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ACCOUNTING FOR GROWTH AND PRODUCTIVITY: FINNISH MULTI-FACTOR PRODUCTIVITY 1975–99*

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This paper presents new calculations for the multi-factor productivity of the non-residential market production in Finland. The new methodology entails quality corrected measures of capital and labour services. The results reinforce the view of a shift taking place in the Finnish growth pattern after the early 1990s recession, from extensive to intensive growth. The exception is the extensive contribution of information and communication capital. Multi-factor productivity has been the engine of growth during the whole observation period from 1975 to 1999, but it experienced a significant step-up in the 1990s. (JEL: O3, O4)

1. Introduction

Growth accounting has experienced a revival in the economics literature. Much of the discussion has focused on the so called New Economy, mainly following the step-up in U.S. productivity in the late 1990s. However, before we can state what kind of impact for instance information and communication technology (ICT) capital has on economic growth and productivity, there are important conceptual issues to settle. How should capital and labour be measured? The OECD (2001a)[1] has published a manual on productivity measurement where it has recommended which measures should be used for capital and labour. This manual is from an economic theory view located in the neoclassical tradition and concerning capital it could be said to belong to the Jorgensonian school. The manual also favours the index approach to productivity measurement rather than the regression approach, since it is intended to help national statistical institutes produce reliable productivity statistics on a continuous basis. The objective of this paper is to apply this best-practice growth accounting methodology to Finnish data using a more detailed asset breakdown than before and to gain new insights of Finland's economic growth. The results reinforce the view of a shift taking place in the Finnish growth pattern after the early 1990s recession, from extensive to intensive growth. The exception is the extensive contribution of information and communication capital. Multi-factor productivity (MFP) has been the engine of growth during the whole observation period from 1975 to 1999, but experienced a significant step-up in the 1990s.

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[1] *For a nice summary of the Productivity Manual's main points, see Aulin-Ahmavaara (2001).*

Previous growth accounting studies for Finland include Tiainen (1994), Niininen (1999), Björkroth and Kjellman (2000), Colecchia and Schreyer (2002), and Jalava and Pohjola (2002). Tiainen (1994) is a thorough Denison type[2] growth accounting study for the whole Finnish economy over the years 1900–90. His measure of output is net domestic product at basic values. As a measure of capital he uses net capital stocks (which he adjusts for rate of utilization using changes in output) and land (forests, agricultural and other). His measure of labour is adjusted for quality (education, sex and age). Niininen (1999) is also a Denison style growth accounting exercise for the non-farm non-residential business sector for the years 1983–96. As measures of output Niininen uses both gross and net value added at basic values. He quality adjusts the labour input by level of education. The capital measure he uses is also the net capital stock of fixed capital. The growth of net value added, which Niininen defines as gross value added less depreciation, captures, as Hulten (2001) shows the welfare aspects of productivity. However, it seems that Niininen's (as well as Tiainen's) measure of depreciation is the national accounts consumption of fixed capital, something which Diewert (2001a) calls time-series depreciation – the decline in the value of a homogeneous capital good at consecutive time periods – in contrast to cross-section depreciation – the difference in the value of the same capital good's different vintages at the same time period – that productivity researchers usually refer to when they are talking about economic depreciation. The net capital stock – which is compiled by Statistics Finland (2000) using linear time series depreciation – is actually the wealth capital stock, i.e. the market value of the capital stock, and as such not suited for growth accounting purposes. This means that the capital measure is not corrected for compositional changes in Tiainen's and Niininen's work. Furthermore, neither Tiainen nor Niininen use superlative indexes in their aggregations.

Björkroth and Kjellman (2000) is a study with a slightly different focus, since they use a parametric approach to test whether public sector capital plays an important role in stimulating private sector total factor productivity (TFP). Their measure of output is business sector output, and their measure of capital is the net non-residential capital stock, which is adjusted for the rate of capacity utilization. Björkroth and Kjellman (2000) did not find that changes in the public non-residential capital stock had a significant effect on private sector TFP.

Colecchia and Schreyer (2002) have calculated the contribution of capital services, showing separately ICT capital services, to the economic growth of certain advanced countries' business sectors. Their study – though very useful in applying the same methodology for different countries – is only a partial growth accounting exercise, since it lacks the measures for labour services and thus cannot calculate MFP. Both Colecchia and Schreyer (2002) and Jalava and Pohjola (2002) have corrected their capital inputs for quality changes. However, neither Colecchia and Schreyer (2002) nor Jalava and Pohjola (2002) included inventory stocks and land in their capital measure. There is a consensus in the literature on the importance of taking into account land and inventories in the capital measure. Diewert and Lawrence (1999) recently showed how the omission of land and inventories lead to a decline in average total factor productivity growth rates in Canada of about 0.1 per cent per year. This is a lot in relative terms, since the average growth rate of TFP in Canada averaged 0.5–0.6 per cent over the years 1963–96.

This paper also deals with the matter of whether capital has been inefficient or not in the past decades prior to the 1990s (Pohjola, 1996), that is, whether capital productivity growth was low or not in the years 1975 to 1990? This ques-

[2] *Tiainen finds the key difference between Denison and Jorgenson type growth accounting to be the stricter adherence to the assumption of perfect competition by Jorgenson. Furthermore, in a neoclassical sense Tiainen lists the major shortcomings of Denison's methodology as: i) it is not strictly based on the neoclassical production function, ii) the chosen index-method is not based on index theory and leads to spurious indexes, and, iii) the used production factors contain measurement errors. However, in a purely empirical sense Tiainen finds numerous good qualities in the Denisonian approach, which he chose to use in his own empirical work.*

tion cannot be answered definitively by performing a single-country growth accounting study. However, according to the results of van Ark and Timmer (2001) and OECD (2001b), the level of labour productivity in Finnish manufacturing was in 1987 still only 74.3 per cent of the U.S. level. This changed by Finland catching up with and even surpassing U.S. manufacturing (106.6 per cent by 2000). The computations in this paper also implicitly show a significant increase in capital productivity in the 1990s, thus it can be stated that capital efficiency definitely increased markedly in Finland in the 1990s.

The paper is organized in the following way. Section 2 shows the production function used in this paper and Section 3 presents the methodology used for calculating capital and labour services. Section 4 demonstrates the empirical results for capital and labour services for Finland. Section 5 presents the empirical data on the decomposition of the growth in Finnish non-residential market production[3] in 1975–99 and discusses briefly the fundamental structural change taking place due to ICT. Section 6 concludes this paper.

2. The aggregate production function

The aggregate production function is often presented in the form:

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

where, at any given time *t*, aggregate value added *Y* is produced from aggregate inputs consisting of capital services *K* and labour services *L*. 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) $\hat{Y} = (1-\alpha)\hat{K} + \alpha\hat{L} + \hat{A}$,

where the ^-symbol indicates the rate of change, α is the income share of labour and $(1-\alpha)$ is the income share of capital.

Neoclassical growth accounting basically divides output growth into the contributions of input growth, i.e. labour and capital, with multi-factor productivity growth being the residual. The inputs are corrected for changes in quality and weighted with their marginal products – their market prices[4]. Since MFP catches all unmeasured factors such as disembodied technical change (a shift of the production function), organisational improvements, economies of scale and measurement errors, Abramowitz (1956) quite rightly called the residual a *'measure of our ignorance'*.

The neoclassical theory is based on many assumptions, which are important to keep in mind when analysing the results. Most importantly, capital – though considered the engine of growth in the short run – is seen to suffer from diminishing returns, so that productivity growth in the long run is completely exogenous[5]. Another important assumption underlying the aggregate production function is that of a representative firm. As Bartelsman and Doms (2000) point out, research carried out with longitudinal micro-data has found evidence of large variations in productivity levels between firms, and this may imply that factor substitution or scale elasticities do not represent the marginal responses of industries. Furthermore, Berndt and Fuss (1986) showed using a short-run production function and treating capital as quasi-fixed that for profit-maximizing firms the values of their marginal products do not necessarily equal the transaction prices, which implies that the output elasticities differ from the value shares.

3 Market production is the production of goods and services sold at economically significant prices. This is in contrast to non-market production, which is performed by general government and non-profit institutions serving households and mostly financed through taxes or income transfers. Market production was 71 per cent and non-residential market production 62 per cent of GDP at market prices in 1999.

4 For labour the wages and salaries of each homogeneous labour type is used, and for capital the rental price of each homogeneous asset type is used.

5 The endogenous growth theory was developed to circumvent the restricting view of long run growth being determined by exogenous technical change. See Stiroh (2001) for more on this subject.

Leading growth accountants are aware of the challenges that the framework faces. Dale Jorgenson (2001) recently stated that an important challenge for growth accounting is to find measures for R&D outputs to match the R&D inputs. Diewert (2001b) lists even more that need to be endogenized by the growth accounting framework: knowledge capital (such as patents, research and development expenditure, etc.) and infrastructure capital. A further elaboration of the pros and cons of neoclassical growth accounting is, however, beyond the scope of this paper. The interested reader is referred to the sources listed in the references.

3. *Capital and labour services methodology*

The classic production function of Solow (1957) 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. For homogeneous capital asset types, the Perpetual Inventory Method (see, e.g., OECD, 2001c) is applied, but when aggregating different heterogeneous capital goods into an aggregate, they must be weighted by their respective user costs. Intuitively, when adding up e.g. the stocks of non-residential buildings and computer software, we must in the production function take notice of the fact that their respective service lives and price changes are very different (computer software must generate revenue in a much shorter period than buildings, since capital theory tells us (Diewert, 2001a) that the capital assets value equals the discounted flow of future rental payments that the good is expected to accrue.).

Following Jorgenson and Stiroh (2001) a geometric age-efficiency pattern[6] is used to construct productive capital stocks[7] for the Finnish non-residential market sector. The productive capital stock at time t for a homogeneous capital asset type is defined as the following Perpetual Inventory Equation:

$$(3) \quad K_t = K_{t-1}(1-d) + I_t = \sum_{\tau=0}^{\infty}(1-d)^{\tau} I_{t-\tau} ,$$

where I is gross fixed capital formation and d is the rate of depreciation. The symbols for industry and asset type (*i&j*) have been left out for notational simplicity. The choice of which age-efficiency pattern to use is naturally of fundamental importance for the results. Whereas empirical studies of economic depreciation are scarce, Hulten and Wykoff (1981) found in a very influential empirical study that, even though a constant rate of depreciation is not exactly equal to the Box-Cox depreciation rates their results pointed at, it is a reasonable statistical approximation.

The user cost or rental price of capital is defined as the rate of return plus depreciation minus capital gain/loss:

$$(4) \quad r_t = p_{(t-1)}q_t + p_t d_t - (p_t - p_{(t-1)}),$$

Here, r is the rental price, p designates the price index for new capital goods and q is the rate of return. There are two principal ways of estimating user costs. The opportunity or ex-ante approach uses some exogenous value of the rate of return i, for example the base rate of the central bank. The residual or ex-post approach estimates the internal rate of return q with the help of an accounting identity. Defining capital income to equal nominal value added less labour compensation[8], and given information about depreciation, holding gains and capital stock, the rate of return can be estimated residually as

[6] *Which equals the age-price profile as shown by Jorgenson, Gollop and Fraumeni (1987). I.e. the productive capital stock equals the wealth capital stock at constant prices, which is very convenient for the practical calculations.*

[7] *The OECD Productivity Manual recommends using an appropriate retirement pattern to calculate gross capital stocks (GCS), and from the GCS using age-efficiency patterns to proceed to productive capital stocks. This is where the method used in this paper differs from the one recommended by OECD (2001a).*

[8] *This is the national accounts compensation of employees to which has been added the labour income of the self-employed. This income component is estimated by using the hours worked by the self-employed multiplied by the average wages of employees.*

$$q_t = \frac{capital\ income - \{p_t d_t - (p_t - p_{t-1})\} K_{t-1}}{p_{t-1} K_{t-1}}, \tag{5}$$

where K is the real capital stock and pK the nominal capital stock, i.e. the market value of the capital stock. The user costs are used to aggregate the productive capital stocks by asset type. The productive capital stocks for each asset type represent the flow of capital services delivered by the asset type to production, with the assumption being that the quantity of services per unit of capital is constant. Aggregate capital services is a translog function[9] of the services of individual assets. Thus the aggregate volume index of capital services is:

$$c_{it} = \frac{K_{it}}{K_{i(t-1)}} = \prod_j \left(\frac{K_{ijt}}{K_{ij(t-1)}} \right)^{v_{ijt}}, \tag{6}$$

where the weights v are defined as

$$v_{ijt} = \left(\frac{r_{ijt} K_{ijt}}{\sum_i r_{ijt} K_{ijt}} + \frac{r_{ij(t-1)} K_{ij(t-1)}}{\sum_i r_{ij(t-1)} K_{ij(t-1)}} \right) / 2. \tag{7}$$

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

As a measure of labour services hours worked adjusted for labour quality is used. The hours worked are cross-classified by educational level and by the average wages and salaries of each educational group. The aggregate volume index of labour services is a translog function of the services of individual labour types:

$$l_{it} = \frac{L_{it}}{L_{i(t-1)}} = \prod_m \left(\frac{L_{imt}}{L_{im(t-1)}} \right)^{v_{imt}}, \tag{8}$$

where the weights are given by the average shares of each labour type in the total value of labour compensation:

$$v_{imt} = \left(\frac{p_{imt} L_{imt}}{\sum_i p_{imt} L_{imt}} + \frac{p_{im(t-1)} L_{im(t-1)}}{\sum_i p_{im(t-1)} L_{im(t-1)}} \right) / 2 \tag{9}$$

with p_m denoting the wage rate of labour type m. A six-category classification of labour by the level of education is applied. The classes are: lower secondary education (or less), upper secondary education, first stage of tertiary education (i–iii) and second stage of tertiary education.

4. Capital and labour services calculations

The volume index of capital services was calculated using the ex-post approach in calculating rates of return[10]. The indexes of Finland's non-residential market production's capital stock and capital services have been aggregated from eight different fixed capital asset types: non-residential buildings, civil engineering and other structures, transport equipment, other machinery and equipment, mineral exploration, computer software, entertainment, literary or artistic originals and improvement of land. Furthermore, inventory stocks by four asset types (materials and supplies, work-in-progress, finished goods and goods for resale) and forests (as a proxy for land, since forests and wooded areas were 68 per cent of Finland's total area in 1999), were also used[11]. Table 1 shows the shares of each asset type of the nominal capital stock. Inventories and forests are half of the value of the capital stock in 1975 and still 31 per cent in 1999. Thus it is understandable that especially when calculating the internal rate of return it makes a difference what the scope of capital is, i.e. the rate of return is too high when excluding inventories and land.

Capital services grew at a rapid pace until 1990 with the assistance of a slower capital

[9] *Diewert (1976) showed that the Törnqvist quantity index – which is used in this paper – is in discrete time exact for the translog production function. The Törnqvist (1936) index is a weighted average of the logarithmic change from period t-1 to period t, with the weight being the arithmetic average of the income shares in these periods.*

[10] *Berndt and Fuss (1986) found using U.S. manufacturing data, that during cyclical output fluctuations using the ex-ante rate of return seriously overstated the impacts on TFP, as compared to using the ex-post rate of return.*

[11] *I thank Annika Paavola for the data on inventory stocks 1975–89 and Jukka Muukkonen for the forest data 1975–99.*

Table 1. Value of capital stock per asset type, %.

	1975	1980	1985	1990	1995	1999
Non-residential buildings	16.8	20.7	22.8	29.0	25.4	26.3
Civil engineering etc.	8.0	8.9	8.6	8.8	9.3	9.0
Transport equipment	4.5	4.8	4.5	4.5	4.9	4.7
Other machinery and eq.	18.2	20.2	20.3	23.6	24.5	24.6
Mineral exploration	0.0	0.0	0.0	0.1	0.1	0.1
Computer software	0.2	0.4	0.6	1.0	1.3	1.7
Originals	0.3	0.4	0.4	0.4	0.6	0.6
Improvement of land	2.4	2.6	2.5	2.4	2.6	2.3
Inventories	18.0	20.4	18.6	10.0	10.1	9.3
Forests	31.6	21.6	21.8	20.3	21.3	21.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

Calculations based on data from Statistics Finland's National Accounts Database.

goods' price change and a shift to capital goods with shorter service lives (the rate of depreciation, which is calculated excluding inventories and forests, has been slowly increasing during the whole observation period). In 1986 capital quantity[12] decreased – mainly due to a sharp reduction in inventory stocks. Thus capital quality increased. Capital quality increases if the share of assets with higher user costs also increases. This is due to a shift into capital assets with shorter service lives, or alternatively that annual price increases are lower. The most significant feature visible in the capital services series is the sharp decline at the beginning of the 1990s, due to Finland's deep economic recession. The average annual growth rate of capital services in the years 1995–99 was 0.9 per cent compared with 0.8 per cent for the capital stock, which indicates an increase in capital quality. The significance of capital quality to capital services was, however, greater 1975–90 than in the 1990s, since capital services grew on average by 2.8 per cent per annum and the capital stock by 1.9 per cent. In the years 1990–95 capital services declined on average by 3.7 per cent yearly when the capital stock by comparison declined by only 0.6 per cent. The most significant contributions to the aggregate capital services in the latter 1990s came from other machinery and equipment, computer software and inventories. The time series by asset type are given in Table 2. It should be kept in mind that the time series by asset type are the price index weighted volume indexes of the productive capital stocks, and that the total capital services series is the user cost weighted sum of these series. Thus, in 1990, for example, the sum of aggregate productive capital stock series is 130.9 whereas the capital services series is 148.0.

In calculating the volume index of labour services the longitudinal census file for the years 1975, 1980, 1985, 1990 and 1995 (the intermediate years were interpolated) is used to obtain data on hourly wages by educational groups. For the years 1996–99 the labour force survey is used to obtain the share of hours worked by each level of education (which is then adjusted to national accounts figures), and the wage structure statistics is used to obtain average wages by level of education. The contribution of persons with tertiary education to labour services has increased markedly during the observation period. The average annual growth of labour services was –0.4 per cent in 1975–90, with the contribution of persons with tertiary education being 0.7 percentage points. This changed by labour services growing 2.9 per cent and the contribution of persons with a

[12] *Capital quantity is defined here as the volume index of productive capital stocks with the weights being the price indexes for new capital goods. Aggregate productive capital stocks are analogous to equation 6, with the difference from aggregate capital services being that aggregate productive stocks are not weighted with their user costs (r in equation 7) but with the price index p.*

Table 2. Volume indexes of total capital services and productive capital stocks, 1975=100.

	1975	1980	1985	1990	1995	1999
Non-residential buildings	100.0	103.0	106.7	112.3	111.1	111.8
Civil engineering etc.	100.0	100.7	101.2	101.8	101.8	102.0
Transport equipment	100.0	99.9	100.0	100.7	99.4	99.5
Other machinery and eq.	100.0	102.5	106.2	112.6	108.4	109.9
Mineral exploration	100.0	100.0	100.0	100.1	100.1	100.1
Computer software	100.0	100.2	100.4	100.8	100.9	101.3
Originals	100.0	100.1	100.1	100.1	100.1	100.2
Improvement of land	100.0	100.0	100.0	99.8	99.5	99.3
Inventories	100.0	102.1	102.7	98.2	97.2	97.8
Forests	100.0	101.6	102.4	102.2	103.2	103.7
Total capital services	100.0	111.5	123.5	148.0	114.7	119.8

Calculations based on data from Statistics Finland’s National Accounts Database.

Table 3. Volume indexes of labour services, 1975=100.

	1975	1980	1985	1990	1995	1999
Lower secondary ed. (or less)	100.0	90.7	81.5	76.6	66.8	65.8
Upper secondary education	100.0	104.3	109.8	110.9	103.7	109.6
First stage tertiary I	100.0	101.2	104.5	106.1	105.1	107.5
First stage tertiary II	100.0	100.4	101.9	102.0	101.5	104.0
First stage tertiary III	100.0	100.1	101.9	102.8	102.6	106.2
Second stage tertiary	100.0	100.0	100.1	100.2	100.1	100.4
Total labour services	100.0	96.2	97.2	94.7	75.8	85.8

Calculations based on data from Statistics Finland’s National Accounts Database.

tertiary education being 2.1 percentage points in 1995–99. Equally remarkable is the change in the contribution of persons with an educational level of lower secondary education or less increasing from –1.8 percentage points 1975–90 to –0.5 percentage points in the latter part of the 1990s. The time series by level of education are in Table 3.

5. *The growth picture*

Following Finland’s severe economic recession in the early 1990s, there has been a structural shift concerning capital from extensive to intensive growth. Extensive growth means growth achieved through investment in capital equipment, whereas intensive growth means that growth is achieved through productivity. This reflects the fact that capital was used rather inefficiently in Finland in the past decades (Pohjola, 1996) and that a considerable improvement in capital productivity has taken place since the recession. Pohjola shows – using data from the Penn World Table, Mark 5.6 – that in 1960–90 the investment ratio in Finland was approximately 9 percentage points higher than on average in other industrialised countries. This led to a higher capital intensity and lower level of consumption per employee and to a rapid decline in the marginal productivity of capital. He points out that the central government had a prominent role in promoting investments, since catching-up with other industrialized countries was seen to demand massive investments, and thus consumption was restrained so it would not crowd out the investments. Pohjola calculates best-practice frontiers for Finland and 13 other developed countries, and shows that Finland was far from the production frontier both in 1970 and 1990[13]. Pohjola acknowledges that the extensive policy led to growth, his point being that growth would have been attained by a lesser social cost with more moderate fixed investments. Haltia and Leppämäki (2000) show that a low capital productivity can even be combined with a reasonable return from the shareholders' perspective[14].

According to the results of van Ark and Timmer (2001) and OECD (2001b) the level of labour productivity in Finnish manufacturing was in 1987 still only 74.3 per cent of the U.S. level. This changed by Finland catching up with and even surpassing U.S. manufacturing (106.6 per cent by 2000). Thus, by the end of the 1980s the massive investments had not made the Finnish manufacturing industry's level of labour productivity catch up with the U.S. Only the decrease in labour quantity during the early 90s recession combined with the pick-up in MFP (Table 4) made us surpass the labour productivity level of the U.S. in manufacturing. Micro-level studies (Maliranta, 2001) have found evidence of creative destruction in Finnish manufacturing in the 1990s, i.e. that firms with weaker productivity performance exited the market when the economy slumped, and that the then released capital and labour shifted to more profitable firms, resulting in an increase in aggregate productivity. Hyytinen and Kauppi (2002) find an interesting coincidence with the structural change of the Finnish economy and the liberalization of Finnish financial markets in the 1990s. They conclude that the growing importance of stock markets in financing new firms was of paramount importance for innovative and high-risk ventures as compared to the previous decade when the primary source of financing came from financial institutions.

In Table 4[15] it can be seen that the contribution of capital services is in the latter part of the 90s only half of what it was in 1975–90. A new feature for the late 90s is that the growth contribution of labour quantity is positive for the first time. Labour quality has also slightly increased its contribution. On the other hand, MFP has been the main engine of economic growth in Finland over the whole observation period, and it grows actually at almost double the speed in the period 1995–99 compared to 1975–90. MFP can also be expressed as the geometric average of labour and capital productivity, therefore the increase in MFP in the 90s came from an increase in capital efficiency as the average annual growth of labour productivity in 1995–99 decreased to a low of 3.5 per cent (having been 3.9 per cent 1990–95 and 3.7 per cent 1975–90). Both Tiainen's (1994) and Niininen's (1999) results also point at MFP being the major contributor to growth in Finland. Tiainen found MFP to account for 38 per cent of the growth in 1900–48, which increased to 60 per cent in the years 1948–85. Niininen found MFP to contribute 97 per cent of gross output growth and 119 per cent of net output growth in the years 1983–96. The results of this study point at MFP accounting for 78 per cent of the growth in 1975–90 and 65 per cent in 1995–99.

[13] *Capital intensity grew more rapidly in Finland, but labour productivity on approximately a par with the U.K., which had a more modest growth of capital intensity. Tax incentives allowed tax deductions for firms that invested much. Pohjola furthermore points out that the government's regulation of the economy and the lack of competition in the closed sector kept the prices of consumer goods high. Investment goods' prices on the other hand were low, since the real interest rate was negative for most of the years from the late 1960s until the mid-80s. After the mid-1980s the price of capital was higher, when the rate of inflation significantly slowed down and the nominal interest rates increased. An important part of the Finnish growth strategy was also keeping wage increases moderate, which the employees were motivated to agree with by receiving more services from an extended welfare state, i.e. free education, and virtually free day-care and health-care services.*

[14] *They refer to the Artto-Pohjola paradox, i.e., the claims by Artto (1997) that in the same period Pohjola observed an inefficient use of capital Artto found that the return on capital in the paper industry was quite reasonable.*

[15] *A weakness with the multi-factor productivity calculations presented here is that intermediate consumption is not included as an independent variable in the production function. Implicitly intermediate consumption is considered, since value added is used as the production function's output instead of gross output per se. However, if there are structural differences in how an industry's intermediate consumption and value added change, then these changes are not captured by these productivity calculations. The KLEMS (the letters stand for capital, labour, energy, materials and services) growth accounting framework addresses this problem, since the intermediate consumption of industries is taken into account, and gross output instead of value added is used as a measure of output.*

Table 4. Contributions to growth in non-residential market production, 1975–99.

		1975–90	1990–95	1995–99
Average annual growth of gross value added[1]		3.2	–0.7	6.0
Contributions[2] from	Capital stock	0.7	–0.2	0.3
	Capital quality	0.3	–1.1	0.1
	Labour hours	–0.4	–2.9	1.3
	Labour quality	0.2	0.2	0.3
	Multi-factor productivity	2.5	3.3	3.9
Income shares[1]	Capital	35.6	38.7	44.3
	Labour	64.4	61.3	55.7
Growth rates[1]	Capital quantity	1.9	–0.6	0.8
	Labour hours	–0.7	–4.5	2.4

Notes: [1]per cent. [2]percentage points. Numbers may not add to totals due to rounding.
Calculations based on data from Statistics Finland's National Accounts Database.

Finland experienced a significant structural change in the 1990s. Whereas the average growth in non-residential market production resulted in a six-fold increase in nominal gross value added between 1975 and 1999, there was a 21-fold increase in the ICT producing industries. The rapid growth led to a quite significant increase in the share of ICT industries in the gross value added of market production, which increased from 3.7 per cent in 1975 to 5.8 per cent in 1990 and 13.0 per cent in 1999 as reported by Jalava and Pohjola (2002). They define ICT production as encompassing the following industries: ISIC 30 Office machinery and computers, ISIC 31 Electrical machinery, ISIC 32 Radio, television and communication equipment, ISIC 33 Medical and precision products, ISIC 642 Telecommunications services and ISIC 72 Computer software and services. The structural change that has taken place is not only restricted to ICT production. The absolute contribution of ICT use has also increased in the late 1990s in all nations surveyed by Colecchia and Schreyer (2002). They have calculated the contribution of capital services, using the same hyperbolic age-efficiency profiles for all countries and separately showing ICT capital, to the economic growth of certain advanced countries. Colecchia and Schreyer's (2002) results corroborate Jalava and Pohjola's (2002) view of the main exception to the otherwise intensive Finnish growth picture after the 1990s depression being the extensive growth contribution of the use of ICT capital. Indeed, as a referee pointed out, it is likely that improved efficiency in the use of traditional capital goods, as reported in Table 4, has masked the technical progress embodied (quality improvement of capital goods) in ICT capital. Jorgenson and Stiroh (2001) also found a step-up in the contribution of ICT capital services in the late 1990s to U.S. private domestic growth[16]. What is a striking contrast between the U.S. and the Finnish evidence is that the contribution of capital services in the U.S. for the period 1959–98 is approximately twice as big as the contribution of TFP (though U.S. TFP also experienced a significant increase in the late 90s), whereas recent Finnish economic growth has predominantly relied on MFP.

6. Conclusion

The objective of this paper was to quantify the sources of growth in the Finnish non-resi-

[16] They also exclude the government sector, but include services from consumers' durables and owner-occupied housing in their measure of output.

dential market sector 1975–99. To attain this target, a best-practice growth accounting framework superior to those used in previous studies was utilized. The Finnish growth picture has been dominated by multi-factor productivity during our observation period. Since the capital term contributes significantly less to output growth in the 1990s than it used to do, it can be concluded that growth in Finland in the 90s less relied on embodied technical change per se, and more than previously on MFP. The only exception to this is the extensive contribution of ICT capital services as reported by Colecchia and Schreyer (2002) and Jalava and Pohjola (2002). As MFP can also be expressed as the geometric average of labour and capital productivity, and labour productivity growth slowed down in the late 1990s, our results point at a significant increase in capital efficiency taking place. However, when analyzing the results of this paper it is important to keep in mind that Finnish National Accounts do not as yet utilize double deflation consistently, that the volume measures are of Laspeyres type with a fixed base year, and that the volume measures of services face the same problems as most other countries do.

Applying new and advanced techniques in measuring MFP growth in Finland has reinforced previously held views but also given new insights. However, as Stiroh (2001) has it: *'Modern growth accounting is more about measuring technical change than explaining it'*. The fact that the former socialist states' growth strategy relied on capital deepening (an increase in capital per labour) through massive investments – and their subsequent economic collapse, makes one wonder whether MFP really is just *'manna from heaven'* in the traditional neoclassical sense or whether research and development and economic innovations are not a major factor underlying Western economic success. At the moment the growth accounting framework cannot endogenize R&D output. The System of National Accounts (SNA93) does not currently capitalize R&D expenditure either, but treats it as intermediate consumption. This is clearly unsatisfactory, and distorts our view of the true sources of economic growth.

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Appendix

Table A1: The Volume Indexes, 1975=100

	Value added	Capital services	Capital quantity	Labour services	Labour quantity	MFP
1975	100.0	100.0	100.0	100.0	100.0	100.0
1976	99.1	103.5	102.2	98.0	97.7	99.5
1977	97.8	105.4	103.7	95.1	94.5	99.7
1978	100.0	105.0	103.6	93.8	93.0	103.1
1979	107.8	108.9	108.0	94.8	93.8	108.9
1980	114.9	111.5	110.4	96.2	94.9	114.0
1981	116.7	113.8	112.7	97.8	95.9	113.8
1982	118.9	116.0	114.7	97.9	95.5	115.1
1983	122.8	119.3	117.8	97.1	94.2	118.2
1984	128.1	121.2	119.4	97.2	93.9	122.5
1985	132.3	123.5	121.1	97.2	93.5	125.7
1986	135.4	128.4	116.7	95.1	91.3	128.5
1987	141.8	132.3	118.3	95.7	91.6	132.6
1988	149.1	135.8	120.5	96.9	92.6	137.0
1989	159.3	143.4	127.2	97.6	93.0	142.6
1990	160.0	148.0	130.9	94.7	90.0	144.0
1991	143.0	138.2	129.8	86.2	81.6	140.1
1992	135.4	110.2	127.5	79.4	74.8	151.4
1993	138.3	117.5	124.0	74.5	69.9	157.1
1994	146.1	114.8	122.7	74.4	69.5	167.7
1995	152.6	114.7	123.0	75.8	70.6	173.3
1996	160.5	114.5	122.7	78.6	71.9	178.8
1997	173.2	115.6	123.7	80.9	74.1	188.9
1998	184.7	118.2	126.4	82.9	75.9	196.9
1999	195.3	119.8	127.4	85.8	78.3	203.0

Calculations based on data from Statistics Finland's National Accounts Database.