In 1990-95 six industries as well stood out to their advantage. Now the peak performers were the electronic industry and the oil refining industry with -3.3 per cent, respectively. After 1995 the story is similar to that for LP and MFP. Only two industries distinguished themselves: the electronic industry with -7.9 per cent and the wood industry with -1.4 per cent.

Table 9. Average growth of unit labour cost by manufacturing sub-industry, 1975-2003*, ln per cent.

	Industry	*1975-1990*	*1990-1995*	*1995-2003**
DA	Man. of food prod., bever. and tobacco	7.2	-1.5	0.3
DB	Man. of textiles and textile products	6.2	-0.1	2.0
DC	Man. of leather and leather products	6.1	0.8	1.0
DD	Man. of wood and wood products	4.5	-0.6	-1.4
DE	Man. of pulp, paper, etc., publ. and print.	5.1	-2.4	0.8
DF	Man. of ref. petr. prod., coke and nuclear fuel	6.9	-3.3	2.8
DG	Man. of chemicals and chemical products	5.4	0.2	1.1
DH	Man. of rubber and plastic products	3.0	1.3	3.4
DI	Man. of other non-metallic mineral products	6.4	-0.1	1.7
DJ	Man. of basic metals and fabricated metal prod.	4.1	-1.7	2.1
DK	Manufacture of machinery and equipment n.e.c.	5.5	0.7	2.3
DL	Manufacture of electrical and optical equipment	4.8	-3.3	-7.9
DM	Manufacture of transport equipment	8.4	1.2	1.5
DN	Manufacturing n.e.c. and recycling	6.2	1.1	2.4

To ascertain whether the relative variation of hourly compensation, unit labour cost, labour productivity and multi-factor productivity around their means has increased or decreased we calculated the coefficients of variation (*CV*) from 1975 to 2003. The coefficient of variation was obtained by dividing the standard deviation *s* with the mean (see Feinstein and Thomas, 2002).

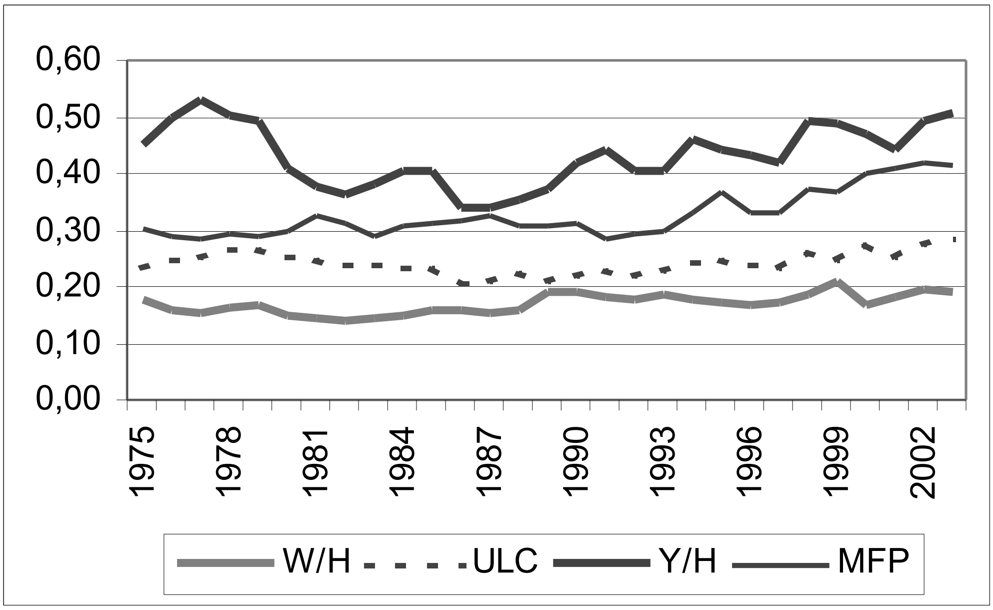
(9) $$CV = s / \overline{X},$$

where

(10) $$s = \sqrt{\frac{\sum \left(X_i - \overline{X}\right)^2}{n}}.$$

In Figure 4 we see not only changes over time in the individual *CV's* but also their performance relative to each other. The coefficient of variation in hourly compensation was the smallest relative to the others. Hourly compensation's *CV* fluctuated between 0.14 and 0.21. In 1975 it was 0.18 and it ended up at 0.13 in 2003. Unit labour cost's *CV* shows a slight increase from 0.23 in 1975 to 0.28 in 2003. MFP's coefficient of variation shows a clear increase over time as it started off at 0.3 and expanded to 0.41. Highest up on our graph is the *CV* of labour productivity. LP's *CV* was 0.45 in 1975 and first showed a declining trend with the lowest observations at 0.34 in 1986-7. After that the sign of the angular coefficient turned positive and our latest observation is at 0.51.

Figure 4. Coefficients of variation of hourly compensation (W/H), unit labour cost (ULC), labour productivity (Y/H) and multi-factor productivity (MFP) in manufacturing, 1975–2003*, per cent.



5. MANUFACTURING'S IMPACT ON THE TOTAL ECONOMY

Having gone through our number crunching effort for the manufacturing industry the natural follow-up question is: What are the implications for Finnish economic growth? During the whole 1975 to 2003 period the volume of value added increased more rapidly in manufacturing than in the whole economy (Tables 2 and 10). Manufacturing's nominal share was approximately a quarter of the whole economy (Table 11). Combining the sub-industries nominal shares in Table 11 with their growth rates from Table 4 the contributions of manufacturing and its sub-industries can be calculated (Table 12).[13] In the period 1975-90 as much as 0.9 percentage points of the aggregate 3.1 per cent growth stems from manufacturing. That amounts to 29 per cent of the growth as 0.9/3.1=0.29. A tenth of a percentage point came from: food and tobacco, wood, chemicals, machinery and equipment, and electronics, respectively. Both the paper industry and the basic metal and fabricated metal products contributed 0.2 percentage points each. During the early 1990s manufacturing's contribution

[13] In practice we calculated the contributions annually by multiplying the average t and t-1 value added share with the sub-industry's value added growth $\ln(x_t/x_{t-1})$.

was 0.6 points of a total -0.7 per cent. After 1995 the contribution increased to 1.3 percentage points of a total 3.6 per cent growth, or 36 per cent (=1.3/3.6). Electronics alone managed 0.8 percentage points. A tenth of a point each came from: wood, paper, basic and fabricated metals, and machinery and equipment. Thus more than a third of Finnish economic growth originated from the manufacturing industry.

The post-1995 value added growth was combined with an increased labour input in half a dozen manufacturing industries: rubber and plastics, non-metallic minerals, basic and fabricated metals, machinery and equipment, electronics, and other manufacturing (see Table 4). As the electronics industry made the average growth of value added high none of the six could match it. But all of them beat the average manufacturing hours worked increase of 0.6 per cent. At least in these industries growth was not of the jobless kind.

Table 10. Average growth of total economy's value added, 1975-2003*, ln per cent.

	Industry	*1975-1990*	*1990-1995*	*1995-2003**
GDP bp	Total economy, current price value added	10.4	1.7	4.9
GDP bp	Total economy, price of value added	7.2	2.4	1.4
GDP bp	Total economy, volume of value added	3.1	-0.7	3.6
GDP bp	Total economy, hours worked	0.0	-3.7	1.3
GDP bp	Total economy, labour productivity	3.1	3.0	2.3

Table 11. Share of man. industries in total economy's cp value added, 1975, 1990, 1995 and 2003*, per cent.

	Industry	*1975*	*1990*	*1995*	*2003**
DA	Man. of food prod., bever. and tobacco	3.4	2.5	2.5	1.8
DB	Man. of textiles and textile products	2.2	0.8	0.6	0.4
DC	Man. of leather and leather products	0.3	0.1	0.1	0.1
DD	Man. of wood and wood products	1.1	1.5	1.3	1.0
DE	Man. of pulp, paper, etc., publ. and print.	5.3	4.9	6.8	4.3
DF	Man. of ref. petr. prod., coke and nuclear fuel	0.3	0.4	0.3	0.3
DG	Man. of chemicals and chemical products	1.6	1.5	1.7	1.3
DH	Man. of rubber and plastic products	0.8	0.7	0.8	0.8
DI	Man. of other non-metallic mineral products	1.1	1.1	0.7	0.8
DJ	Man. of basic metals and fabricated metal prod.	2.6	2.4	3.0	2.6
DK	Manufacture of machinery and equipment n.e.c.	3.2	3.0	3.0	2.5
DL	Manufacture of electrical and optical equipment	1.6	2.2	3.3	5.9
DM	Manufacture of transport equipment	1.9	1.2	1.1	0.9
DN	Manufacturing n.e.c. and recycling	1.0	0.8	0.6	0.5
D	Manufacturing	26.5	23.2	25.8	23.1

May not sum to totals due to rounding.

Table 12. Contributions to total economy's volume of value added growth by manufacturing sub-industry, 1975-2003*, ln percentage points.

	Industry	*1975-1990*	*1990-1995*	*1995-2003**
DA	Man. of food prod., bever. and tobacco	0.1	0.0	0.0
DB	Man. of textiles and textile products	0.0	-0.1	0.0
DC	Man. of leather and leather products	0.0	0.0	0.0
DD	Man. of wood and wood products	0.1	0.0	0.1
DE	Man. of pulp, paper, etc., publ. and print.	0.2	0.2	0.1
DF	Man. of ref. petr. prod., coke and nuclear fuel	0.0	0.0	0.0
DG	Man. of chemicals and chemical products	0.1	0.0	0.0
DH	Man. of rubber and plastic products	0.0	0.0	0.0
DI	Man. of other non-metallic mineral products	0.0	-0.1	0.0
DJ	Man. of basic metals and fabricated metal prod.	0.2	0.1	0.1
DK	Manufacture of machinery and equipment n.e.c.	0.1	0.0	0.1
DL	Manufacture of electrical and optical equipment	0.1	0.3	0.8
DM	Manufacture of transport equipment	0.0	0.0	0.0
DN	Manufacturing n.e.c. and recycling	0.0	0.0	0.0
D	Manufacturing	0.9	0.6	1.3

May not sum to totals due to rounding and averages.

6. CONCLUSIONS

Our objective in this paper was to pinpoint the proximate sources of growth in the Finnish manufacturing industry which by the 1990s had leap-frogged to the LP level of the US. Interestingly labour costs and unit labour costs remained at only three quarters of the US level, although real hourly compensation increased steadily. The productivity improvement began already in the mid-1980s which means that it was not solely an electronic industry story. The electronic industry's performance in the 1990s is, however, quite extraordinary and can only be compared to the introduction of an earlier general purpose technology, i.e., electricity.

The structure of the manufacturing industry changed during our observation period, with especially textiles, food, and transport equipment losing ground and the non-electronic metal industry and particularly the electronic industry gaining. Our growth accounting results showed that in the Finnish manufacturing industries MFP was the most important source of labour productivity growth. This is in contrast to the US, where capital deepening mattered most. As was the case with LP the MFP growth in the Finnish manufacturing industry was very polarized, mushroom-like, at the end of our time series. In fact the electronic industry contributed alone close to half of the aggregate MFP increase in the 1995 to 2003 period. By then Finnish growth was transformed from the investment driven sort to the innovation driven kind, with four Finnish manufacturing sub-industries, the paper industry, the wood industry, the basic metals industry and the telecommunications industry, at the technology frontier. These industries could not copy technology elsewhere developed, but had to undertake substantial R&D efforts themselves. As a result the ratio of research and development to GDP rose, in fact, to a record 3.5 per cent by 2003.

More than a third of overall Finnish post-1995 period economic growth originated from the manufacturing industry, while its nominal share was a quarter. The value added growth was combined with an increased labour input in half a dozen manufacturing sub-industries. So at least in these industries growth was not of the jobless kind.

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APPENDIX

Industry classification NACE 2002:

D	Manufacturing
DA	Manufacture of food products, beverages and tobacco
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
DB	Manufacture of textiles and textile products
17	Manufacture of textiles
18	Manufacture of wearing apparel; dressing and dyeing of fur
DC	Manufacture of leather and leather products
19	Manufacture of leather and leather products
DD	Manufacture of wood and wood products
20	Manufacture of wood and wood products
DE	Manufacture of pulp, paper and paper products, publishing and printing
21	Manufacture of pulp, paper and paper products
22	Publishing and printing
DF	Manufacture of refined petroleum products, coke and nuclear fuel
23	Manufacture of refined petroleum products, coke and nuclear fuel
DG	Manufacture of chemicals and chemical products
24	Manufacture of chemicals and chemical products
DH	Manufacture of rubber and plastic products
25	Manufacture of rubber and plastic products
DI	Manufacture of other non-metallic mineral products
26	Manufacture of other non-metallic mineral products
DJ	Manufacture of basic metals and fabricated metal products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products
DK	Manufacture of machinery and equipment n.e.c.
29	Manufacture of machinery and equipment n.e.c.
DL	Manufacture of electrical and optical equipment
30	Manufacture of office machinery and computers
31	Manufacture of electrical machinery and apparatus n.e.c.
22	Man. of radio, television and communication equipment and apparatus
33	Manufacture of medical and precision products
DM	Manufacture of transport equipment
34	Manufacture of motor vehicles, trailers and semi-trailers
35	Manufacture of other transport equipment
DN	Manufacturing n.e.c. and recycling
36	Manufacturing n.e.c.
37	Recycling