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PLANT PRODUCTIVITY IN FINNISH MANUFACTURING

- Characteristics of high productivity plants

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The characteristics of the high productivity plants in Finnish manufacturing are investigated in this study by using the industrial statistics. This is a large panel data set covering practically all manufacturing plants that have at least 5 persons. For the analysis the most exceptional observations are eliminated from the data.

A multilateral total factor productivity index is used as an indicator of a plant's performance level. To implement this indicator, the input shares for each plant are estimated by using both industry-level and plant-level information on labour and capital costs.

The relationship between the level of productivity and a wide variety of explanatory factors are studied. Industry specific spillovers seem to prevail both within firms and regions. The level of productivity is high for example among young plants, plants that have high foreign ownership and plants that are located in the South. We obtained some indication that high shares of male or non-manual workers are positively associated with productivity. The results concerning the favourableness of exports are somewhat dubious, because the export and domestic prices may differ and, in addition, the direction of the causality is uncertain. However, we are inclined to conclude that the real competitiveness of the export orientated plants is relatively good.

KEY WORDS: Productivity, total factor productivity, panel data, Finnish manufacturing, plant

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Tässä tutkimuksessa selvitetään korkean tuottavuuden toimipaikkojen ominaispiirteitä Suomen tehdasteollisuudessa käyttämällä teollisuustilastoaineistoa. Tämä suuri paneeliaineisto kattaa käytännöllisesti katsoen kaikki vähintää 5 hengen toimipaikat. Analyyseja varten aineistosta on putsattu kaikkein poikkeuksellisimmat havainnot.

Multilateraalista kokonaistuottavuusindeksiä käytetään yhtenä toimipaikan suorituskyvyn osoittimena. Tätä indikaattoria varten kullekin toimipaikalle on estimoitu panososuudet käyttämällä hyväksi sekä toimiala- että toimipaikkatason tietoa työ- ja pääomapanoskustannuksista.

Tuottavuustason ja useiden selittävien tekijöiden välistä yhteyttä on tutkittu. Toimialaspesifin tiedon leviämistä näyttää esiintyvän sekä yrityksen että alueen sisällä. Korkea tuottavuus on esimerkiksi uusilla toimipaikoilla, sellaisilla toimipaikoilla, joilla on korkea ulkomaalaisomistusosuus sekä toimipaikoilla, jotka sijaitsevat etelässä. Saatiin myös näyttöä siitä, että miesten ja toimihenkilöiden korkea osuus työvoimasta on positiivisessa yhteydessä tuottavuuden kanssa. Viennin hyödyllisyyttä koskevat tulokset ovat jossain määrin epävarmat, koska vienti- ja tuontihinnat saattavat poiketa toisistaan ja koska kausaliteetin suunta on epäselvä. Kuitenkin vaikuttaa siltä, että vientiinsuuntautuneiden toimipaikkojen reaalinen kilpailukyky on suhteellisen hyvä.

ASIASANAT: Tuottavuus, kokonaistuottavuus, paneeliaineisto, Suomen tehdasteollisuus, toimipaikka

Yhteenveto — Finnish summary

Tutkimuksessa tarkastellaan Suomen tehdasteollisuuden toimipaikkojen välisiä tuottavuuseroja. Aineistona käytetään teollisuustilastoa, joka kattaa periaatteessa kaikki vähintään viiden hengen toimipaikat. Tästä ns. tasapainottamattomasta paneeliiaineistosta on poistettu joukko kaikkein poikkeuksellisempia havaintoja.

Keskeisenä toimipaikan suorituskyvyn tunnuslukuna käytetään ns. multilateraalista kokonaistuottavuusindeksiä. Se soveltuu monenvälisiin vertailuihin, mutta ottaa myös huomioon toimipaikkojen panosrakenteiden erot. Taustalla on mm. oletus, että toimipaikkatasolla vallitsee ns. vakiot skaalatuotot.

Aineiston tarkastelu paljastaa, että toimipaikkojen välillä on sangen huomattavia tuottavuuseroja, eli tuotoksen ja käytössä olevien panosten välinen suhde vaihtelee hyvin paljon. Merkittävä osa tuottavuustasojen vaihtelusta johtuu aineiston epätarkkuuksista, mutta myös teknologian taso ja tekninen tehokkuus ovat erilaisia erityyppisissä toimipaikoissa.

Tutkimuksen tärkein päämäärä on selvittää, mitkä tekijät ovat yhteydessä toimipaikan kykyyn käyttää tuotantoresurssejaan tuottavasti. Tämä on hyödyllistä tietoa, kun halutaan ymmärtää, miksi jotkut toimipaikat eivät menesty tai jos halutaan parantaa teollisuuden kilpailukykyä teollisuuspolitiikan keinoin.

Työn tuottavuus on erityisen korkea suurissa toimipaikoissa, mutta tämä selittyy suurelta osin korkealla pääomakannan ja työpanoksen välisellä suhteella. Kun toimipaikan suorituskykyä mitataan kokonaisvaltaisemmalla tuottavuuden mitalla — kokonaistuottavuudella — pienten, keskisuurten ja suurten toimipaikkojen välillä ei havaita kovin merkittäviä eroja.

Tutkimus osoittaa, että maantieteellinen sijainti on tuottavuuden kannalta olennainen tekijä. Kokonaistuottavuus on yleisesti ottaen korkea etelässä. Koska toimipaikkaspesifin tiedon leviäminen näyttää jossain määrin rajoittuvan alueellisesti, sijainnin ja tuottavuuden välinen yhteys on monitahoisempi. Tulokset viittaavat siihen, että toimipaikka hyötyy siitä, että samalla alueella ja samalla toimialalla (4-numerotaso tol79-luokituksessa) toimii muita toimipaikkoja, joilla on korkea kokonaistuottavuuden taso. Ilmeisesti on alueelle edullista, jos sen toimipaikat keskittyvät samoille toimialoille, jolloin toimipaikat voivat hyötyä toisistaan.

Tiedon leviämistä esiintyy myös yrityksen sisällä. Tulokset osoittavat, että toimipaikalla on korkea kokonaistuottavuuden taso silloin, kun samassa yrityksessä toimii muita korkean tuottavuuden toimipaikkoja samalla toimialalla (4-numero taso).

Tehdasteollisuuden tuleva tuottavuustaso ja niinmuodoin reaalinen kilpailukyky ovat osin riippuvaisia siitä, missä laajuudessa ja kuinka korkeatasoisia toimipaikkoja syntyy. Elinkaarensa alkuvaiheessa toimipaikan työn tuottavuus on tavallisesti alhainen ja ne ovat kooltaan pieniä. Tästä syystä uusilla toimipaikoilla on lyhyellä aikavälillä melko marginaalinen vaikutus koko tehdasteollisuuden tasolta katsottuna. Toisaalta, uusilla toimipaikoilla on tyypillisesti pieni pääomakanta työpanosyksikköä kohti, mikä selittää sen, että tässä saatujen tulosten mukaan uusien toimipaikkojen kokonaistuottavuuden taso on vanhoja toimipaikkoja korkeampi. Tämä saattaa johtua esimerkiksi siitä, että uudet toimipaikat käyttävät edistyksellistä teknologiaa. Uusien toimipaikkojen kokonaistuottavuus näyttää kasvavan nopeammin kuin vanhojen, mikä vahvistaa uusien toimipaikkojen myönteistä vaikutusta pitkällä aikavälillä. Havaittiin, että jostain syystä uudet toimipaikat ovat olleet erityisen suorituskykyisiä vuodesta 1988 lähtien.

Uusien toimipaikkojen heikkous on, että niiltä puuttu kokemuksen myötä karttuvaa toimipaikka- ja toimialaspesifiä inhimillistä ja organisatorista pääomaa. Tätä heikkoutta voi lievittää tiedon leviäminen. Saatiin joitakin viitteitä siitä, että tiedon leviäminen yrityksen sisällä on erityisen hyödyllistä uusille toimipaikoille. Myös pienet toimipaikat näyttävät hyötyvän suuria enemmän tiedon leviämisestä. Nämä kysymykset ansaitsevat kuitenkin vielä huolellisemman tarkastelun.

Esimerkiksi teollisuuspolitiikan kannalta eräs tärkeä kysymys on, millainen vaikutus ulkomaisella omistuksella on tuottavuuteen. Tutkimuksessa saatiin monenlaista näyttöä siitä, että kokonaistuottavuus oli normaalia korkeampi ulkomaalaisomisteisissa toimipaikoissa. Ulkomaalaisomisteisella toimipaikalla tarkoitetaan tässä sellaista toimipaikkaa, joka kuuluu vähintää 20 prosenttisesti ulkomaisessa omistuksessa olevaan yritykseen.

Toinen väylä, jota pitkin kansainvälisesti parhaaksi osoittautuneet toimintatavat saattavat siirtyä Suomeen, on kansainvälinen kauppa. Tutkittaessa vientiosuuden (vienti/kokonaistoimitukset) vaikutusta reaaliseen suorituskykyyn törmätään joihinkin ongelmiin, jotka vaikeuttavat tulosten tulkintaa. Tuottavuusmittauksessa taustalla oleva oletus, että vientihinnat ovat samat kuin kotimarkkinahinnat ei ole välttämättä voimassa — varsinkaan silloin, kun markka on erityisen vahva. Tästä syystä voimakkaasti vientiin suuntautuneiden toimipaikkojen kokonaistuottavuuden taso saatetaan aliarvioida. Toinen ongelma liittyy kausaliteettiin: johtaako korkea tuottavuuden taso vientiin vai päinvastoin? Kun otetaan huomioon hintoihin sisältyvä problematiikka, näyttää siltä, että vientiosuus on selvästi positiivisesti yhteydessä kokonaistuottavuustason kanssa. Kausaliteettiongelma vaatii lisäselvittelyä.

Myös vuotuisen keskimääräisen työajan ja kokonaistuottavuuden tason välistä yhteyttä on tutkittu. Lyhyt vuosityöaika näyttää olevan tilastollisesti merkitsevästi yhteydessä korkean kokonaistuottavuustason kanssa. Toisaalta yhteys ei ole kuitenkaan asiallisesti ottaen kovinkaan merkitsevä, varsinkin kun pidetään mielessä, että mittausvirheiden takia kokonaistuottavuuden taso saatetaan yliarvioida lyhyen työajan toimipaikoissa.

Toimipaikan kokonaistuottavuuden tason ja toimipaikan työvoimarakenteen välillä on riippuvuus. Regressiotulosten perusteella näyttää siltä, että ne toimipaikat, joissa miesten osuus koko työvoimasta oli hyvin suuri vuonna 1984, olivat myös kokonaistuottavuudeltaan vahvoja vuosina 1985-1992. Osa regressioanalyyseistä kertoo, että kokonaistuottavuus on korkea erityisesti sellaisissa toimipaikoissa, joissa toimihenkilöiden osuus on suuri. Tämä on odotettu tulos, sillä toimihenkilöt ovat tyypillisesti hyvin koulutettuja ja kykeneviä käyttämään uusinta tekniikkaa. Toisaalta, kun regressiomalliin liitetään kiinteät toimipaikkatermit, korkean toimihenkilöosuuden myönteinen vaikutus näyttää katoavan. Toimipaikkatermien voidaan tulkita mittaavan toimipaikan pysyväisluonteista teknologista tasoa. Näyttää ilmeiseltä, että korkea toimihenkilöosuus (tai hyvin koulutettujen osuus) ei ole yksinään hyödyksi tuottavuudella vaan edellyttää myös sopivaa teknologiavalintaa.

Tämä oli ensikatsaus tekijöihin, jotka selittävät Suomen teollisuustoimipaikkojen välisiä tuottavuuseroja. Suuri joukko tärkeitä kysymyksiä jäi selvittämättä. Joitakin ekonometrisia pulmia jätettiin pienelle huomiolle tai sivuutettiin. Tällaisia kysymyksiä ovat simultaanisuus, heteroskedastisuus (josta todettiin selviä merkkejä), autokorrelaatio tai poikkileikkauskorrelaatio. Näistä ongelmista johtuen tilastollisten merkitsevyyksien arviot saattavat olla jonkin verran harhaisia.

Jatkossa mm. toimipaikkadynamiikka kaipaa tarkempaa analyysiä. Koulutuksen ja muiden työpanoksen ominaisuuksien merkitys toimipaikan tuottavuudelle kannattaa tutkia seikkaperäisemmin. Tämä voidaan tehdä yhdistämällä henkilötason tietoja toimipaikkatietoihin, mihin suomalaiset aineistot antavat kansainvälisesti vertaillen poikkeuksellisen hyvän mahdollisuuden. Olisi myös hyödyllistä käyttää sellaisia muuttujia, jotka mittaavat suoraan toimipaikan teknologian ominaisuuksia. Tähän tarjoaa joitakin mahdollisuuksia teknologiakysely vuodelta 1990, jota on suunniteltu hyödyntää myöhemmin.

1 Introduction

1.1 Background for the study

Maliranta (1997) studied how aggregate productivity growth is affected by the fact that there are considerable differences in the productivity levels and growth rates of productivity among plants, and that the input shares change in the process of the evolution of the manufacturing sector. The micro-structural factors seem to have been essential for the aggregate labour and the aggregate total factor productivity in the Finnish manufacturing especially since the mid 80's.

The Finnish manufacturing sector as well as the whole economy experienced a severe recession in the early 90's. The output of the Finnish manufacturing sector fell by 11 per cent and labour hours by 14 per cent from 1989 to 1991. As the productivity level of a plant gains more emphasis in the more competitive business environment, it is important to understand the factors affecting the ability to use the input resources productively and thus competitively.

The successfulness of a unit — a plant, a firm or a nation — has many dimensions and different perspectives. The owners are interested in profits, and the workers are concerned about their real wages and employment. The citizens and policy makers wish for the material prerequisites for well-being to be at a high level in the nation. Profits may be increased at the expense of consumers or workers when product prices are increased or wages are lowered. A nominal wage increase, when it is not accompanied by a sufficiently high growth rate of productivity, causes an acceleration of inflation or the deterioration of competitiveness and employment. The traditional measure of standard of living, GDP per capita, may reflect high participation rates, high working hours or high saving rates in the past and thus this indicator may overestimate the well-being of a nation while ignoring the sacrifices — less leisure and the postponement of consumption.

1.2 Some explanations for plant productivity

Various possible explanations for the differences in the productivity levels among plants are investigated in this study. The effect of plant (or firm) size on productivity or profitability is extensively studied empirically. Politicians and the media often emphasise the importance of small and medium-sized firms as they are claimed to create jobs. On the other hand, the small firms (or plants) account for a fairly small share of industrial jobs.[1] The labour productivity level is usually quite low in the small firms and plants. However, this does not, of course, necessarily mean that the small units are harmful or undesirable for a nation. Firstly, the capital stock per labour input is typically smaller in the small plants than in the large ones and thus the differences in the total factor productivity level may be smaller or not occurring between the small and large plants (see Maliranta, 1996, 149-150).

Secondly, the building of a large and a productive plant or a firm involves all sorts of adjustment costs. For that reason the growth process of a plant or a firm may take a long time (see Maliranta, 1997). Therefore the size and the age of a plant or a firm are typically associated with each other. The productivity level of an entrant, i.e. a plant that is new to the manufacturing sector, may be low but some

[1] The employment share of the plants employing less than 10 persons (less than 20 persons) was 2 per cent (8 per cent) in the Finnish manufacturing in 1994. The corresponding wage shares were even smaller. See discussion in Baldwin (1995) and especially in Davis et al. (1996).

of them have the potential to grow and improve their productivity as plant-specific human capital, managerial skills and organisational capital are increased through learning by doing. Thus the small plants as a group might be expected to be especially heterogeneous in terms of productivity levels and survival and growth prospects, depending on the age or the ability that are at least partly unobservable to a researcher.

The importance of the geographical location for the plant's performance level is investigated here. This issue is studied in various ways. Firstly, it is possible that in the certain areas that are favourable to industrial production, the plants may typically have high productivity irrespective of the industry or other characteristics. In other words, a particular geographical area may have an absolute advantage over others in all industries because of a superior environment, infrastructure or educational level. In the regression analysis this can be controlled by using dummy variables for the regions.

On the other hand, the different industries may have absolute advantage in different areas. As Krugman (1991) has pointed out, if there are externatilities and increasing returns to scale within an area and industry, the absolute advantage of a certain industry may exist in a certain geographical area simply due to the fact that there happens to be a lot of production in that industry. In the United States the plants that operate in the same narrowly defined industry are locally rather concentrated and this concentration has increased over time. This is an indication that it is rational for the plants operating in the same industry to locate near to each other. There are various reasons why the plants locating in the same geographical location may gain benefit from each other. For example, crucial industry specific information may be conveyed efficiently only through face to face contacts.[2] This issue is studied here by looking at, how the concentration in a geographical area is associated with the productivity level within industries.

The importance of spillover effects is studied here in greater detail. We investigate to what extent a plant's total factor productivity is related to that of the other plants operating in the same industry and in the same firm. Also the relationship between a plant's productivity performance and that of the other plants that operate in the same industry and in the same region is explored — while we have controlled the general differences between regions by dummy variables.

Globally competitive companies are typically those that have current best practice conduct in their branches. Technology is transferred across the borders as these companies set up new transplants in other countries. The failure of the domestic producers to adopt the best practice or so-called 'frontier' technology is reflected to some extent in the differences in productivity levels between domestic-owned and foreign-owned plants. On the other hand, foreign-owned plants may also affect positively the productivity level of the domestic-owned plants through the diffusion of technology or increased competition in the domestic markets (see Gersbach — Baily, 1995).

This study focuses on productivity, which is one of the factors affecting profitability. The nominal (census) value added is deflated here by the price indices at the industry-level. Industry specific deflators are retrieved from the national accounts. It is impossible (or very difficult) to measure the prices at the plant-level. Thus, implicitly we are assuming that plants producing the same products share the same output prices. To the extent that this assumption is violated, we are not, strictly speaking, able to measure the relative productivity levels nor draw a sharp distinction between productivity and profitability.

[2] Other factors favouring concentration are discussed in Krugman (1991).

2 Data

2.1 Construction of sample

The Finnish industrial statistics for the period from 1975 to 1994 is used as a major data source in this study. This panel data set covers, in principle, all the Finnish manufacturing plants having at least 5 person. A researcher who is trying to become acquainted with this kind of data set may become troubled when realising a considerable amount of extreme outliers. It is certainly the case that for some reason or other some plants send poor quality data. For example, for a multi-unit firm it may be difficult to divide costs between plants appropriately.

The manufacturing sector is divided into 15 industries, which are shown in table 2.1. This classification (NA classification from now on) corresponds approximately the one used in the Finnish national accounts nowadays. Nominal value added and machinery and equipment (including transport equipment) investments of a plant is converted into 1990 prices by using implicit price indices of a corresponding industry defined by NA classification. For the period from 1975 to 1984 also fire insurance values for different types of capital are available.[3] The same deflators as for investments are applied for them, too.

Table 2.1. Classification of plants into 15 industry groups (NA classification)

Industry index, ISIC (tol 79)	Industry group (NA industry)
310	Manufacture of food, beverages and tobacco
320	Textile, wearing apparel and leather industries
330	Manufacture of wood and wood and cork products
341	Manufacture of paper, and paper products
342	Printing, publishing and allied industries
351/2	Manufacture of industrial chemicals (351) and other chemical products (352)
353/4	Petroleum refineries (353) and miscellaneous products of petroleum and coal (354)
355/6	Manufacture of rubber products (355) and plastic products n.e.c. (356)
360	Manufacture of non-metallic mineral products, except products in (35B)
370	Basic metal industries
381	Manufacture of fabricated metal products, except machinery and equipment
382	Manufacture of machinery except electrical
383	Manufacture of electrical machinery, apparatus, appliances and supplies (383) and instruments (385)
384	Manufacture of transport equipment
390	Others

The data set contains a number of observations, which can be seen as erroneous or can be viewed as 'outliers'. As a few extreme observation may distort the results and the interpretations, there is a good case for cleaning the data from this kind of observations. We try to use transparent methods, when cleaning the data set. The cleaning of data sets is carried out in stages, by making increasingly stricter criteria that the observation that will be analysed should meet.

At the first stage, our raw data — which is used for example in the construction of capital input measures — includes all the plants available in the industrial statistics. For example, our raw data set includes the so-called 'investment plants', which are the plants under construction and producing no output.

[3] In this study fire insurance values of machinery stock is used solely in the estimation of initial stocks (see below).

To construct data sets for the analysis, the following four criteria is applied for each NA industry separately.

The first one can be called as basic criteria and it is used for example in Maliranta (1997) when decomposing aggregate labour productivity growth.

Criteria 1: Value added > 0 and the number of persons > 4 and the plant is having industrial activities.

In the formulating the criteria 2 (labour input criteria) and criteria 3 (capital input criteria) we are using similar approach than Mairesse et al. (1993). We cut the extreme tails of the distribution of a few important ratios. Let R_{it} be a ratio (*Y/L*, for example) of a plant *i* in the year *t* and m_t is the average in the year *t* and σ_t is the standard deviation of log m_t. Observation *i* is deemed as an 'outlier' if $|Log\ R_{it}/m_t| > 4.4\sigma_t$.

Criteria 2: Criteria 1 and $|Log\ R_{it}/m_t| > 4.4\sigma_t$, where *R*=Labour hours/the number of persons and, $|Log\ R_{it}/m_t| > 4.4\sigma_t$, where R=nominal value added/labour hours.

Criteria 3: Criteria 2 and $|Log\ R_{it}/m_t| > 4.4\sigma_t$, where *R*=real value added/machinery stock measured by PIM (see below).

Criteria 4: Criteria 3 and $|Log\ R_{it}/m_t| > 4.4\sigma_t$, where *R*=*TFP*-measure (four versions, see below).

If *log R* has normal distribution, the probability that an observation lies outside an acceptance region is less than 1 to 100 000.

The consequence of applying these criteria to our data set is shown in table 2.2. As the criteria becomes stricter, the number of plants decreases, but deleted plants are typically the small ones. Consequently, the plants meeting our editing requirements cover a very large share of total value added, hours worked and the consumption of electricity.

Table 2.2. Effect of cleaning data sets in 1980 and 1994

	Year 1980				Year 1994			
	Number of plants	Nominal value added[4], millions Fmk	Hours, 000's	Elecricity in mwh	Number of plants	Nominal value added, millions Fmk	Hours, 000's	Electricity in mwh
The raw data	7082	53537	910880	21452414	5379	131230	528140	34302180
Criteria 1*	94.7 %	100.2 %	98.7 %	95.7 %	97.2 %	99.8 %	99.6 %	98.4 %
Criteria 2*	94.0 %	100.1 %	98.5 %	95.6 %	96.4 %	99.4 %	98.9 %	98.0 %
Criteria 3*	87.0 %	96.2 %	94.6 %	95.0 %	83.7 %	93.3 %	91.4 %	96.4 %
Criteria 4*(a)					83.6 %	93.3 %	91.3 %	96.4 %

* compared to the raw data set. (a) here constructed with *ITFPa*-measure (see below).

2.2 Measurement of variables

In this study output is measured by the so-called census value added concept. It is defined as gross value of output excluding non-industrial services minus cost of raw materials, packaging, energy inputs and contract work. Consequently, the value of purchased non-industrial services, such as advertising, accountancy, etc., are not subtracted. It seems that census value added is more consistent over the time and between the plants than total value added used in the national accounts. The latter takes into account both the revenues and the costs from non-industrial services.

[4] Note that the value added share of a subgroup may exceed 100 % because some plants that are deleted have negative value added.

Labour input is measured here by hours worked. The Finnish industrial statistics contains the information about the hours done by employees. The number of owners working in the plant is included but the number of hours is lacking. Here it is assumed that the average annual hours worked by owners in a plant is the same as the average annual hours worked by employees in the plant in question. The number of hours worked by owners is probably underestimated to some degree, but the bias must be negligible.

For the capital input measure we have several alternatives. We prefer the machinery and equipment stock including transport equipment, which we call machinery stock for brevity henceforth. The machinery stock can be measured in two different ways. For the period from 1975 to 1984 we have the fire insurance value of the stock available, which is deflated into 1990 prices by industry specific (NA classification) deflators for the investments in machinery and equipment obtained from the Finnish national accounts.

In this study we apply, however, an estimate of machinery stock constructed by using the so-called perpetual inventory method (PIM), which is based on the following formula:

(2.1) $K(t+1) = (1-\delta)*K(t)+I(t+1)$,

where $K(t+1)$ is net machinery stock in the year $t+1$, $I(t+1)$ is real investments and δ is a constant depreciation rate, which is assumed to be 15 %.

The problem with PIM is that the initial level of stock is needed. It is estimated by using the industry specific proportions of fire insurance value. The proportion for each 15 NA industry is estimated in a way that the PIM estimate per fire insurance value is as stable as possible in the period from 1975 to 1984 for a full panel set of plants at the industry-level.

For each industry the initial stock $K(0)$ in 1975 is defined by

(2.2) *K(0)=X*fire insurance value of machinery stock in 1975.*

The proportion X is determined in the following way:

minimise standard deviation [log(NC in 1975/GC in 1975), log(NC in 1976/GC in 1976), ... , log(NC in 1984/GC in 1984)],

where NC is net capital stock calculated by the formula (2.1) (and using 15 per cent as a depreciation rate) and GC is gross capital stock measured by fire insurance value. In the period from 1975 to 1984 the first value of net capital measure of a plant i in the industry j is $K_{i,j}(0)=X_j*GC_{i,j}$.

The proportion was typically about one third but varied between industries to some extent. The proportion was rather low for plants in the basic metals (18.5 per cent) and high for the plants that operate in printing and publishing (51.0 per cent).

For the most industries the two measures of machinery stock yield quite consistent picture of the development of capital productivity, that gives some reliance on the capital input measure (see Maliranta, 1997, 23-27).

3 Measurement of total factor productivity indicator

The measurement of productivity is extremely easy in the case of single output and single input. The relative productivity between unit i and j is measured by

$$(3.1) \qquad \frac{Y^i/X^i}{Y^j/X^j} = \frac{Y^i/Y^j}{X^i/X^j}.$$

The great advantage of this kind of single indicator is that it is easily calculated. It may be a useful measure of performance level especially when applied within the sufficiently narrowly defined groups of units, for example at the detailed industry-level.

In the multi-output and multi-input setting the measurement of relative productivity or efficiency becomes slightly more complicated. Quite commonly the different outputs are aggregated with prices and then output volume may be expressed in fixed prices. In principle, the total input could be measured in fixed prices, too. Usually the different capital items are aggregated by using prices, but labour input and capital input and possibly different capital input categories like machinery and buildings are kept separated.

Multilateral index of total factor productivity provides a more comprehensive indicator of performance level than a single indicator. Under some special assumptions it is equivalent to an indicator of technical differences (between plants) or technical change (over time). For binary comparisons a representative unit is defined as a benchmark. Labour productivity of the benchmark plant is denoted here by $\tilde{Y}/\tilde{L}$ and capital intensity by $\tilde{K}/\tilde{L}$. Furthermore, to give suitable weights for different types of input, we have to estimate cost shares of inputs for the benchmark plant and for each plant in each year separately.

Caves et al. (1982) introduces the translog multilateral productivity index. When two types of inputs are used in the production, the index can be calculated by the following formula:

$$(3.2) \qquad \ln TFP_{it} = \ln\left(\frac{Y_{it}/L_{it}}{\tilde{Y}/\tilde{L}}\right) - \frac{S_{it}+\bar{S}}{2}\cdot\ln\left(\frac{K_{it}/L_{it}}{\tilde{K}/\tilde{L}}\right),$$

where S_{it} is the cost share of capital input in the plant i in the year t and it is calculated by

$$(3.3) \qquad S_{it} = \frac{KCOST_{it}}{KCOST_{it}+LCOST_{it}},$$

where $KCOST_{it}$ is the (nominal) capital costs and $LCOST_{it}$ is the costs of labour — covering wages and social security payments and other supplements. $\bar{S}$ denotes the average capital cost share among all plants in a given industry in the whole period. The *TFP* of the benchmark plant is defined to be one.

Under the assumption of constant returns to scale this method of measuring total factor productivity has attractive properties.[5] The index can be derived from the translog transformation function, which is a flexible multifactor representation of the structure of production. For that reason this index is called superlative (see Diewert, 1976) and as this index is transitive (in other words it satisfies the so-called circularity requirement) it is suitable for multilateral comparisons. Furthermore, while suitable for multilateral comparisons, a high degree of characteristicity is maintained, which is an important property of an index, as the great heterogeneity of the plants is a prevailing feature.

[5] Evidence for the CRS assumption at plant-level in the US manufacturing is provided for example by Baily et al. (1992).

The formulation (3.2) shows that labour productivity level is dependent on the total factor productivity and capital intensity. The bigger is the cost share of capital input, the bigger emphasis is given to the capital intensity. To implement this method we have to estimate the cost shares for each observation (S_{it}) and for the benchmark ($\overline{S}$). In this study this carried out by using the following procedures.

Two different total factor productivity indices is calculated for each plant in the period from 1975 to 1984 and from 1985 to 1994: one (MTFP) for comparisons at manufacturing level, where the benchmark is the average cost share of capital input in the total manufacturing in the period and another for comparisons at NA industry-level, where $\overline{S}$ is the average capital cost share is in the NA industry in the period. This indicator is denoted by *ITFP*.

For the both total factor productivity indicators, the benchmark $\overline{S}$ is estimated from the national accounts. The nominal capital cost in the total manufacturing or in a given NA industry is the depreciation of total capital stock in current prices plus 5 per cent (real interest rate) of net capital stock in current prices.[6] The labour input costs, in turn, are measured by total labour compensation, which includes wages, salaries and many sorts of supplements. Graph 3.1 shows the capital cost share in the total manufacturing since 1975. The capital cost share in the total manufacturing was about one fourth till the mid 80's, but has increased to some extent since then.

The constancy of the long-term real interest rate can be called into question. For example in the late 70's, the real interest rate may have been even negative in Finland. As the interest rates have increased in the course of the time, it is possible that the increase of capital input cost shares depicted in graph 3.1 may be underrated. However, as the graph illustrates, the trends of income share and cost share have rather similar pattern at least since the early 80's.

The benchmark capital input share $\overline{S}$ is an unweighted average of annual shares during the period in question. There is a considerable amount of variation in the capital input cost shares among 15 NA industries. In the period from 1985 to 1994 the share was highest in the petroleum refineries and miscellaneous products of petroleum and coal, ISIC 353/4, (51 per cent) and paper industry (49 per cent) and low in the printing and publishing (18 per cent) and in the electrical machinery etc. (17 per cent) and in the manufacture of machinery and equipment (17 per cent).

An alternative way to determine the weight to the capital input is to use the income share. The capital income share, which is one minus labour compensation per value added, is depicted in graph 3.1. As the graph shows, the income share of capital has been somewhat higher. Thus the use of income shares would render a less favourable picture of the performance level in those plants that have relatively capital intensive production technologies.

We have also constructed cost shares in a way that they are in keeping with the income shares at the total manufacturing level. For that reason we have defined implicit interest rate so that at the total manufacturing level the average capital income and capital cost share in the period under investigation agrees. The implied interest rate for the period from 1975 to 1984 is 12.3 per cent and 13.0 per cent for the period from 1985 to 1994. The capital input share derived from these rates is shown in graph 3.1, too. When the smaller rate of interest is used, it is denoted henceforth by small '*a*' letter in the total factor productivity variable (for example *MTFPa*) and when the bigger one is applied, it is denoted by small '*b*' letter (*MTFPb*).

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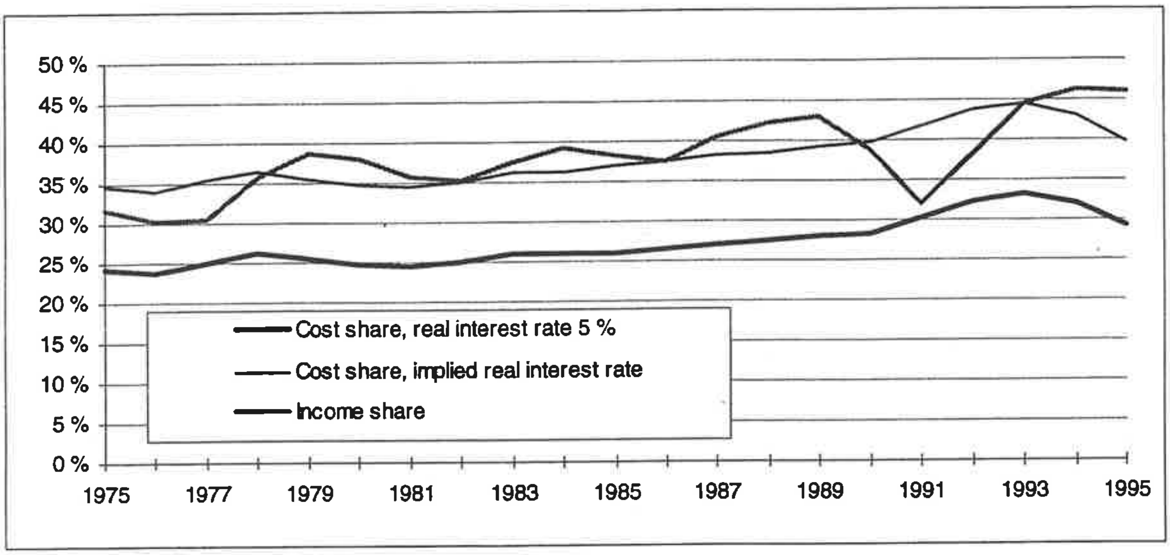
[6] The same rate of interest is used in Griliches - Regev (1995).

Graph 3.1. The share of capital input



Next step is to estimate the capital cost share S_{it} for each plant. Here we make use of both the national accounts and the industrial statistics.

The total factor costs are defined here by

(3.4) $$TOTCOST_{it}=W_{it}\cdot L_{it}+C_b\cdot BC_{it}+C_m\cdot MC_{it},$$

where W is the price (wages plus supplements) of labour input, BC is building capital input and MC is machinery capital input. The terms $C_b \cdot BC$ and $C_m \cdot MC$ are the nominal costs of building capital input and machinery capital input, respectively.

The capital input cost share in the plant i in the year t can be calculated by

(3.5) $$S_{it} = \frac{C_b \cdot BC_{it} + C_m \cdot MC_{it}}{TOTCOST_{it}}$$

$$\Leftrightarrow S_{it} = 1 - \left(\frac{C_b \cdot BC_{it} + C_m \cdot MC}{W_{it} \cdot L_{it}} + 1 \right)^{-1}.$$

$W_{it}\cdot L_{it}$ is obtainable from the industrial statistics and the machinery capital input costs is 20 per cent of the machinery stock (here in current prices). The problem is that we are lacking relatively reliable information on the buildings and other capital stock. Therefore, when constructing *ITFP* indicator we make an assumption that the total capital cost per machinery capital cost is the same in a given year for all plants in the given industry and when deriving *MTFP* measure in the total manufacturing. Thus for each plant it holds

(3.6) $$\frac{C_b \cdot BC_{it} + C_m \cdot MC_{it}}{C_m \cdot MC_{it}} = a_t,$$

In other words, in deriving *ITFP* indicator we allow the ratio to vary between NA industries and change over the time. In the case of *MTFP* indicator, the ratio is allowed to change in the course of time. At the manufacturing level the ratio has steadily decreased from 1.7 to 1.3 in the period from 1985 to 1994. In other words, the relative importance of machinery stock has increased, when assessed with the cost share.

By incorporating (3.6) into (3.5) we obtain

$$(3.7)\qquad 1 - S_{it} = \left(\frac{a_t \cdot C_m \cdot MC_{it}}{W_{it} \cdot L_{it}} + 1 \right)^{-1}.$$

To determine a_t for each NA industry or total manufacturing, we postulate that for our sample of plants the following equation holds:

$$(3.8)\qquad \left(\frac{a_t \cdot \sum C_m \cdot MC_{it}}{\sum W_{it} \cdot L_{it}} + 1 \right)^{-1} = 1 - \overline{S}_t,$$

where $\overline{S}_t$ is the capital input cost share in a NA industry (in the case of *ITFP* indicator) or in the manufacturing (*MTFP*) in the year t, which is obtained from the national accounts. Note that

$$(3.9)\qquad \overline{S} = \frac{\sum_t \overline{S}_t}{10}.$$

By solving (3.8) we obtain

$$(3.10)\qquad a_t = \frac{\overline{S}_t \cdot \sum w_{it} \cdot L_{it}}{(1 - \overline{S}_t) \cdot \sum C_m \cdot CM_{it}}.$$

Now we are able to calculate plant and time-specific capital input cost shares by

$$(3.11)\qquad S_{it} = 1 - \left(a_t \frac{\sum_i C_m \cdot CM_{it}}{\sum_i W_{it} \cdot L_{it}} + 1 \right)^{-1}.$$

4 Some descriptive analysis of productivity levels

As the very first look, we investigate some possible explanations for productivity differences between plants by using simple productivity indices — the relative labour productivity and total factor productivity indicators — that were described above. We try to grasp an overview, how the productivity levels differ between different kinds of plants and how the productivity differences among the plants have evolved in the course of time. The comprehension about the main features of the productivity in our data set is of great use, when aiming to model the relationships concerning productivity in order to study this issue later with more sophisticated methods. We are seeking the factors, which are potentially important for the good productivity. We are also pursuing some guidelines, how to take into account the time factor. Is it possible to distinguish some periods out of ordinary that should be taken into account when explaining productivity differences among the plants?

4.1 Productivity differences between different groups of plants

For the subsequent analysis the data set is cleaned by using criteria 4 (see table 2.2). We have calculated some relative measures for groups of the different kinds of plants. The averages are normalised by setting the mean of the one of the groups equal to one. To obtain more reliable results, the calculations are repeated for each year in the period from 1990 to 1994. Geometric averages from the period are provided in table 4.1.

As table 4.1 indicates, the relative labour productivity (measured here by nominal value added per hour) is positively related with plant size and age. Likewise, the results suggest that the labour productivity is relatively high in the plants, which belongs to a foreign-owned or multi-plant firm. The labour productivity level is high in Uusimaa and in the Northern Finland and low in the Eastern Finland and Åland.

The exposure to the global competition may compel plants to use their resources efficiently. Furthermore, the connections to global markets may help plants to adopt new and more productive technologies. On the other hand, the plants capable of operating productively and thus competitively may find it profitable to tend to the international markets. Thus we have several reasons to expect that the productive performance of the export orientated plants is high.

In order to study this issue we first sort the plants by the export share (export as a fraction of total deliveries) and divide the plants into three category: the most closed plants (in practise export share = 0 per cent, which accounts about 50 percentage of all plants), medium group (less than 20 per cent of all plants) and the most open plants (one third of plants). As can be seen in table 4.1, the labour productivity is clearly associated positively with the openness. The plants most open to the global competition had 28 per cent higher labour productivity than the closed ones.

An aspect in the measurement of productivity is worth of mentioning is this context. We are assuming (implicitly) that there are no price differences between plants or that the price differences reflect the quality differences. It is, however, quite possible that the export prices are lower than domestic prices especially in the boom times, when the domestic demand is strong. When making comparisons between the Finnish and US manufacturing sector, Maliranta (1996) indicates that the relative price level of the Finnish manufacturing industry is negatively associated with its export share. For example, in the paper industry, which is important for Finnish export, the price difference between the two countries was negligible in 1987, but in the sheltered food industry the price level was some 90 per cent higher in Finland than in the United States. In other words, the real productivity level of the export orientated plants may be underrated.

The labour productivity is a deficient indicator of performance level as the capital intensity levels vary between different groups as suggested by *MCINT* (=machinery stock per hour) and *ELINT*

(=consumed electricity in mwh per hour) variables. The big, old, export orientated and domestic-owned plants seem to use a relatively big amount of capital per hour. Capital intensity tends to be high also in the multi-plant firms and in the Northern Finland.

Our measure of the machinery capital stock provides information of owned machinery capital but rental capital is ignored. One possibility is to estimate the rental capital stock on the basis of rents. As the rental capital may be rather different by nature than owned capital, we decided to use rents as a separate explanatory variable. As a whole, the importance of rental machinery capital is rather small; on average, the machinery rents accounts less than 5 per cent of the costs of the owned machinery capital.[7]

Table 4.1 indicates that some differences in the usage of rental capital between different groups can be found. For example, while the foreign-owned plants seem to have smaller own machinery stock per hour than domestic-owned plants, they tend to have more rental capital (include all capital here) per hour. Similarly, the new plants use more rental capital per hour than the old ones, which might be expected as the entrants may be unwilling to accept big sunk costs before the prerequisites for continuation are revealed.

The total factor productivity measure *MTFPa*, suitable for the comparisons among all the manufacturing plants, suggests some substantial differences in the performance level between different groups of plants. Firstly, the big plants seem to have higher total factor productivity levels than the smaller ones. Some reservation should, however, be made. The benchmark cost share of capital input, which were used in deriving *MTFPa* was 29 per cent, that may seem rather low for manufacturing. As we can see in graph 3.1, the income share would give a substantially bigger weight to the capital input than cost share when the assumed real interest rate is 5 per cent.

Alternatively we have defined the interest rate so that the average income and cost share of capital in the manufacturing in the period from 1985 to 1994 are the same — 40.0 per cent. As stated earlier, the implied interest rate is 13.0 per cent, which is used in deriving the *MTFPb* indicator. According to this indicator, the bigger plants have rather lower than higher total factor productivity level. The group of the biggest plants is an exception in this profile but, on the other hand, the number of these plants is very small (see table 4.2).

Secondly, the results shown in table 4.1 (or later in table 4.3) does not prove that the size causes the high total factor productivity level. Plants may be big because they have found a way to use resources in a productive way. The investigation of the effect of size on the productivity level requires more sophisticated analysis for which the panel data in hand provides a good basis.

We find a striking result that the total factor productivity level in the new plants is very high, especially if the assumed real interest rate is 13.0 per cent. This seems to be the case even though most of the new plants are small — at least so far. As table 4.2 indicates, some 67 per cent of the new plants (three years old or less) is having labour less than 20 persons.

One might expect that the performance level of a new plant improves through learning by doing and as the plant-specific skills of the labour force and organisational capital increases. This should be the case especially in the plants of a new and single-unit firm. An essential factor for the high total factor productivity level in the new plants is the relatively low capital intensity level, suggested by both *MCINT* and *ELINT* variable. On the other hand, the total factor productivity indicators overrate slightly the performance level of the new plants in that respect that rental capital is ignored.

The results suggest that the owner matters. The plants that are owned by a firm, where the share of the foreigners is at least 20 per cent are having substantially higher labour and especially total factor pro-

[7] The cost of machinery stock is (interest rate + depreciation)*machinery stock. We assumed here real interest rate as 5 per cent and depreciation of machinery and equipment as 15 per cent.

ductivity level. The interesting issue to be investigated is that are these plants productive because of the foreign owners or are they foreign-owned because they are so productive? Also the plants owned by a multi-plant firm seems to be more productive than the solitary plants, if we use the smaller weights for the capital input but the difference is rather small when the bigger weights are applied.

The total factor productivity seems to be positively related with the export share. If the assumed real interest rate is 5 per cent, the difference in total factor productivity between the most open and the most closed plants is some 11 per cent. If we use a higher real interest rate the difference is smaller.

There seem to be substantial differences in the total factor productivity levels between major regions. The results suggest that resources are used unproductively in the North and East. Total factor productivity is low in the North because of the low capital productivity, which can be inferred from table 4.1 (*LP/MCINT* or *LP/ELINT*).

Table 4.1. Summary statistics at the total manufacturing level, geometric averages from 1990-1994

		LP	*MCINT*	*ELINT*	*RENTINT*	*MTFPa*	*MTFPb*
Size	5-19 persons	1.00	1.00	1.00	1.00	1.00	1.00
	20-99 persons	1.18	1.59	1.37	1.15	1.02	0.97
	100-999 persons	1.54	3.01	4.82	1.42	1.08	0.95
	1000- persons	1.80	3.28	4.66	0.95	1.24	1.09
Age	15- years	1.00	1.00	1.00	1.00	1.00	1.00
	4-14 years	0.94	0.65	0.50	1.10	1.13	1.18
	1-3 years	0.88	0.36	0.25	1.29	1.24	1.38
Owner	Foreign	1.00	1.00	1.00	1.00	1.00	1.00
	Domestic	0.93	1.29	2.83	0.70	0.84	0.81
Firm type	Single-plant	1.00	1.00	1.00	1.00	1.00	1.00
	Multi-plant	1.40	2.06	2.98	0.99	1.11	1.03
Export share,	Closed (0 %)	1.00	1.00	1.00	1.00	1.00	1.00
export/total	Medium	1.12	1.15	0.92	1.49	1.04	1.03
deliveries	Open	1.28	1.63	2.71	1.24	1.11	1.05
Major region	Uusimaa	1.00	1.00	1.00	1.00	1.00	1.00
	Southern Finland	0.86	1.18	2.42	0.53	0.80	0.78
	Eastern Finland	0.80	1.10	2.71	0.32	0.75	0.74
	Mid-Finland	0.87	1.25	3.01	0.37	0.80	0.78
	Northern Finland	1.00	1.84	3.66	0.44	0.77	0.71
	Åland	0.70	0.57	0.52	0.11	0.77	0.82

N.B.: LP = nominal labour productivity level, *MCINT* = machinery capital per hour, *ELINT*= electricity consumption in mwh per hour, *RENTINT* = rents per hour, *MTFPa* and *MTFPb* = total factor productivity. All are presented in relative terms — figures are normalised by setting one group equal to one. All measures are weighted by hours, except *MTFPa* and *MTFPb*, which are weighted by the sum of labour and capital costs. A plant is called foreign-owned if it is owned by a firm where the foreigners' share is at least 20 per cent. The data set is cleaned by using criteria 4.

Table 4.2 illustrates some characteristics of the different groups of the plants. The size seems to be positively related with the age and the export share. Similarly, foreign-owned plants and the plants belonging to a multi-unit firm tend to be big more often than domestic-owned plants or solitary plants. Foreign-owned plants have somewhat bigger export share. As table 4.2 shows, the number of foreign-owned plants is relatively small. On the other hand, the number of foreign-owned plants has steadily increased in recent years. Both the size and age profiles are rather similar in the different major region, excluding Åland. The share of foreign-owned plants is the biggest and the export share is the smallest in Uusimaa (Helsinki and it's surrounding region).

Table 4.2. Summary statistics at the total manufacturing level, averages from the period 1990-1994

		Plant size,%			Age, %			Owner, %	Export share, %	Number of plants per firm	Number of obs.
		5-19	20-99	100-	1-3	4-14	15-	Domestic	Export/ deliveries		
Size	5-19				18	49	33	98	8	2.0	2214
	20-99				9	34	58	94	19	3.1	1914
	100-999				3	17	80	92	42	6.2	725
	1000-				0	5	95	85	59	7.0	23
Age	1-3	67	28	4				96	28	2.0	590
	4-14	57	36	7				96	39	2.2	1642
	15-	33	44	23				95	39	3.9	2644
Owner	Domestic	47	39	15	12	38	50		38	3.0	4668
	Foreign	18	53	29	11	37	51		45	3.2	208
Firm type	Single-plant	56	38	7	14	43	43	86	31	1.0	3530
	Multi-plant	18	43	38	8	25	67	92	42	8.4	1345
Export	Closed (0 %)	63	32	4	14	41	45	98	0	2.8	2494
	Medium	38	48	14	10	37	53	96	3	2.7	773
	Open	21	46	33	10	33	57	92	56	3.6	1609
Major Region	Uusimaa	45	40	15	11	36	54	92	33	3.0	993
	Southern Finland	44	39	17	12	37	50	96	41	4.3	2139
	Eastern Finland	46	40	14	12	42	45	98	36	3.2	552
	Mid-Finland	49	38	13	12	38	49	97	44	2.4	788
	Northern Finland	50	36	14	13	41	46	99	39	3.4	379
	Åland	45	55	0	5	36	60	93	36	1.3	26
TOTAL		46	39	15	12	37	51	95	41	3.1	4876

The differences in the productivity levels and other related measures between different groups, visible in tables 4.1 and 4.2 may reflect differences in the industry structure. To evaluate differences in the technology levels or differences in the ability to utilise production potential, comparisons are more meaningful when carried out at a more detailed industry-level. To control the industry-mix effect, the comparisons are made at the 3-digit industry-level. As above, the data set is cleaned by using criteria 4. In addition, only those industries were included, which had at least 15 observation (25 or 26 industries depending the year). The comparisons for each industry are made in a similar manner than at the total manufacturing level. We took a geometric average (weighted by valued added) from the industry results. This procedure was repeated for each year in the period from 1990 to 1994. Finally for each variable we took a geometric average from the period and these results are reported in table 4.3.

For the purpose of exploring the relationship between the size and performance we first sorted the plants in each 3-digit industry by the number of persons into three groups: (relatively) small, medium size and large plants.[8] Those plants that are relatively small in their 3-digit industry tend to have lower total factor productivity level than among medium-sized and large plants, when the assumed real interest rate is 5 per cent. On the other hand, if the real interest rate is assumed to be 13.0 per cent, the differences are negligible.[9]

The findings concerning the age differ in some respect from the ones obtained at the manufacturing level. The differences in the labour productivity in respect of age vary less at the 3-digit level than at the total manufacturing level. The relative capital intensity in the middle aged plants seems higher at 3-

[8] This was, of course, repeated for each year in the period under study.

[9] The lowest limit for small plants was 9 persons (in the manufacture of leather and products of leather etc. in 1992 and in the manufacture of furniture and fixtures, except primarily of metal in 1993 and 1994) and the highest limit was 93 persons (in the beverage industries in 1991).

digit level than at the total manufacturing level, when measured by machinery stock. Furthermore, both the new and middle aged plants seem to have relatively higher capital intensity at 3-digit level, when the capital intensity is evaluated on the basis of the electricity consumption (see tables 4.1 and 4.3). In other words, it seems that the old plants tend to operate in those industries where the labour productivity and capital intensity are relatively high. The relative total factor productivity level of the old plants seems slightly higher when evaluated at 3-digit level than at the total manufacturing level, but it is still considerably lower than in the newer ones.

By comparing tables 4.1 and 4.3 it can also be concluded that industry structure of the domestic-owned plants is favourable for labour productivity. An explanation for this seems to be that domestic-owned plants tend to operate in such industries where capital intensity is high. When the domestic and foreign-owned plants are compared at 3-digit level, the labour productivity gap is bigger in favour of foreign-owned ones and the difference in the capital intensity is smaller than at the total manufacturing level. The gap in the total factor productivity narrows slightly. Similar kinds of findings can be made also when the solitary plants are contrasted with the plants of multi-unit firms. The differences in the labour productivity and capital intensity are substantially smaller, when evaluated at 3-industry-level than at the total manufacturing level.

To study the importance of export on the performance at the 3-digit level, we sort the plants in each year and in each 3-industry into two groups by export share: those whose export share is at median level or less (relatively closed) and those whose export share is bigger than the median of the 3-digit industry in that year (relatively open). The results are reasonably in line with the ones obtained earlier at the total manufacturing level.

The differences in the total factor productivity level between different major regions are smaller at 3-digit than in the total manufacturing level. In the latter case, for example, the labour productivity of the plants that locate in the North seems rather high and the capital intensity very high.[10] When the industry-mix effect is controlled by making comparisons at the 3-digit level, the results change considerably. The relative labour productivity as well as the relative capital intensity of the plants in the North decreases substantially. The relative total factor productivity in turn improves to some extent, but it is still clearly lower than in the South.

Maliranta (1997) investigated the importance of the changes in the plant structure for aggregate productivity growth. In turned out that micro-structural changes play an important role in the evolution of manufacturing sector. The structure within a plant may in turn explain some of the differences in the productivity growth rates or productivity levels between the plants. Thus the micro-micro-structural factors should be taken account, too.

It is generally believed that an increase in the degree of 'outsourcing' of service inputs by manufacturing plants is a characteristic feature in the process of industrialisation. Services can be divided into two groups: industrial and non-industrial. The former includes such activities as repair and maintenance and the latter comprehends legal and accountant's charges, advertising etc.[11] The labour productivity level of a plant may be low if a large share of its labour force is dealing with service activities, where the value added per labour input ratio may be low. However, one of the reasons why the labour productivity is low in the service activities is that capital intensity is low. Thus we might expect that extensive outsourcing of services and relatively high capital intensity are related with each other. The use of total factor productivity measure as an indicator of the performance level alleviates the problem.

We construct two measures of outsourcing; one focus on all services and another on non-industrial services. We measure how much services per labour input is acquired from the outside of a plant. As a

[10] When evaluated by machinery stock or electricity consumption per labour hour.

[11] Census value added concept, which is applied here, is a devicient indicator in a sense that the non-industrial servises are neglected.

nominator we use acquired net services that are measured after deduction of the receipts from services. The labour input is measured here by total labour costs, similarly as Caves et al. (1990) and Yoo (1992). The outsourcing variables are measured as follows:

OUTSOURC1=(costs of industrial services + costs of non-industrial services - receipts from industrial services - receipts from non-industrial services)/labour costs;

OUTSOURC2=(costs of non-industrial services - receipts from non-industrial services)/labour costs.

In other words, if a plant produces more services to outside than it acquires from outside, it is service intensive and it has negative value of 'outsourcing' variable.

The level of outsourcing may be heavily dependent on the industry and for that reason the effect of the outsourcing is natural to explore at industry-level. We divide the plants of each 3-industry in each year into three equal sized groups; high outsourcing, medium outsourcing and low outsourcing. Table 4.3 suggests strongly that the level of outsourcing is associated with performance level. There is a substantial gap in the labour productivity between the plants most and least service intensive. As expected, the gap is more moderate when measured by the total factor productivity indicator, but the gap is considerable anyhow.[12]

Our data set contains information on the number of females in the plants and of the amount of domestic and foreign input. This provides an opportunity to assess, how the female share (female/total number of persons) and the share of the imported input (imported raw material per imported plus domestic raw material) is related with the performance of the plant. Both ratios vary considerably between different industries. For example, the female share is big and import share is small in the food industry, but in many metal industries the ratios are reversed. For that reason we have classified the plants in each year within each 3-digit industry into three equal sized groups; those having (relatively) small, medium and large share of female or imported input.

The relative performance level seems to be high among those plants that have either large male share or especially large female share. Those plants that have relative female preponderance have an average labour productivity level but as they have low capital intensity (measured by electricity or machinery stock) their capital productivity and total factor productivity are high.

The results concerning the performance level of the plants that use relatively large amount of imported raw materials are more ambiguous. Those plants have high labour productivity level, but as their capital intensity is also high, the relative total factor productivity performance is dependent on how much weight is put on the capital input.

[12] We have also measured outsourcing by service input to total intermediate input ratio. The importance of outsourcing for performance level is studied similarly than with other measures. The performance level is positively associated with the level of outsourcing especially in the 90's although the relationship is not as strong as with *OUTSOURC1* or *OUTSOURC2* variable. However, the explanatory power of our third measure of outsourcing gains more strength in the regression analysis as will be seen later.

Table 4.3. Summary statistics calculated at 3-digit level, geometric averages from the period 1990-1994

		LP	*MCINT*	*ELINT*	*RENTINT*	*ITFPa*	*ITFPb*
Relative size	Small	1.00	1.00	1.00	1.00	1.00	1.000
	Medium	1.10	1.31	1.13	0.99	1.03	0.997
	Large	1.33	2.04	1.60	1.20	1.07	0.996
Age	15-	1.00	1.00	1.00	1.00	1.00	1.00
	4-14	0.99	0.76	0.83	1.13	1.07	1.10
	1-3	0.94	0.34	0.60	1.20	1.21	1.33
Owner	Foreign	1.00	1.00	1.00	1.00	1.00	1.00
	Domestic	0.83	0.97	1.16	0.81	0.86	0.85
Firm type	Single-plant	1.00	1.00	1.00	1.00	1.00	1.00
	Multi-plant	1.20	1.31	1.30	0.93	1.11	1.08
Relative export share	Closed	1.00	1.00	1.00	1.00	1.00	1.00
	Open	1.26	1.46	1.39	1.28	1.16	1.13
Geographical area	Uusimaa	1.00	1.00	1.00	1.00	1.00	1.00
	Southern Finland	0.87	0.90	0.98	0.85	0.90	0.91
	Eastern Finland	0.88	0.86	0.98	0.51	0.91	0.92
	Mid-Finland	0.82	0.78	0.77	0.61	0.89	0.91
	Northern Finland	0.80	0.75	0.93	0.42	0.85	0.88
	Åland	0.80	0.35	0.62	0.34	0.91	0.99
OUTSOURC1	High	1.00	1.00	1.00	1.00	1.00	1.00
	Medium	0.76	0.75	0.82	0.58	0.84	0.86
	Low	0.71	0.60	0.63	0.50	0.82	0.86
OUTSOURC2	High	1.00	1.00	1.00	1.00	1.00	1.00
	Medium	0.79	0.80	0.96	0.67	0.85	0.87
	Low	0.71	0.70	0.79	0.43	0.80	0.82
Period from 1980-1984							
Relative female per total workforce ratio	Low	1.00	1.00	1.00	1.00	1.00	1.00
	Medium	0.95	1.04	0.94	1.18	0.97	0.97
	High	0.99	0.80	0.68	0.94	1.10	1.14
Share of foreign input	Low	1.00	1.00	1.00	1.00	1.00	1.00
	Medium	1.08	1.18	1.18	1.13	1.04	1.03
	High	1.11	1.27	1.18	1.60	1.05	1.03

N.B.: See notes of table 4.1 and text.

4.2 Evolution of relative productivity levels over the time

The geometric averages from the annual results were shown in tables 4.1-4.3. These figures hide some variation in the course of time. Graph 4.1 illustrates the development of the relative *ITFPa* of the small, young, foreign-owned and export orientated plants and those having relatively high outsourcing rate (*OUTSOURC1*). In all cases the other plants are normalised equal to one. The comparisons are made at the 3-industry-level and the observations are weighted by the sum of labour and capital input costs. The geometric averages (weighted by value added share) from the industry results in the period from 1975 to 1994[13] are depicted in graph 4.1.

The graph suggests that the changes in the relative productivity levels were slightly more unstable since the mid 80's than before. There is a downward tendency in the relative productivity level of the small and foreign-owned plants. On the other hand, while the share of the foreign-owned plants has increased substantially, the positive effect of foreign-owned plants on the aggregate productivity has increased although the relative productivity level is decreased to some extent. The labour hour share of

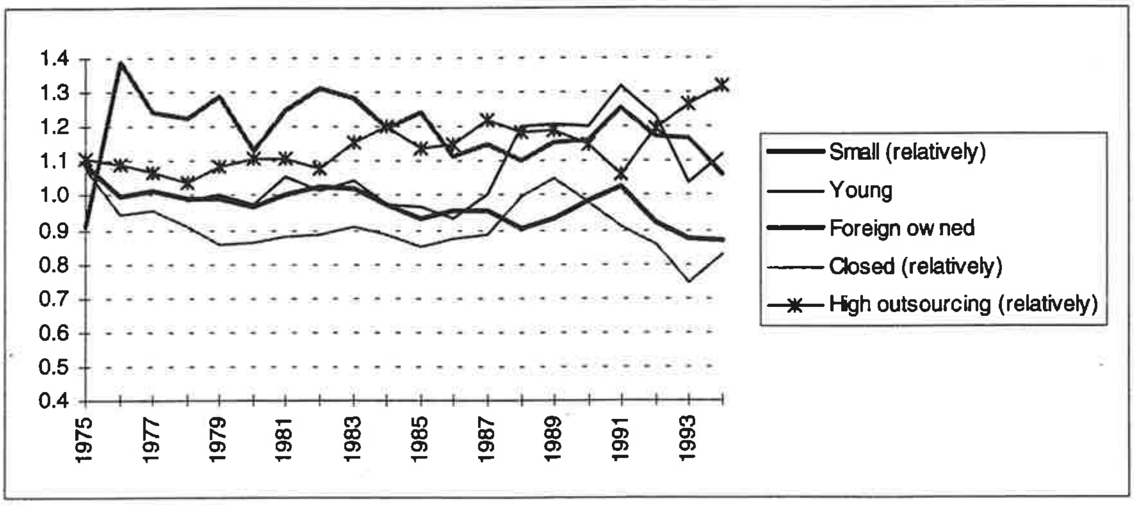
[13] For young plants in the period from 1978 to 1994.

the foreign-owned plants was about 4 per cent of total hours in the mid 80's but it has increased notably till 1994, when the share was 11 per cent in our data set.

The relative total factor productivity of the plants that have high outsourcing rate shows upward tendency in the period from the mid 70's to the mid 90's. Also the extent of outsourcing has increased substantially since the mid 70's. Large scale outsourcing is common for example in the food manufacturing (ISIC 312) and beverage industries (ISIC 313) and relatively small in the metal industries (ISIC 381-385).

There are many similarities among the series exhibited in graph 4.1. Among the small, young and foreign-owned plants the relative total factor productivity was higher in 1991 than for a long time. Then the recession was at severest. As the business conditions began to improve since 1992, the relative performance level seems to have decreased in these groups of plants. A counter-cyclical variation in the total factor productivity level can be explained by a more flexible structure of the factors of production. Especially the new and small, but also the closed plants have relatively low capital intensity level (see table 4.3). As the labour input can be adjusted more flexibly than capital input, the plants having low capital intensity level may perform relatively well in the downward trend. This hypothesis can be investigated by looking the development of relative labour productivity and capital intensity (measured both with machinery stock per hour and electricity consumption per hour).

Graph 4.1. Relative total factor productivity in the manufacturing, measured at 3-digit level, other plants = 1



N.B.: Real interest rate is assumed to be 5 per cent. Criteria 4 are used as a deletion rule. Only those 3-digit industries are selected where the number observation is at least 15 in a given year.

Although the series of the relative total factor productivity exhibited in graph 4.1 bear many similarities, there is a noticeable lack of concurrence in the underlying factors between the different groups of plants (see the graph in the appendix). The relative labour productivity of the small plants shows itself an upward trend in the period from 1988 to 1991 (and in a smaller extent from 1980 to 1982) suggesting possibly that these plants were able to adjust their labour input better than the bigger ones. In the period from 1991 to 1994 the downward trend is even steeper than in the case of the total factor productivity. This is a result of the fact that the capital intensity (measured both with machinery stock and electricity consumption) decreased among the small plants relative to the bigger ones (see the graphs in the appendix).

The development of the relative labour productivity of the young plants, on the contrary, differs significantly from the development of the total factor productivity.[14] The relative labour productivity stayed reasonably constant over the period from 1978 to 1994, but the capital intensity dropped mark-

[14] It should be noted that the group of new plants is, by definition, subject to a continuous renewal.

edly (when evaluated with both measures of capital intensity) in 1988, which explains the relatively high total factor productivity in the turn of the decade. Since 1988 there has been a moderate upward tendency in the capital intensity, which is partly reflected in the decline of the relative total factor productivity level.

The development of the relative labour productivity and total factor productivity of the foreign-owned plants have very similar pattern during the period under investigation. The relative capital intensity has declined slightly in the early 90's.

According to graph 4.1, the relative total factor productivity of the those plants that were relatively closed in their 3-digit industry improved their performance from the mid 80's to 1989. In the late 80's the total factor productivity of the closed plants seems to have been even higher than in the open ones, which is a somewhat surprising finding. One explanation for these results could be that the export prices fell relative to the domestic prices. It seems, that since 1989 the relative total factor productivity of the closed plants declined.[15] This deterioration, in turn, may be a reflection of the changes in the domestic prices in relation to the export prices. In other words, it is probable that graph 4.1 do not indicate accurately the development of relative real performance in this case. Similar kind of pattern in the development of the relative positions was experienced in the second half of the 70's.

Although the relative total factor productivity of the closed plants (as well as the relative labour productivity) rose from the mid 80's to 1989, the relative capital intensity (when measured by machinery stock or electricity consumption) descended till 1991. On the other hand, it started to rise while the relative labour and total factor productivity level were decreasing (see the appendix).

Two indicators of relative capital intensity are shown in graphs in the appendix (and in table 4.1 and 4.3). It seems that the relative capital intensity of the small and the new plants at industry-level is lower when evaluated with PIM estimate of machinery capital than with electricity consumption since the late 80's. If the new plants had some capital before they appeared for the first time in our data set, it is possible that the relative capital intensity of the new plants is underrated, when measured with a PIM estimate. Consequently, the relative performance level the new plants may be overrated to some extent. It is worth noting that probably this is not a problem in the period from 1975 to 1984 as the initial level of capital stock is estimated with the help of fire insurance value. Secondly, we may conclude from the third graph in the appendix that the total factor productivity performance of the foreign-owned plants would appear even higher when evaluated with the electricity consumption instead of PIM estimate of machinery capital.

Next we explore the development of productivity variation among the plants in the course of time. In the competitive environment, the permanently inefficient plants disappear unless they are not able to improve their conduct. As such factors as the technology, the quality of capital input and labour input are not taken into account in our measure of productivity, the differences in the productivity levels do not reflect solely differences in the ability to utilise production potential. In other words, the efficiency differences are ignored.

We have calculated each plant's logarithmic labour productivity difference to the manufacturing or 4-digit industry average (weighted by hours) for each year during the period from 1975 to 1994. This is done by applying the following formula for each year and — when measuring at the industry-level — for each 4-digit industry:

$$\textit{Logarithmic productivity difference} = \ln\left(\frac{NVAL_i}{HOUR_i} \Big/ \frac{\sum NVAL_i}{\sum HOUR_i} \right),$$

[15] The pattern of the development of relative labour productivity among the closed plants is quite similar with the total factor productivity.

where *NVAL* is nominal valued added, *HOUR* is the number of hours. *NVAL* and *HOUR* are summed over the total manufacturing or over the 4-digit industry for each year.

The calculations are performed for all plants meeting the criteria 4. When differences are measured at 4-digit level, we have chosen only those industries having at least 5 plants. Separate calculations are carried out for the plants that have at least 50 persons.

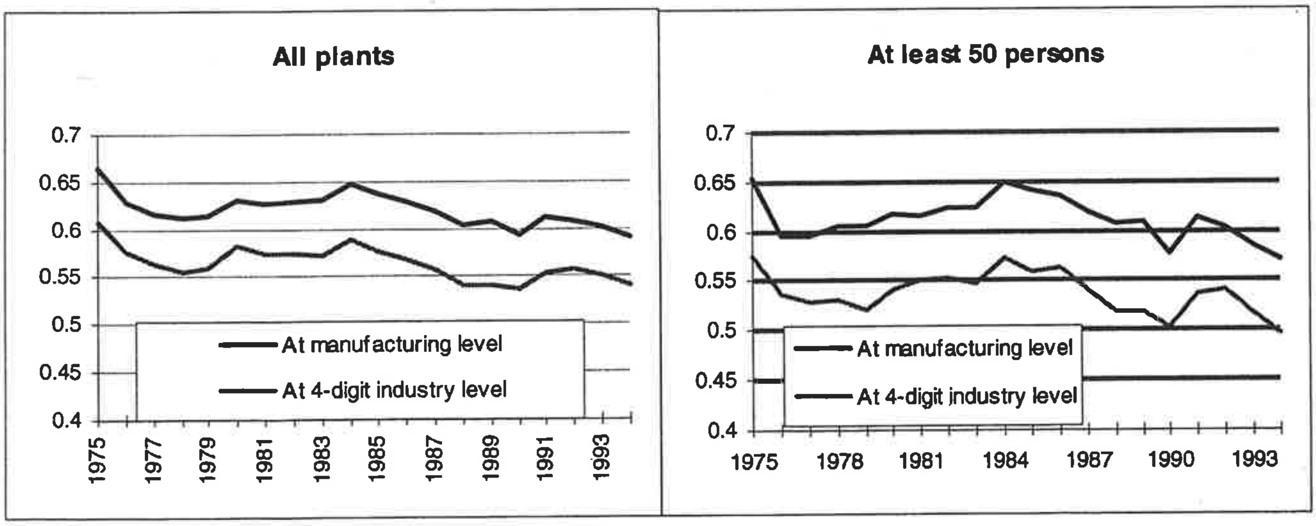
To assess the variation of productivity differences, we have taken standard deviation from logarithmic productivity differences and the results are shown in graph 4.2. The series gives quite agreeable picture on the development of labour productivity differences. The variation in the labour productivity differences began to diminish since 1984 and this tendency was interrupted temporarily by the recession in the early 90's. This tendency may be an indication of the diminishing inefficiency and/or technology differences among the plants. Another potential explanation for this development is the reduced variation of capital intensity levels.[16]

For that reason we have also investigated the productivity differences also with the total factor productivity indicator. Each plant's productivity difference to the manufacturing and industry average is calculated in the similar manner than above with labour productivity, but now the nominal total factor costs (labour costs + capital costs) are used as a weight instead of hours.

For one thing, graphs 4.2 and 4.3 reveal that the productivity differences are notably smaller when measured by the total factor productivity than when measured with the labour productivity measure. This is the case, as may be expected, especially when studied at the total manufacturing level, but single indicator seems to clearly overrate the differences in the performance levels also when applied at the 4-industry-level. Graphs 4.2 and 4.3 illustrate also that the variation in both labour productivity and total factor productivity is smaller among the bigger plants than in the smaller ones.

Graph 4.3 demonstrates that also the variation of the total factor productivity levels abated considerably during the second half of the 80's. As recognised with the labour productivity measure, the productivity variation expanded during the recession. As graph 4.4 points out, the variation in the total factor productivity levels is lower among the big plants, but the variation is more sensitive to the changes in the business conditions. Probably this is a reflection of a more inflexible production structure.

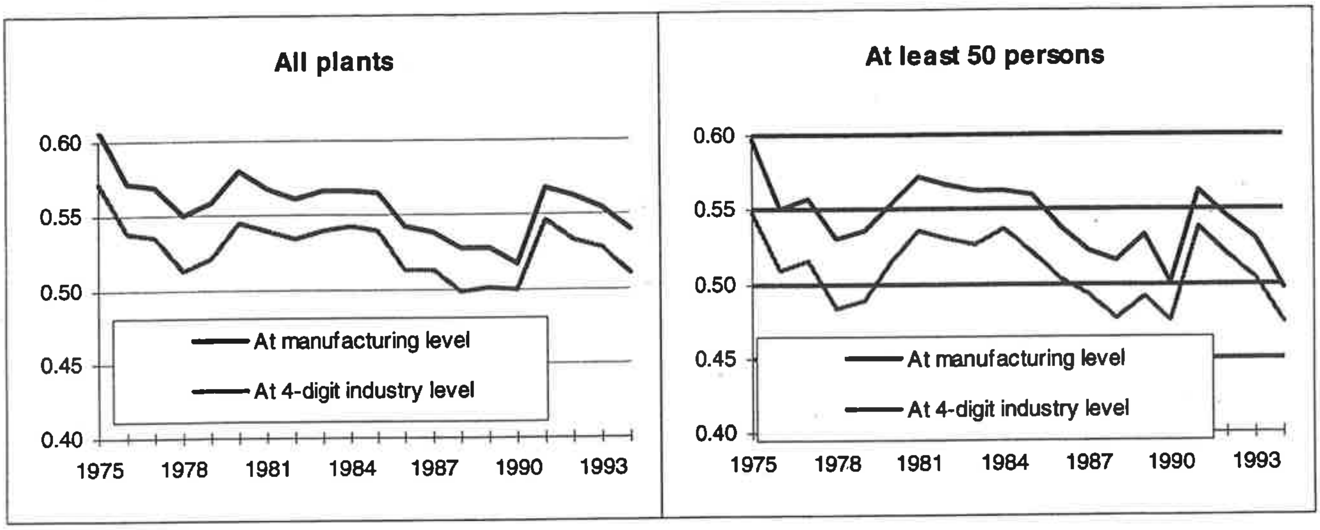
Graph 4.2. Standard deviation log-differences in the labour productivity levels at the total manufacturing and 4-digit industries



N.B.: The productivity difference of a plant is measured as a log-difference to the manufacturing or industry average (weighted by hours).

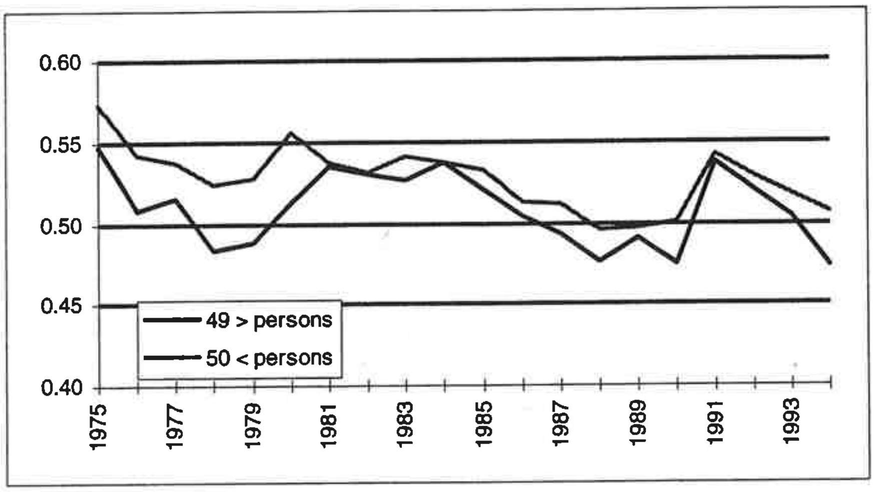
[16] It is also possible that there has been convergence in the price levels.

Graph 4.3. Standard deviation of log-differences in the total factor productivity levels within total manufacturing and 4-digit industries



N.B.: The total factor productivity difference of a plant is measured as a log-difference to the manufacturing or industry average (weighted by total costs).

Graph 4.4. Standard deviation of log-differences in the total factor productivity levels at 4-digit level



N.B: See notes of graph 4.3 and text.

An alternative way to assess the development of technical inefficiency is to measure the share of an input type, that is used in the (very) inefficient plants. Here we define a plant as inefficient, if its productivity level falls below half of the weighted average productivity level in its 4-digit industry group and very inefficient if the level of productivity falls below one fourth of the industry average.

Firstly we study the development of the inefficiency with the relative labour productivity measure. We pick out those plants that meet the criteria 4. Furthermore, we accept those 4-digit industries, that has each year at least 5 observations. Then we calculate the labour input share of the inefficient and very inefficient plants from 1975 to 1994.

A quite similar pattern of the development comes into sight with the analysis of the share of the inefficient plants as when we studied the variation of productivity levels (see graph 4.5). An apparent downward tendency can be found with relative labour productivity measure since the mid 80's until 1990. In the early 90's the share of the (very) inefficient plants increased.

We evaluate the evolution of the inefficiency by using the total factor productivity measure in a similar manner. For each 4-digit industry and each year we calculate an average total factor productivity level (weighting by the sum of plant's labour costs and capital costs). Then we calculate the labour input share, capital input share and electricity consumption share of the plants that have less than one half (inefficient plants) and less than one fourth (very inefficient) of the industry average.

Again we secure some evidence that the inefficiency moderated in the second half of the 80's and that the recession increased the inefficiency (see graph 4.6). The capital input share of the inefficient plants, in particular, rose sharply during the slow-down, which is understandable as the adjustment of owned capital is more difficult than the labour input.

It can be inferred from graph 4.6 that the capital intensity is on average higher than among the inefficient plants and among the very inefficient plants in particular. As it seems, the relative capital intensity of the inefficient plants increases sharply as the recession hits. The state of affairs is retrieved as the capital input is managed to adjust or as some of the inefficient plants disappear.

There are two potential explanations why the average capital intensity among the (very) inefficient plants increases during the recession. The average capital intensity among the (very) inefficient plants may increase due to the changes in the plant composition. This may be the case, if the plants having capital intensive production technologies become inefficient more typically than the ones that use the labour intensive technologies.

Secondly, as our measure of capital input does not account the intensity of the actual usage of capital stock, it can be argued that the expansion of the inefficiency — in strictly technical sense — will be overrated during a recession. This is the case, when the slow-down hits plants differently and consequently the variation in the plants' utilisation rates of capital input increases. A plant may appear inefficient when the output has fallen because of the decline in the demand, but the capital stock has not been adjusted correspondingly. A plant may be able to adjust better the labour input by lowering the average annual working hours or by reducing the number of employment and consequently the capital stock per hour may increase. On the other hand, if it may be expected that the fall in the demand is temporal it may be rational to hoard labour input.

As there is no need (or possibilities) to hoard electricity we may assume that the short term change in the electricity consumption is a reasonable proxy for a change of the machinery hours. For that reason electricity consumption measure is useful, when one wish to judge whether a compositional change or exceptionally low utilisation rate among the inefficient plants may explain the increase in the capital stock per hour ratio among the (very) inefficient plants.

As graph 4.6 illustrates, the share of electricity and labour hours has accorded reasonably closely with each other till 1992 among the inefficient plants and till 1991 among the very inefficient plants (the years 1982 and 1983 are the exceptions to the rule). In other words, the electricity consumption per hour does not differ substantially between inefficient and 'efficient' plants. That the capital stock share has been regularly somewhat higher than the shares of more flexible factors of production — electricity and labour — may be an indication that some of the plants are inefficient because they have underutilised the machinery stock in that year.[17]

The finding that the share of the capital stock increased more than the electricity consumption in the early 90's suggests, in turn, that the increase of the inefficiency discernible in graph 4.6 tells more about the lowering relative utilisation rates among some plants than about the rise of inefficiency in strictly technical sense. The share of the electricity consumption and the share of the machinery stock in particular rose considerably more than labour input share among the very inefficient plants in 1992. Thus, the very inefficient plants had relatively large amount of machinery stock per hour and, in addi-

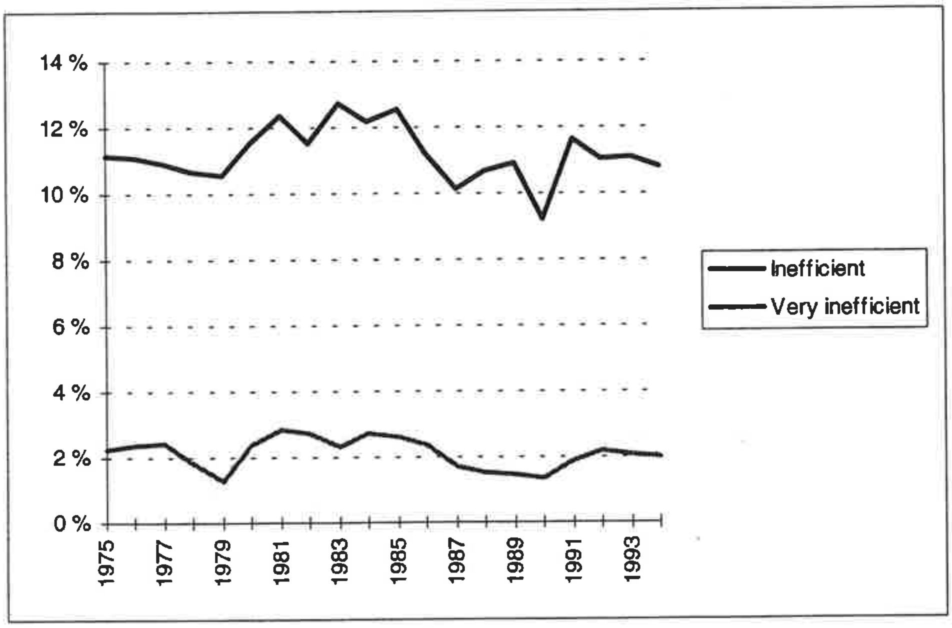
[17] Furthermore, this finding may reflect the inaccuracy of machinery stock estimate. Some plants may appear inefficient in the light of *TFP* indicator as their machinery stock is overestimated.

tion, used a lot of electricity per hour in 1992. Possibly those plants were locked into the capital intensive technologies.

The share of the electricity consumption declined markedly since 1992 and the labour input share remained quite stable. The inefficient plants had very low electricity consumption per hour ratio in 1994. Also the machinery stock per hour ratio was exceptionally low at that time. Generally, it seems that the characteristics of the (very) inefficient plants are different in 1994 than earlier and in the early 90's in particular.

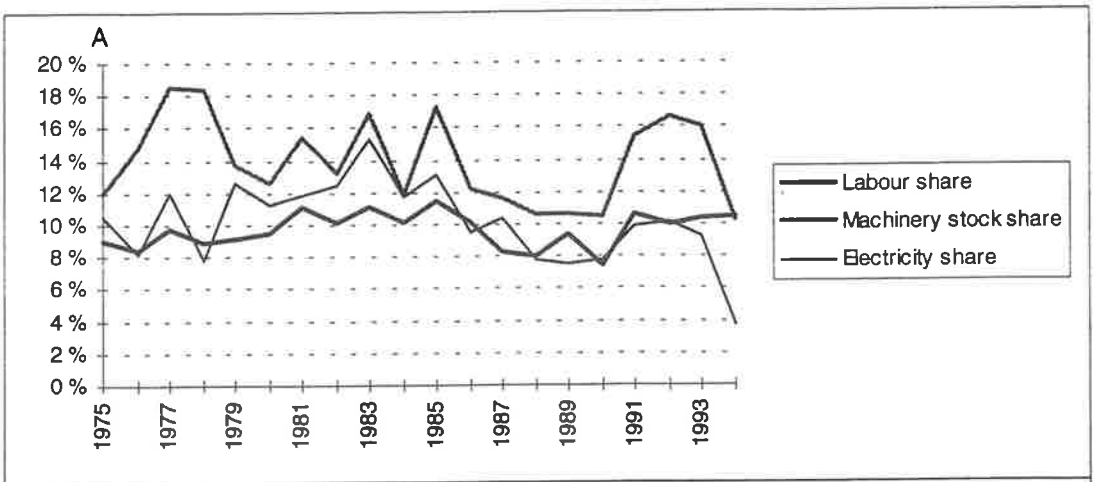
A part of the short-term variation in the extent of the inefficiency when measured with total factor productivity indicator is clearly associated with the fact that capital stock cannot be adjusted abruptly and the extent of the required adjustment varies between plants. This notion is in line what can be suspected when graphs 4.5 and 4.6 are compared; the increase of inefficiency is not as outstanding when evaluated with the relative labour productivity measure than with the relative total factor productivity indicator. On the other hand, also the labour productivity measure suggests an increase of the inefficiency during the slow-down, which may indicate the labour hoarding.

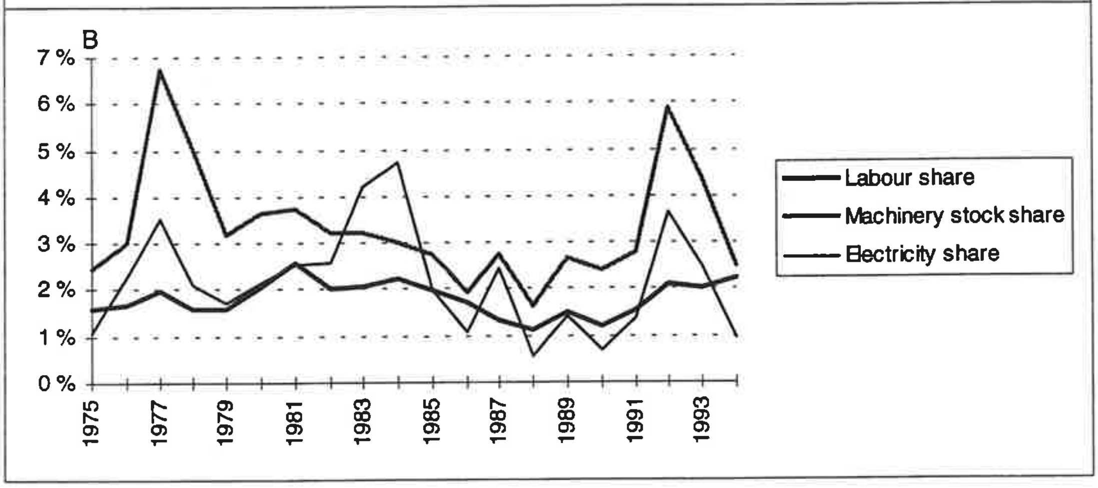
Graph 4.5. Labour input share of the inefficient and very inefficient plants, measured by relative labour productivity indicator



N.B.: Measurements are made at 4-digit level. Those industries are included, that has each year at least 5 observation. See text.

Graph 4.6. The shares of the inefficient plants (A) and very inefficient plants (B), the inefficiency is defined with *TFP* indicator





N.B.: The inefficiency of a plant is determined at 4-digit level. Those industries are included which have each year at least 5 observation. See text.

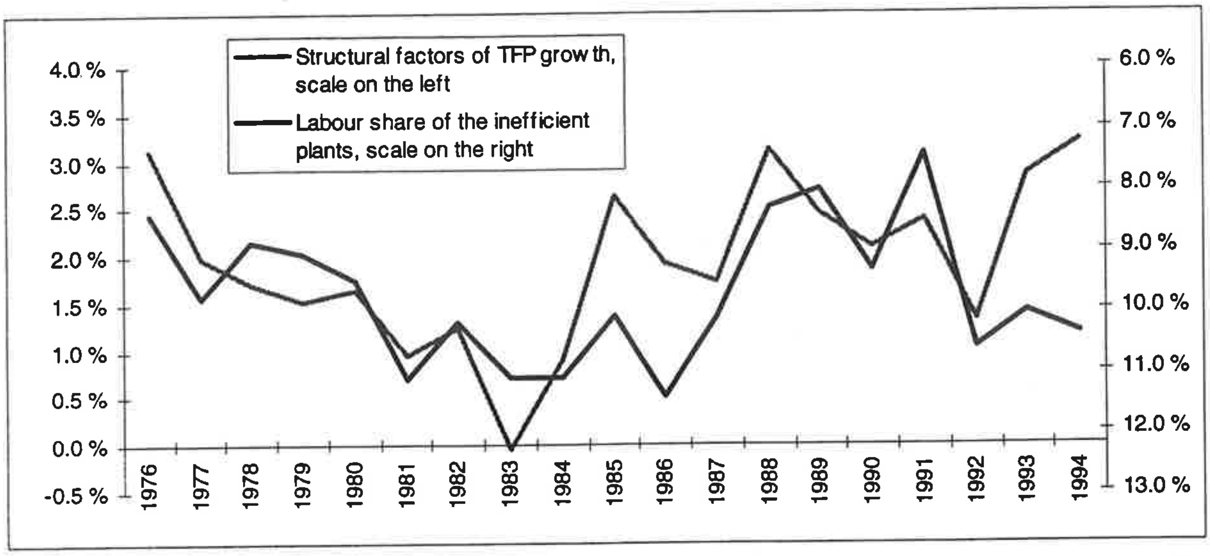
As it was demonstrated in Maliranta (1997), the entry-exit process and the reallocation of resources among stayers have effect on the aggregate productivity development. Furthermore, the contribution of these micro-structural factors has varied during the time span. Quite interestingly, graph 4.7 points out that the contribution of micro-structural factors on the annual *TFP* change and the inefficiency — when measured in a simple way as in graph 4.6 — are closely related with each other. The connection is not, however, quite uniform over time. There seems to be a some kind of structural break in 1983 and therefore a correction is made to graph 4.7. The labour share of the inefficient plants graphed below show the amount of the inefficiency in the year in question from 1976 to 1983, but a lagged measure is used since 1984.[18]

After this adjustment of a structural break in 1983, there seems to be both medium and short-term tie between the extent of the inefficiency and the contribution of micro-structural factors. While the inefficiency increased from the mid 70's to early 80's also the contribution of the micro-structural factors diminished. The decrease of the inefficiency till early 90's was concomitant with the increase in the importance of the structural factors. A more detailed investigation reveals that also the so-called share effect (see Maliranta, 1997) and the extent of the inefficiency is associated with each other. This means that when the extent of inefficiency is low, the positive effect of the re-allocation of input shares for the total factor productivity growth at aggregate level is high. It seems reasonable to expect

[18] Thus, the amount of inefficiency in 1983 is used twice in graph 4.7.

that both the contribution of the micro-structural factors and the extent of inefficiency are affected by same factors, like the traits of economic environment.[19]

Graph 4.7. Contribution of micro-structural factors on annual *TFP* growth and inefficiency of plants



N.B. The annual contribution of micro-structural factors is obtained from Maliranta (1997). The inefficiency is measured by the labour hour share of those plants, whose total factor productivity level is less than 4-digit industry average (see graph 4.6). For the period from 1984 to 1994 we have used the lagged shares.

4.3 Towards more detailed analysis of productivity differences

The previous descriptive exploration indicated several points that should be considered when an econometric model for the analysis of productivity and (in)efficiency is constructed. A great variety of potential explanatory factors of productivity were identified like size, age, ownership, composition of labour force, outsourcing and geographical location are associated with a plant's relative productivity performance. The investigation demonstrated that these factors are linked to each other. In other words, there are multicollinearity that may be a problem, if the number of observations is small. This aspect seems to suggest that one should use comprehensive data sets consisting of a large number of different plants.

On the other hand, the dependence between different factors may vary substantially between different industries or between other groups of plants. A factor, which is advantageous for productivity somewhere may be irrelevant elsewhere. For example, the effect of the age on the productivity may be different among the small plants than among the large plants. An interesting issue to be investigated is how the effect of age differs between different kind of industries or clusters. One might expect that plant age is relatively important when organisational capital plays an essential role. In those industries or clusters, where the technology transforms rapidly the role of the age may be of minor importance. Thus the productivity should be analysed also at a more specific group of plants.

The longitudinal data sets expand considerably the possibilities to analyse the plant productivity. The number of observations is multiplied, as we have information from several points of time. This increases the possibilities to carry out the analysis among reasonably homogeneous groups of the plants. The incorporation of time aspect, however, involves additional problems. As we saw in graph 4.1 the relative productivity levels seem to be different in different time periods. Different kind of periods can be distinguished in the Finnish manufacturing. In the period from 1985 to 1987 the relative total factor

[19] This issue is discussed for example in a report of the Conference Board (Summer 1997). The evidence from the US manufacturing suggest that a sector is more prone to the intesive restructuring at the times of recessions. Furthermore, it seems that reallocations at micro-level play a role in explaining fluctuations in growth rates.

productivity of the closed and the new plants was lower than in the period from 1988 to 1991. Also the relative productivity level of the small plants and foreign-owned plants increased during the latter period.

In addition, also the dispersion in the labour and total factor productivity levels declined as well as the input shares of the inefficient and very inefficient plants. The input shares were at a low level till 1990 among the inefficient plants till 1991 among the very inefficient plants. The period since 1991 or 1992 is the period when the relative total factor productivity declined among small, new, closed and foreign-owned plants and when the inefficiency seems to have alleviated in the Finnish manufacturing.

5 Regression analysis of productivity differences

5.1 Applied approaches

To explore the characteristics of the high productivity plants or to find some explanations for the variation of the relative productivity levels between plants, we have run several regressions by using total factor productivity measure, that is constructed at the NA industry-level, as a depend variable. In other words, we use *ITFP*-indicators. This kind of approach, where a total factor productivity indicator is used as a dependent variable is applied for example in Baily et al. (1992) and Baltagi et al. (1995).

First two models in table 5.3 are estimated with a pooled regression. Although we have used a wide range of variables to control differences between plants, there is a bulk of unobservables of a permanent nature — like the quality of management, the quality of technology and so forth — that may create an omitted variable problem and hence bias the estimates. For that reason we have also incorporated a plant-specific term into the model. In the so-called fixed effect model this term (α_i) is treated as a fixed constant over time. Alternatively, we may treat the plant-specific effect as a random variable. In this case the residual term consists of two components:[20]

$v_{it}=\alpha_i+u_{it}$,

where u_{it} is the traditional disturbance term. This kind of models can be estimated by maximum likelihood method (ML).

On the contrary to the fixed effect model, in the random effect model we have to assume that unobservable plant-specific characteristics are not correlated with other explanatory variables in the model. This may be an unreasonable assumption as pointed out by Mundlak (1978). Random variable (α_i) may reflect for example unobservable managerial ability. Plants with high quality management tend to produce more output and use more inputs. In this situation plant-specific random term and inputs cannot be independent. Fixed effect model is based on the within group variation, in other words, it is based on the deviations of original observations from the individual plant means. This is equivalent to including plant dummy variables in the regression equation — this is called least-squares dummy-variable approach (LSDV). This is the method applied here.

An advantage of fixed effect model is that the independence assumption of the unobservable traits of plant and other explanatory factors is not required. The problem with this method is that as it is based solely on the within variation, the plant attributes that have relatively little variation over time like capital stock or (foreign) ownership cannot be estimated efficiently. At the extreme are such time-invariant but important factors like location for which LSDV estimator cannot be computed at all. There is another weakness in the fixed effect method. While all the cross-sectional information of data — which accounts typically for most of its variability — is discarded, measurement errors inherent in this kind of data tend to have a greater dominance in the remaining variation.

To check the robustness of our results obtained with the total factor productivity indices we also use a somewhat more common approach, where a certain type production function is estimated. In the complementary analysis we use Cobb-Douglas and translog-specification.

[20] It would be possible to include also a time-specific term λ_t term. This possibility is not, however, applied here.

5.2 Description of variables and some descriptive statistics

A wide set of variables is used to explain total factor productivity measures ln(*TFPa*) and ln(*TFPb*) (see table 5.1).

Table 5.1. Description of variables used in the regression models

Spillover	
$FIRMTFP_{it}$	The average *TFP* of other plants in the same firm that operate in the same 4-digit industry than plant *i* in *t*, weighted by the sum of labour and capital costs.
$REGIONTFP_{it}$	The average *TFP* of other plants operating in the same region and in the same 4-digit industry than plant *i* in *t*, weighted by the sum of labour and capital costs.
$REGCONC_{it}$	Value added of other plants than *i* in the same region and in the same 4-digit industry per total value added in Finland in the 4-digit industry in question.
$MULTI_{it}$	Dummy variable, indicates the plants that belong to a multi-plant firm
Exposure to the global competition	
$EXPORT_{it}$	Export per total deliveries
Time and periods	
TREND	Time trend
$P8790_{it}$	Dummy variable, indicates the period from 1987 to 1990
$P8892_{it}$	Dummy variable, indicates the period from 1988 to 1992
$P91_{it}$	Dummy variable, indicates the year 1991
$P92_{it}$	Dummy variable, indicates the year 1992
Age or vintage effect, etc.	
$YOUNG_{it}$	Age < 4 years
OUT_{it}	Dummy variable, disappears within two years
Rented capital and new investments	
$RENTSH_{it}$	Total rents per machinery and equipment stock (measured by PIM)
$MINVSH_{it}$	Machinery investments in year *t* per machinery stock in *t*
$MINVS12SH_{it}$	(Machinery investments in year *t*-2 * $(0.85)^2$ + machinery investments in year *t*-1 * 0.85)/machinery stock in *t*
Foreign ownership	
$FOREIGN_{it}$	Dummy variable, at least 20 per cent of the firm is owned by foreigners
Relative size	
$MEDIUM_{it}$	Dummy variable, indicates the relatively medium-sized plants, see text
$LARGE_{it}$	Dummy variable, indicates the relatively large plants, see text
Outsourcing	
$OUTSOURC2_{it}$	(Costs of non-industrial services - receipts from non-industrial services)/labour costs.
$OUTSOURC3_{it}$	Costs of non-industrial services per total costs of intermediate inputs
Working hours and labour composition	
$AVHOURS_{it}$	Hours per person, in thousands
$NONMANUS_{it}$	Non-manual workers per total labour force
$FEMALESH_{it}$	Females per total labour force

Table 5.2 gives some picture on the characteristics of plants in the Finnish manufacturing. One fifth of the plants belonged to a such firm, which had also another plant that operated in the same 4-digit industry. A small number of plants operated in such region, where there were no other plants that oper-

ated in the same 4-digit industry. There is in great numbers of plants that do not export at all. The export share was about 10 per cent at the third quartile, but as some plants export virtually all the production, the average export share was 12 per cent. In most of the plants the rents per machinery capital stock was reasonably low, but the average is rather high because of some extremely big values especially among the small plants. There is a considerable amount of variation in the shares of new vintages of machinery capital that reflects the fact that capital input shares are changing among stayers. The share of less than one year old machinery capital was 16 per cent in the median plant. The average annual working hours was 1720 in our sample of plants in 1989.

Table 5.2. Some descriptive statistics from the year 1989

Variable	N	Mean	Mean, weighted[1]	Std	Q1	Median	Q3
FIRMTFP	920	1.08	1.10	0.55	0.72	1.00	1.32
REGIONTFP	4701	0.98	1.01	0.30	0.78	0.94	1.14
REGCONC	4959	0.12	0.12	0.14	0.03	0.07	0.14
EXPORT	4959	0.12	0.29	0.23	0.00	0.00	0.10
RENTSH	4959	0.17	0.09	1.29	0.00	0.00	0.05
MINVSH	4959	0.23	0.23	0.50	0.02	0.16	0.36
MINV12HS	4959	0.22	0.26	0.37	0.05	0.24	0.41
OUTSOURC2	4959	0.18	0.29	0.43	0.00	0.10	0.25
OUTSOURC3	4949	0.18	0.21	0.22	0.03	0.11	0.25
AVHOURS	4959	1.72	1.70	0.19	1.62	1.73	1.83
NONMANUS	4959	0.22	0.29	0.19	0.11	0.19	0.28

[1] Weighted by hours.

5.3 Estimation results

5.3.1 Analysis with total factor productivity indicator

We have investigated different type of spillover effects with ln(*FIRMTFP*), ln(*REGIONTFP*) and *REGCONC* variables.[21] The coefficient estimates of ln(*FIRMTFP*) variable indicate that a plant tends to have a high productivity level when the other plants operating in the same 4-digit industry and in the same firm are having high productivity (see Baily et al., 1992, 224). This result is maintained also when the unobservable plant characteristics are controlled by plant-specific term.

The plants may derive advantage from locating near with each other (see Krugman, 1991). There may be externalities in the production within a restricted geographical area that brings about increasing returns to scale. The possibility that a plant benefits from the extent of geographical concentration at 4-digit industry-level is evaluated by *REGCONC* variable. This effect could be characterised as an extent aspect of spillovers. We might expect that a plant gains benefit especially from the high productivity neighbours that operate in the same 4-digit industry — the 'quality' of spillovers is assessed with ln(*REGIONTFP*) variable.

The two measures of regional spillovers effect — 'extent' and 'quality' aspect of the concentration — are correlated with each other. In the pooled regressions the extent obtains emphasis. As the plant-specific terms are incorporated into the model, the relative emphasis of the quality of the neighbours increases. According to the fixed effect models, the extent of concentration is negatively correlated with plant's performance. This seems to be the case even when the ln(*REGIONTFP*) variable is not included in the model. Regional spillovers appear to be less important when the depend variable is

[21] We have also included, but not reported, separate intercepts for those plants whose firm do not have other plants operating in the same 4-digit industry and for those plants that operate such region, where no other plants in the same 4-digit industry exist. When the dependent variable is ln(*TFPa*), the variables ln(*FIRMTFP*) and ln(*REGIONTFP*) are constructed by using *TFPa* indicator. When the dependent variable is ln(*TFPb*), these spillover variables are constructed by using *TFPb* variable.

constructed in a way that input shares are agreeable (on average) with the income shares than when real interest rate is assumed as 5 per cent.

It is worth of noticing that the fact that productivity level is generally high in some (southern) regions, is controlled by region dummies or by plant-specific terms in the fixed effect models. Dummy variables for 21 regions are included in the models A to D. The estimates of these variables are generally in line with the findings made in tables 4.1 and 4.3.[22] The plants that locate in the East and North tend to have somewhat lower total factor productivity level even when a wide range of characteristics is controlled. When the dummy variables for regions are dropped out from the model A and B, the coefficient estimate of *REGCONC* variable becomes substantially bigger as well as the coefficient of the ln(*REGIONTFP*) variable. The importance of controlling region can be noted also by comparing the models C with G and D with H.

When ln(*REGIONTFP*) and *REGCONC* are excluded from the model, the *MULTI* variable has both substantially and statistically significant coefficient estimates. However, as can be seen in table 5.3, there does not seem to be substantially significant advantage of being a part of a multi-plant firm after the industry-specific spillover effects within firm and within area are controlled. Similar results for US manufacturing industries were obtained by Baily et al. (1992).

On the other hand, some location may be favourable to some particular industries because of apt operation environment; well functioning transportation, fitting educational institutions, etc. In this case, we may obtain positive estimates for our regional spillover variables even though there exists no spillover between plants. A particular industry may have concentrated in that particular geographical area or may have high productivity in that area because of suitability of that location for that industry. Thus it may be worth of controlling region characteristics in a greater detail in the future.

As noted earlier, the analysis of the effect of the export on the performance involves some obstacles that should be kept in mind when interpreting findings from the regressions. Firstly, the direction of causality may be a problem as it is pointed out by Bernard et al. (1997). Although the exporters are much larger, more capital intensive and more productive than non-exporters Bernard et al. (1997) provides confirming evidence concerning German manufacturing that success leads to exporting, rather than the reverse (see also tables 4.1-3 above). This finding suggests that positive effect of export may be overrated. Secondly, the assumption that exporters and non-exporters share the same prices — implicitly assumed in the measurement of productivity — can be called into question, as stated earlier.

The findings concerning the relationship between export and performance level are somewhat contradictory. The estimates of the pooled regressions suggest that export and performance level are positively related with each other, but as the plant-specific term is incorporated into the model, the results change substantially, referring again possible omitted variable problem. If one interprets plant-specific term as the plant technology effect, this may be an indication that export in itself does not lead high productivity performance, but have to be accompanied by successful technology choice as well. The fixed effect model and random effect model give quite different results. This may, in turn, reflect the fact that the independence between plant-specific random term and explanatory variables is an invalid assumption. The results suggest again, that the exporters performed relatively worse in the period from 1988 to 1990 than at other times. That period can be characterised as a boom and the Finnish currency was exceptionally strong at the time.

We have also studied the performance level of the young plants relative to the older ones. Generally speaking, the findings are in keeping with the ones obtained above. The new plants appear to be particularly strong in the period from 1988 to 1992. When the time trend is allowed to be different for the

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[22] This is the case especially when the spillover variables and concentration variable are dropped out from the model.

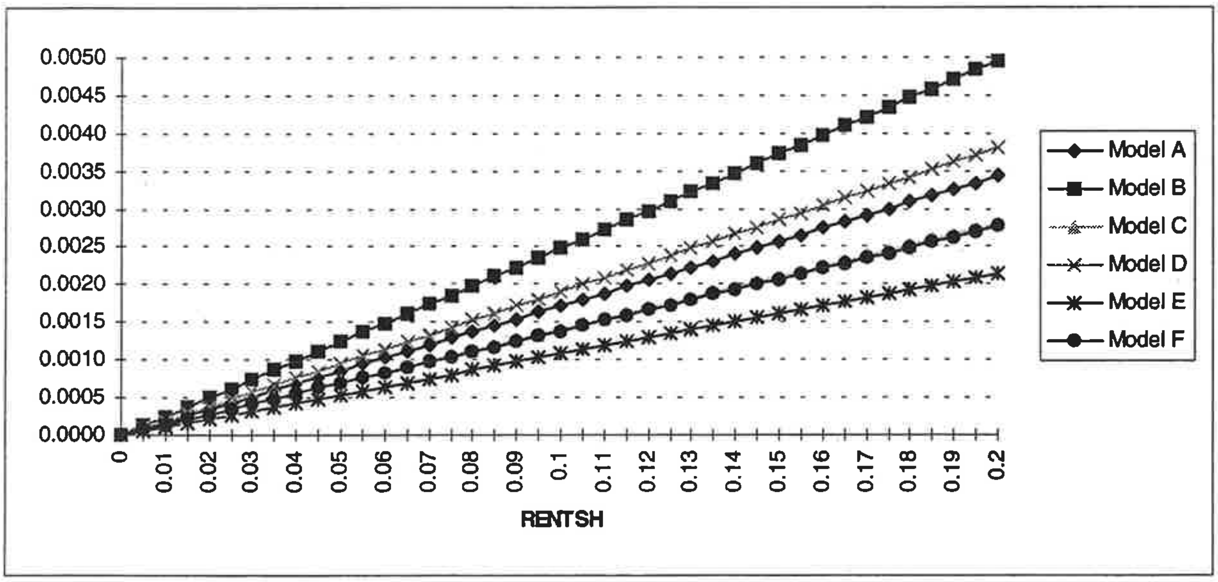
young plants (not reported here), it turns out that the annual growth of total factor productivity is some 2 to 4 per cent faster among the young plants than among the older ones.[23]

It might be expected that different sorts of spillover effects are more important for the young plants than for the older ones. We have used a variety of interactions with the *YOUNG* variable and spillover effects. Generally, the results (not reported here) give some support to the view that spillovers are indeed more important for the young plants than for the older ones. It seems to be beneficial especially for a young plant to be a part of multi-unit firm. In addition, it seems more important for the young plants than for the older ones that the other plants that operate under the same firm and in the same 4-digit industry are having high total factor productivity level. However, the differences between the new and old plants deserve a more comprehensive study.

The plants that are to disappear within two years have substantially lower total factor productivity level than the others, as might be expected. Besides, as we have cleaned our data set and as the disappearing plants often have extremely low productivity (possibly negative value added), the coefficient estimate of variable *OUT* may be substantially underrated.

There are some defects in our measure of capital. For practical reasons, the capital is proxied by machinery and equipment stock. Our measure also ignores the rented capital. *RENTSH* variable, which is total rents per machinery and equipment stock, aims to correct the former deficiency. The results indicate that rented capital is statistically significant, but as expected, substantially rather insignificant factor (see graph 5.1).

Graph 5.1. Relationship between *RENTSH* and ln(*TFPa*) or ln(*TFPb*) according to the regression estimates



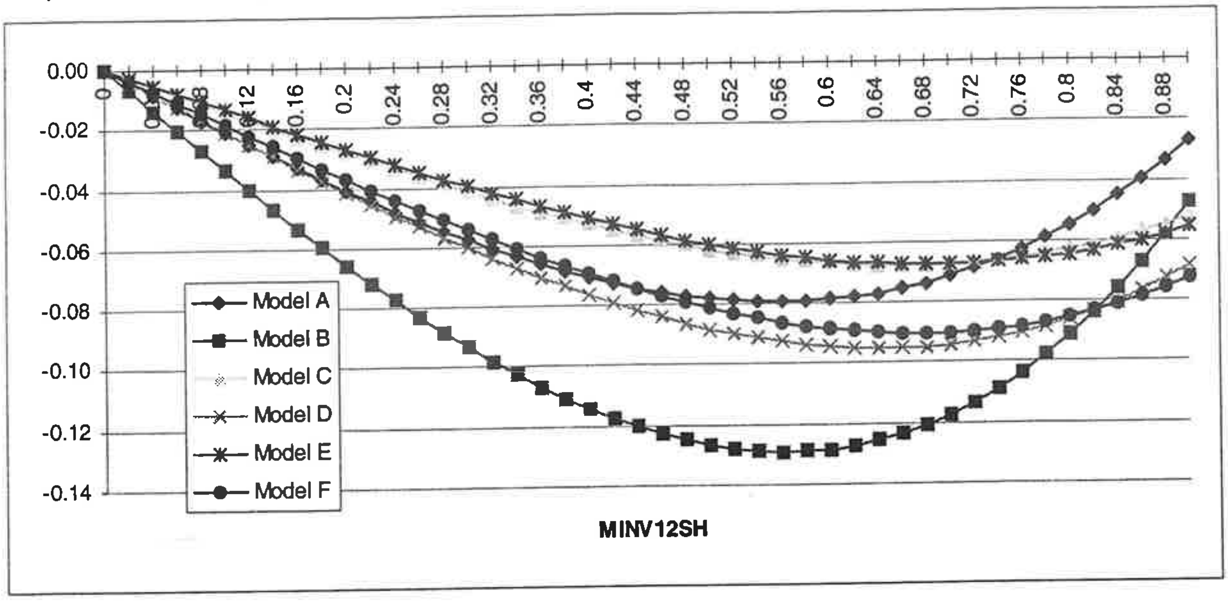
N.B.: The form of the function can be seen in table 5.3.

For various reasons it may take some time before a purchase of new capital increases the actual production potential. Consequently, the plant that had made recently a major investment may appear temporarily inefficient. In the following years the efficiency of capital input usage may improve due to learning by doing, for example (see for example Doms, 1992; Liu, 1993 and Bahk et al., 1993). To adjust this possibility we have constructed variables that measure the share of new machinery and equipment capital: *MINVSH* (less than one year) and *MINV12SH* (one and two years old capital). The results suggest that it takes more than two years before new capital is fully exploitable. According to the results exhibited by graph 5.2, the plants where the share of one and two year's old machinery

[23] It should be kept in mind that the performance level of the new plants may be overrated to some degree because of possible underrating of the capital input, as alluded in section 4.2.

capital accounts one half have some 6 to 13 per cent lower total factor productivity, when compared with the plants that do no have new capital at all.

Graph 5.2. Relationship between *MINV12SH* and ln(*TFPa*) or ln(*TFPb*) according to the regression estimates



N.B.: The form of the function can be seen in table 5.3.

We gain some further evidence that the foreign-owned plants are more capable of using their resources productively. This seems to be the case especially, when the pooled regressions or random effect models are applied. Fixed effect models, in turn, provide some, but statistically rather weak support to the view that foreign ownership is positively associated with a high performance level. As this issue is important for policy considerations, for example, the importance of foreign ownership for the performance deserves a more detailed analysis in the future. In the same context, also the demographical events should be controlled.

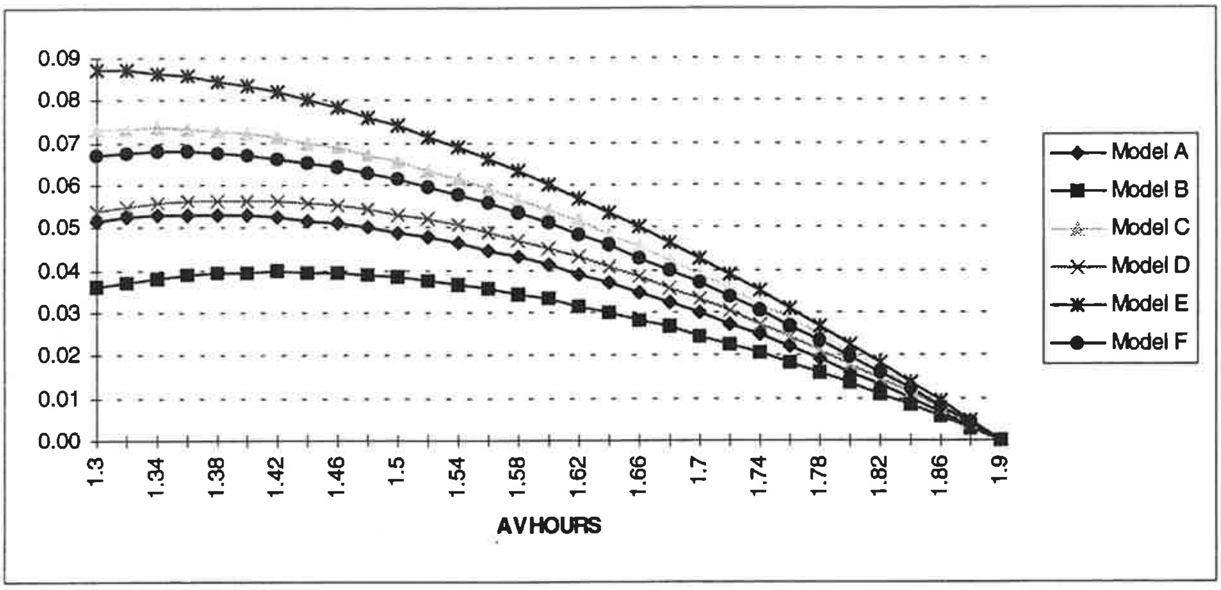
To assess the importance of the size, we have first determined for each NA industry in each year the median size so that one half of persons is working in the plants, which are smaller and one half is working in the plants above this size. We have defined a plant as small if the number of persons is half or less of the median-size and big if the its size is equal or bigger than the median size. The rest of the plants are defined medium size plants. In the pooled regressions the small plants seem to be relatively good in total factor productivity, especially when more weight is put on the capital productivity. On the other hand, when plant-specific constant terms are included, the relative size plays generally an insignificant role.

We have also run some regressions separately for different size groups (results are not reported here). The most striking finding was that the spillover effects play a somewhat bigger role among the small plants, as could be expected. This is especially the case with the spillovers within a firm. Among the big plants, which covers one fifth of our sample, the firm spillover effect was in the pooled regressions both substantially and statistically insignificant and regional spillover effects rather negative than positive.

The micro-micro structures are controlled by two variables: *OUTSOURC2* and *OUTSOURC3*. Outsourcing shows itself as an important explanatory factor even after controlling a wide set of other characteristics of the plants. The plants that have decided to avoid performing the non-industrial service operations themselves, appear to have high total factor productivity.

It has been claimed that a reduction of average hours would increase the efficiency of labour input so that hourly wages can be increased. Arguments have hinged at some case studies, which are not necessarily representative enough for general conclusions. We have investigated the relationship between average annual working hours and total factor productivity level. Regressions provide statistically very significant estimates for the coefficients, but as graph 5.3 demonstrates, within reasonable ranges the relationship is not substantially very significant. According to the industrial statistics, the average annual working hours of employees were some 1620 hours in 1994. Our estimates suggest that the decrease of hours by 10 per cent would increase the total factor productivity level by 1-2 per cent depending on the model. It should be noticed that because of possible measurement errors the positive effects of decreasing hours may be exaggerated. Namely, those plants that have reported too low working hours obtain excessively high total factor productivity estimate. This may be a problem especially when the estimation is based on the within group variation, as in the model E and F.

Graph 5.3. Relationship between *AVHOURS* and ln(*TFPa*) or ln(*TFPb*) according to the estimates



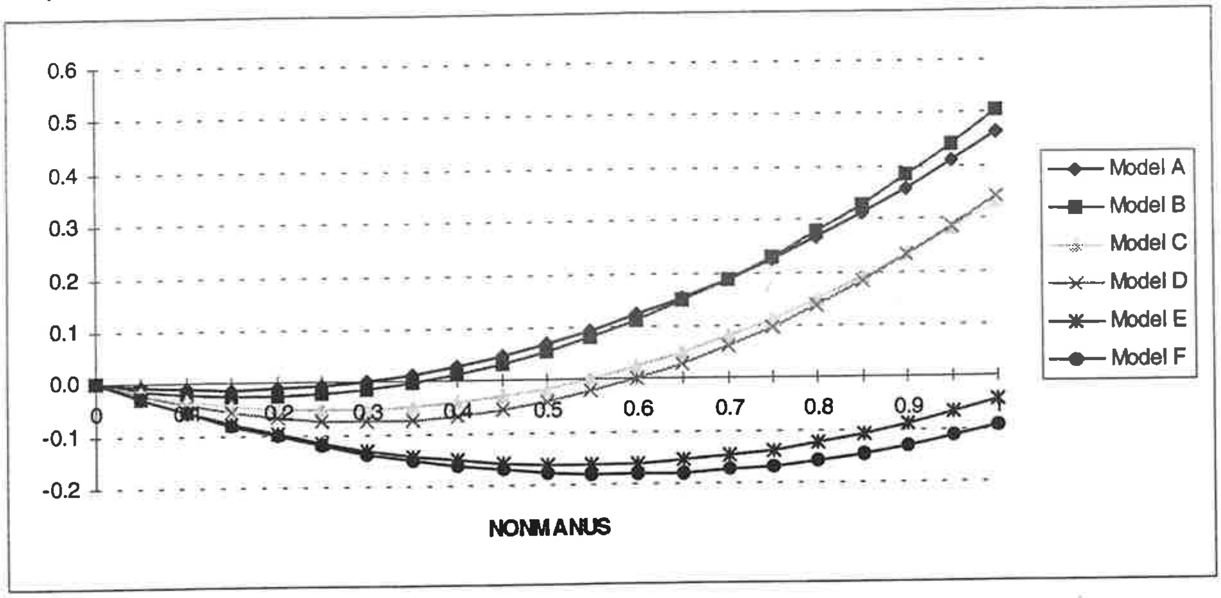
N.B.: The form of the function can be seen in table 5.3.

We have made some exploration to what extent the total factor productivity can be explained by the composition of labour force. The variable *NONMANUS* indicates the ratio of non-manual workers per total number of persons. The results are somewhat perplexing. According to the pooled regressions and random effect models a large share of non-manual workers is associated with relatively high total factor productivity. This is what one might expect as the non-manual workers are well educated and able to adopt new technologies. When the estimation is based solely on the within group variation, the positive relationship between the share of non-manual workers and total factor productivity level vanishes. It seems plausible to expect that a high share of non-manual workers or the high educational level of the staff is not effective by itself if it is not accompanied by an advanced technology. It is unobservable, but presumably is associated with plant-specific term.

We have also studied, how the performance level of a plant is related with the sex composition of the labour force. Information about the share of females in the plants is available only till 1984. We assume that the sex composition is relatively stable and we use the female shares in 1984 as a measure of a plant's female share in the period from 1985 to 1992. Consequently, we have to drop out those plants, that have appeared since 1985. We are not able to estimate fixed effect models, either. The results concerning the coefficients of female share variables are shown in table 5.4. The other variables included in the models but not shown in table 5.4 are the same than in table 5.3, except the terms containing *YOUNG* variable are dropped.

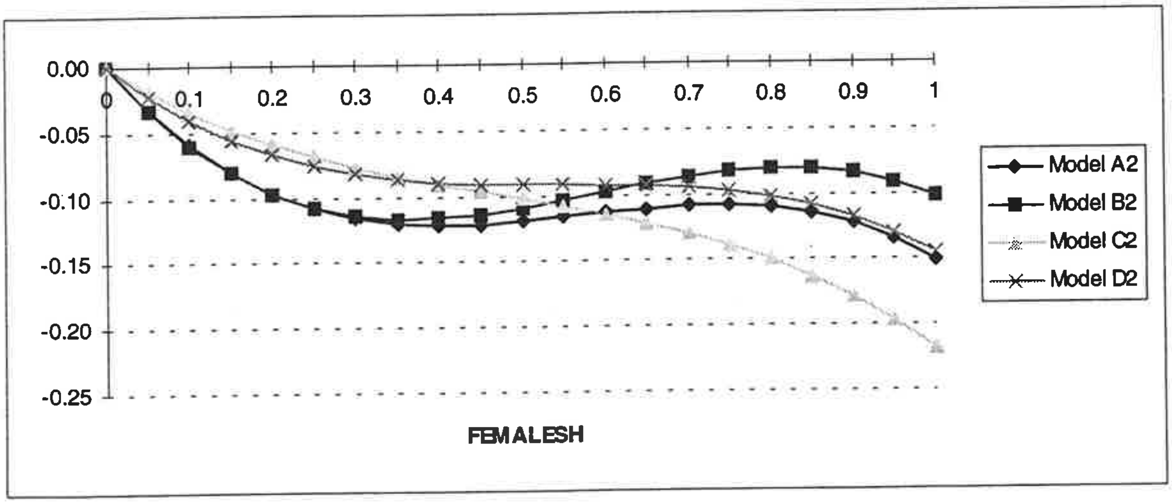
The results concerning the female share are illustrated in graph 5.5. The findings are somewhat different from the ones made in table 4.3. It seems that in the period from 1985 to 1992 those plants that had a very small share of female labour force had higher total factor productivity level than those that had moderate or large female share.

Graph 5.4. Relationship between *NONMANUS* and ln(*TFPa*) or ln(*TFPb*) according to the estimates



N.B.: The form of the function can be seen in table 5.3.

Graph 5.5. Relationship between female share and ln(*TFPa*) or ln(*TFPb*) according to the estimates



N.B.: The form of the function can be seen in table 5.4.

Table 5.3. Regression estimates for the period from 1985 to 1992, unbalanced panels (t-values in parenthesis)

Model	Model A	Model B	Model C	Model D	Model E	Model F	Model G	Model H
Method	Pooled regression		Random effect, ML		Fixed effect, LSDV		Random effect, ML	
Dependent variable	ln(*TFPa*)	ln(*TFPb*)	ln(*TFPa*)	ln(*TFPb*)	ln(*TFPa*)	ln(*TFPb*)	ln(*TFPa*)	ln(*TFPb*)
ln(*FIRMTFP*)	0.098	0.083	0.080	0.068	0.057	0.053	0.080	0.068
	(8.42)	(7.04)	(7.40)	(6.40)	(4.98)	(4.72)	(7.40)	(6.40)
ln(*REGIONTFP*)	0.013	0.004	0.054	0.042	0.052	0.044	0.054	0.042
	(1.31)	(0.37)	(6.20)	(4.80)	(5.49)	(4.72)	(6.17)	(4.80)
REGCONC	0.089	0.078	0.006	-0.001	-0.299	-0.286	0.140	0.139
	(3.51)	(3.04)	(0.15)	(-0.03)	(-4.90)	(-4.63)	(4.32)	(4.21)
MULTI	0.020	0.004	0.015	0.001	-0.002	-0.003	0.015	0.001
	(2.42)	(0.49)	(1.49)	(0.10)	(-0.18)	(-0.27)	(1.49)	(0.11)
EXPORT, P8890=1	0.050	0.024	-0.040	-0.063	-0.120	-0.124	-0.044	-0.066
	(2.64)	(1.26)	(-2.04)	(-3.11)	(-5.02)	(-5.09)	(-2.23)	(-4.31)
EXPORT, P8890=0	0.124	0.102	0.044	0.024	-0.029	-0.030	0.040	0.020
	(8.87)	(7.11)	(2.67)	(1.44)	(-1.38)	(-1.39)	(2.42)	(1.18)
YOUNG, P8892=1	0.146	0.168	0.135	0.155	0.030	0.049	0.132	0.152
	(14.18)	(15.80)	(14.36)	(13.88)	(3.10)	(3.24)	(12.09)	(13.62)
YOUNG, P8892=0	0.039	0.042	0.023	0.031	0.010	0.014	0.022	0.030
	(2.97)	(3.05)	(1.98)	(2.64)	(0.34)	(1.08)	(1.88)	(2.53)
OUT	-0.179	-0.171	-0.117	-0.113	-0.084	-0.084	-0.116	-0.113
	(-15.28)	(-14.26)	(-12.20)	(-11.60)	(-8.04)	(-7.87)	(-12.09)	(-11.50)
RENTSH	0.017	0.025	0.014	0.019	0.011	0.014	0.014	0.019
	(9.75)	(13.73)	(7.88)	(10.48)	(5.00)	(6.22)	(8.02)	(10.60)
RENTSH^2	-47.1E-6	-81.9E-6	-38.2E-6	-59.0E-6	-46.4E-6	-58.3E-6	-38.8E-6	-59.5E-6
	(-3.81)	(-6.45)	(-3.14)	(-4.74)	(-2.71)	(-4.35)	(-3.19)	(-4.78)
MINVSH	-0.003	-0.004	-0.003	-0.005	-0.004	-0.007	-0.003	-0.005
	(-2.16)	(-3.22)	(-3.00)	(-4.48)	(-2.75)	(-4.51)	(-3.08)	(-4.56)
MINV12SH	-0.213	-0.344	-0.141	-0.207	-0.131	-0.182	-0.141	-0.207
	(-11.93)	(-18.72)	(-9.05)	(-13.10)	(-8.07)	(-11.04)	(-9.05)	(-13.08)
MINV12SH^2	0.002	0.001	-0.038	-0.042	-0.047	-0.053	-0.034	-0.044
	(0.22)	(0.14)	(-4.31)	(-4.67)	(-4.72)	(-5.17)	(-4.45)	(-4.82)
MINV12SH^3	0.223	0.357	0.145	0.209	0.138	0.184	0.146	0.209
	(10.09)	(15.72)	(7.59)	(10.73)	(6.86)	(8.98)	(7.61)	(10.74)
FOREIGN	0.080	0.068	0.073	0.063	0.044	0.043	0.078	0.068
	(5.83)	(4.85)	(3.61)	(3.05)	(1.60)	(1.53)	(3.85)	(3.29)
MEDIUM	-0.036	-0.049	0.010	0.004	0.007	0.022	0.009	0.003
	(-4.27)	(-5.60)	(0.97)	(0.37)	(0.58)	(1.73)	(0.93)	(0.34)
LARGE	-0.032	-0.048	0.019	0.012	0.010	0.039	0.020	0.013
	(-3.40)	(-5.06)	(1.39)	(0.85)	(0.53)	(2.10)	(1.46)	(0.92)
OUTSOURC2	0.219	0.207	0.166	0.157	0.112	0.108	0.166	0.156
	(32.92)	(30.43)	(22.50)	(20.86)	(14.31)	(12.63)	(22.41)	(20.77)
OUTSOURC3	-0.086	-0.088	-0.027	-0.024	0.007	0.005	-0.023	-0.020
	(-5.59)	(-5.58)	(-1.48)	(-1.27)	(0.31)	(0.22)	(-1.28)	(-1.08)
ln(*AVHOURS*)	0.312	0.332	0.340	0.382	0.291	0.344	0.344	0.386
	(5.47)	(5.66)	(6.88)	(7.59)	(5.49)	(6.39)	(6.95)	(7.66)
[ln(*AVHOURS*)]^2	-0.496	-0.471	-0.589	-0.580	-0.576	-0.576	-0.590	-0.580
	(-8.10)	(-7.51)	(-11.15)	(-10.77)	(-10.26)	(-10.09)	(-11.15)	(-10.78)
NONPRODSH	-0.187	-0.290	-0.397	-0.508	-0.604	-0.616	-0.370	-0.480
	(-5.25)	(-7.92)	(-8.15)	(-10.18)	(8.92)	(-8.94)	(-7.61)	(-9.64)
NONPRODSH^2	0.651	0.795	0.729	0.849	0.559	0.523	0.712	0.832
	(16.13)	(19.19)	(12.40)	(14.10)	(6.08)	(5.59)	(12.11)	(13.80)
Dummies for 4-digit indust.	yes	yes	no	no	no	no	no	no
Dummies for regions	yes	yes	yes	yes	no	no	no	no
Number of observations	40758	40764	40758	40764	40758	40764	40758	40764
R^2	0.219	0.204			0.701	0.701		
Root mean square error	0.474	0.487			0.326	0.332		
Variance estimate			0.109	0.112			0.109	0.113
Std estimate			0.330	0.335			0.330	0.335

N.B.: Furthermore, the following variables and interactions are included in all models: dummies for 15 NA industry are allowed to interact with *TREND* and P8790, dummies for 15 NA industry are allowed to interact with P8790, dummy variable for year 1991, dummy variable for 1992, dummies indicating if there is no other plants in the region operating in the same 4-digit industry, dummies indicating if there is no other plants in the firm operating in the same 4-digit industry.

Table 5.4. Regression estimates for the period from 1985 to 1992, unbalanced panels (t-values in parenthesis)

Model	Model A2	Model B2	Model C2	Model D2
Method	Pooled regression		Random effect, ML	
Dependent variable	ln(*TFPa*)	ln(*TFPb*)	ln(*TFPa*)	ln(*TFPb*)
FEMALESH	-0.73	-0.74	-0.40	-0.49
	(-8.68)	(-8.65)	(-2.48)	(-2.97)
FEMALESH^2	1.38	1.46	0.61	0.89
	(6.49)	(6.70)	(1.48)	(2.12)
FEMALESH^3	-0.80	-0.82	-0.42	-0.54
	(-5.26)	(-5.24)	(-1.47)	(-1.83)
Number of observations	33992	33997	33992	33997
R^2	0.226	0.208		
Root MSE	0.461	0.471		
Variance			0.105	0.108
Standard deviation			0.324	0.329

N.B.: The models A2-D2 contains also those variables included in the models A-D, except the terms containing *YOUNG* variable are dropped.

5.3.2 Production function approach

We use two well-known production function formulations. Cobb-Douglas -function can be parametrizised in a following way:

$$\ln\left(\frac{Y}{L}\right) = \text{constant} + \alpha \ln\left(\frac{K}{L}\right) + (\alpha + \beta - 1)\ln(L) + \text{other explanatory variables} + u,$$

where Y is value added, L hours worked, K capital input. The parameters α and β are the labour and capital elasticities, respectively. The coefficient $(\alpha + \beta - 1)$ measures the departure of the elasticity of scale $(\alpha + \beta)$ from constant returns.

The translog production function provides a more general and flexible representation of the structure of production. It can be written as follows:

$$\ln\left(\frac{Y}{L}\right) = \text{constant} + a_1 \ln\left(\frac{K}{L}\right) + a_2 \ln(L) + a_3\left[\ln\left(\frac{K}{L}\right)\right]^2 + a_4[\ln(L)]^2 + a_5\left[\ln\left(\frac{K}{L}\right)\right][\ln(L)] +$$
$$\text{other explanatory variables} + u.$$

The estimation results are shown in table 5.6. Generally all our findings made with total factor productivity indicators remain (spillover effects seem to prevail within firms and regions, foreign-owned plants are having high performance level etc.).

Some results in table 5.6, however, deserves mentioning. The estimate of capital elasticity obtained from the Cobb-Douglas function seems quite small when compared with the estimates obtained with income or cost share. This may reflect among other things the inaccuracy in our capital input measure. While we are using machinery and equipment stock as a proxy of capital input we are ignoring buildings and other constructions. Furthermore our measure of capital input does not take into account the utilisation rate of the stock or the amount of rented capital.[24] Finally, the measurement of capital input involves considerable difficulties and for that reason the true level of machinery and equipment potential may be measured substantially more inaccurately than labour input. All these factors tend to distort capital elasticity estimate downward, especially when the estimation is based on the within variation.

The capital elasticity is allowed to vary among the NA industries in our Cobb-Douglas -specification, when the constant returns to scale assumption is imposed. These estimates of capital input elasticity by

[24] The importance of incorporating both owned and rented capital is discussed extensively by Mairesse et al. (1993). The inclusion of the rented capital increased clearly the elasticity estimate of capital input in the French service industries.

industry are shown in graph 5.6. (other estimates are not reported here). In addition, we have estimated the elasticity of capital input with the average income and cost shares in the period from 1985 to 1994.[25]

Although the Cobb-Douglas estimates render much lower weight for capital input than income or cost shares, the three measures share quite similar industry pattern. This is illustrated more clearly with the scatter plots in graph 5.7. It appears that there is a clear relationship between an industry's cost share and the elasticity estimate and especially between an industry's income share and the elasticity estimate.[26] Capital input is relatively more important for the labour productivity in paper industry, in petroleum refineries etc., chemical industry and in basic metal industry.

We have also made some estimations by proxing capital input with electricity consumption (not reported here). The estimates of capital elasticity were clearly higher than the ones obtained with our PIM estimate. In pooled regression the estimate of the elasticity was 14.3 per cent. As might be expected, the difference was especially pronounced when the estimation was based on the within variation. In the fixed effect model the estimate of capital elasticity was 10.1 per cent. The obvious reason for this gap (some 5.9 per cent) lies in the fact that electricity consumption reflects more accurately the short-run variations within a plant.

The assumption of constant returns to scale was one central assumption made in the construction of total factor productivity indicators earlier. It is claimed on the strength of various theoretical reasoning that there is increasing returns to scale especially in the manufacturing. On the other hand, the researchers at the Center for Economic Studies at the Census Bureau are generally inclined to claim that there are constant returns to scale in the Longitudinal Research Database (LRD) (see Baily et al., 1992, 234-235).

The results obtained with Cobb-Douglas production function here seem to suggest that rather decreasing than increasing returns to scale are prevailing in the Finnish manufacturing sector. In the fixed effect model the scale elasticity appears to be both statistically and substantially decreasing by about 14 per cent[27] (see also Baily et al. 1992 and Mairesse et al. 1993). Again, the spillover effects turn out to play a crucial role: if the spillover variables (*REGIONTFP*, *REGCONC*, *MULTI*) are dropped out from a pooled regression or random effect model, the model seems to suggest statistically significant increasing returns to scale.

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[25] Real interest rate is assumed as 13 per cent here.

[26] Correlation coefficient between the cost share and the elasticity estimate is 0.664 and 0.781 between the income share and the elasticity estimate, respectively.

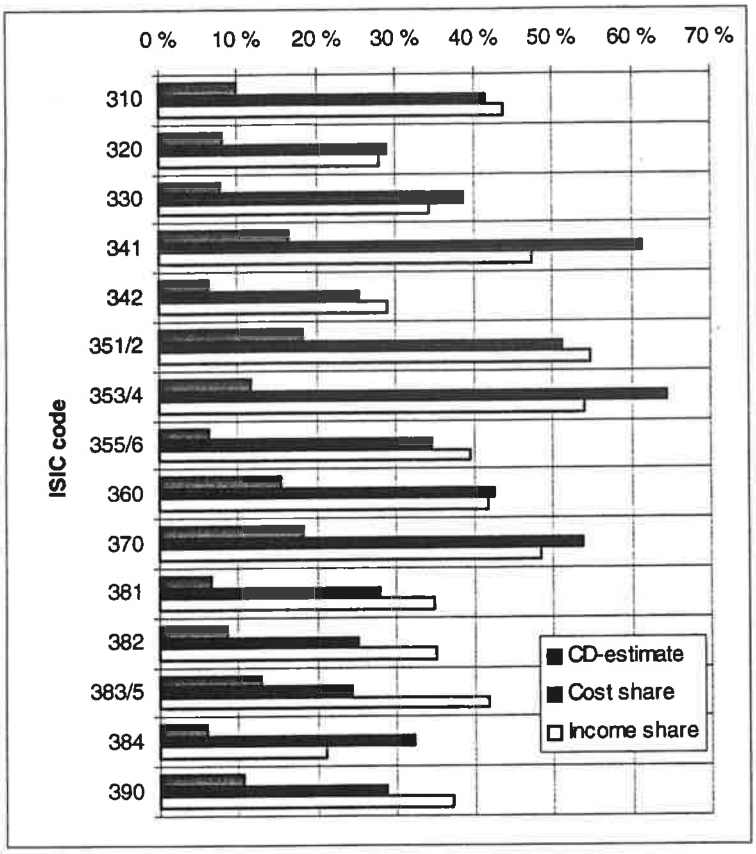
[27] Baily et al. (1992) has studied returns to scale for manufacturing and Mairesse et al. (1993) for service sector. In the latter study it was also noted that the within estimator indicate clearly decreasing returns to scale.

Table 5.5. Cobb-Douglas - and translog-estimates for the period from 1985 to 1992, ln(*Y*) is dependent variable

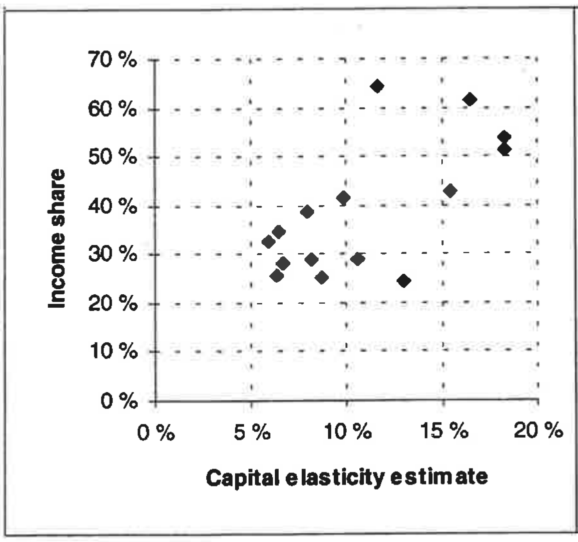
Function	Cobb-Douglas				Translog		
Method	OLS	OLS	Random effects, ML	Fixed effect, LSDV	OLS	Random effects, ML	Fixed effects, LSDV
ln(*K/L*)	0.095	Industry	0.082	0.042	0.005	-0.006	0.004
	(41.24)	specific	(27.44)	(9.64)	(0.72)	(-0.62)	(0.28)
ln(*L*)	-0.014	Industry	-0.010	-0.143	-0.076	-0.182	-0.337
	(-4.83)	specific	(-2.20)	(-16.14)	(-5.82)	(-9.07)	(-10.58)
ln(*K/L*)*ln(*K/L*)					0.022	0.014	0.004
					(24.07)	(13.11)	(2.62)
ln(*L*)*ln(*L*)					0.010	0.019	0.022
					(6.73)	(8.61)	(6.63)
ln(*K/L*)*ln(*L*)					-0.008	0.003	0.005
					(-4.12)	(1.46)	(1.71)
ln(*FIRMTFP*)	0.110	0.110	0.085	0.056	0.103	0.082	0.057
	(9.21)	(9.24)	(7.76)	(4.92)	(8.74)	(7.54)	(5.02)
ln(*REGIONTFP*)	0.020	0.017	0.068	0.063	0.019	0.066	0.062
	(2.00)	(1.73)	(7.61)	(6.58)	(1.90)	(7.48)	(6.55)
REGCONC	0.059	0.043	-0.046	-0.419	0.063	-0.034	-0.404
	(2.28)	(1.67)	(-1.18)	(-6.84)	(2.47)	(-0.89)	(-6.58)
MULTI	0.032	0.033	0.025	-0.016	0.022	0.017	-0.018
	(3.54)	(3.74)	(2.45)	(-1.34)	(2.52)	(1.70)	(-1.54)
EXPORT, P8890=1	0.073	0.065	-0.012	-0.111	0.062	-0.031	-0.116
	(3.79)	(3.32)	(-0.59)	(-4.63)	(3.22)	(-1.51)	(-4.80)
EXPORT, P8790=0	0.149	0.143	0.076	-0.011	0.145	0.067	-0.009
	(10.31)	(9.76)	(4.44)	(-0.53)	(10.09)	(3.90)	(-0.44)
YOUNG, P8892=1	0.123	0.126	0.101	0.012	0.129	0.103	0.012
	(11.59)	(11.92)	(8.99)	(0.81)	(12.24)	(9.21)	(0.83)
YOUNG, P8892=0	0.048	0.049	0.025	-0.019	0.050	0.022	-0.021
	(3.52)	(3.59)	(2.18)	(-1.51)	(3.69)	(1.91)	(-1.65)
P91	-0.202	-0.197	-0.203	-0.212	-0.215	-0.212	-0.213
	(-3.85)	(-3.77)	(-5.50)	(-5.78)	(-4.12)	(-5.76)	(-5.82)
P92	-0.239	-0.233	-0.237	-0.253	-0.253	-0.247	-0.254
	(-3.89)	(-3.82)	(-5.52)	(-5.89)	(-4.16)	(-5.76)	(-5.93)
OUT	-0.194	0.192	-0.128	-0.113	-0.197	-0.133	-0.117
	(-16.25)	(-16.4)	(-13.15)	(-10.63)	(-16.63)	(-13.66)	(-10.97)
RENTSH	0.016	0.013	0.012	0.007	0.007	0.007	0.006
	(8.65)	(6.93)	(6.32)	(3.08)	(3.56)	(3.88)	(2.64)
RENTSH^2	-4.46E-05	-2.87E-05	-3.13E-05	-2.95E-05	-4.48E-06	-1.54E-05	-2.74E-05
	(-3.49)	(-2.24)	(-2.49)	(-1.70)	(-0.35)	(-1.23)	(-1.58)
MINVSH	-1.68E-03	-1.69E-03	-1.64E-03	1.05E-03	-1.92E-04	-9.61E-04	1.12E-03
	(-1.36)	(-1.38)	(-1.46)	(0.70)	(-0.16)	(-0.86)	(0.74)
MINV12SH	-0.136	-0.119	-0.073	-0.011	-0.088	-0.065	-0.012
	(-7.01)	(-6.16)	(-4.47)	(-0.64)	(-4.58)	(-3.99)	(-0.72)
MINV12SH^2	0.004	0.001	-0.031	-0.029	0.002	-0.033	-0.029
	(0.42)	(0.06)	(-3.42)	(-2.90)	(0.23)	(-3.68)	(-2.86)
MINV12SH^3	0.140	0.125	0.075	0.021	0.095	0.071	0.023
	(5.96)	(5.33)	(3.79)	(1.00)	(4.06)	(3.61)	(1.09)
FOREIGN	0.094	0.095	0.085	0.042	0.089	0.086	0.044
	(6.74)	(6.80)	(4.11)	(1.51)	(6.38)	(4.22)	(1.60)
OUTSOUR2	0.245	0.244	0.185	0.114	0.239	0.182	0.113
	(36.80)	(36.58)	(24.96)	(13.49)	(36.10)	(24.60)	(13.38)
OUTSOUR3	-0.092	-0.090	-0.035	0.013	-0.077	-0.030	0.013
	(-5.82)	(-5.69)	(-1.90)	(0.59)	(-4.92)	(-1.64)	(0.57)
ln(*AVHOURS*)	0.351	0.363	0.302	0.300	0.380	0.338	0.317
	(6.01)	(6.24)	(6.00)	(5.59)	(6.53)	(6.72)	(5.91)
[ln(*AVHOURS*)]^2	-0.568	-0.583	-0.620	-0.586	-0.583	-0.628	-0.590
	(-9.10)	(-9.37)	(-11.56)	(-10.37)	(-9.39)	(-11.74)	(-10.43)
NONPRODSH	-0.100	-0.105	-0.271	-0.568	-0.073	-0.249	-0.560
	(-2.67)	(-2.79)	(-5.33)	(-8.32)	(-1.97)	(-4.91)	(-8.20)
NONPRODSH^2	0.547	0.516	0.593	0.521	0.511	0.557	0.499
	(12.87)	(11.96)	(9.65)	(5.62)	(12.03)	(9.10)	(5.38)
Dummies for 4-digit ind.	yes	yes	no	no	yes	no	no
Dummies for regions	yes	yes	yes	no	yes	yes	no
Num. Obs	40839	40839	40839	40839	40839	40839	40839
R^2	0.374	0.380		0.766	0.384		0.767
Root MSE	0.484	0.482		0.329	0.481		0.329
Variance estimate			0.1113			0.1112	
Std estimate			0.3336			0.3334	

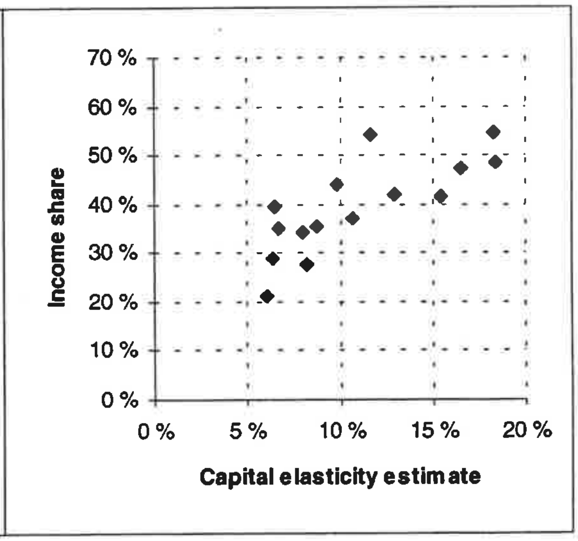
N.B.: The same notes than for table 5.3.

Graph 5.6. Capital elasticity estimate and capital share



Graph 5.7. Capital income and cost share and the elasticity in the NA industries





N.B.: Contant returns to scale restriction is imposed.

To conclude this chapter it is worth of noting several econometric problems involved in the analysis above. The assumptions concerning error term in our models may be violated. In this first look at the data no account is taken of possible auto-correlation in errors over time. The plants especially within the same industry share the same economic environment and are subject to variation of several macroeconomic variables. This ties plants together in varying degrees. As such, it would seem reasonable to allow correlation of disturbances across plants, too.

Furthermore, when we run least squares regression of the squared residuals obtained from the model A on a set of variables included in that model, we obtained clear evidence on the heteroscedasticity. This shallow exploration suggested among other things that the small, young and the plants to disappear soon tend to have a greater variance. In addition, the variance seems to be greater in the plants that belongs to a multi-unit firm than among the solitary plants. This may reflect the fact that in a multi-unit firm there may be some difficulties in dividing some items between plants. The results seem to point out also that variance is greater among domestic-owned plants than among foreign-owned ones. Because of the problems given above, the standard errors of various variables in our models are under-estimated in all likelihood and thus statistical significance of results is overestimated.[28]

Errors-in-variables may be a problem especially as far as capital input is concerned. As we are finding somewhat unreasonably low estimates of capital elasticity, the strive for increasing the accuracy of capital input measure or using methods that alleviate errors in the capital input measure would be presumably worth-while (see Griliches et al., 1995, 200). The sample selectivity problem should not be too severe as we have used unbalanced panels that cover the Finnish manufacturing plants quite comprehensively.

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[28] The use of the robust White estimates of the standard errors would be a remedy to this shortcoming, but unfortunately this would have required too much extra work to be kept within the limits of this project. Fortunately, the statistical significance levels were often rather high because of a large sample size so that a number of conclusions can be done rather safely.

6 Summary and concluding remarks

In this study we have investigated the variation of productivity levels among plants. The productivity differences appear to be outstanding in our data set that covers essentially all the Finnish manufacturing plants. While we have spent a great deal time in studying individual observations and carrying out many kinds of comparisons, we have become fully aware that measurement errors play a very important role. For the analysis we have eliminated the most extreme observations from the data set.

The main issue of interest in this study is to investigate some important characteristics of the plants capable of using their resources productively. This is of a great value in order to understand why some plants perform badly. In general, the firms or plants that have permanently low productivity will not survive if they are not supported financially by the government, for example. They are also incapable of paying high wages. Thus, the familiarity with the factors explaining high productivity is of great use for policy considerations.

A multilateral total factor productivity index is used as an indicator of a plant's productivity performance in this study. The assumption of constant returns to scale at plant-level is imposed when constructing this indicator. To implement this measure, the input shares for each plant are estimated by using both industry and plant-level information on capital and labour costs. The analyses made here suggest that total factor productivity level is not very different between relatively small and relatively big plants.

We obtained evidence that the geographical location matters. Generally speaking, the plants in southern Finland tend to have high total factor productivity and plants in the East and North have a lower level of productivity. However, because of the regional spillover effects, the relationship between region and productivity is not quite as simple. The results suggest that it may be beneficial for a plant if there are other high productivity plants in the same region that operate in the same 4-digit industry. Furthermore, the results obtained with the pooled regressions suggest that a plant may benefit from the fact that a large share of the production of that industry is concentrated in that particular region. A similar kind of finding is made with random effect models, when the regional dummy variables are dropped. It may be useful for a region to focus on some industries so that some advantages from increasing returns to scale at a regional and industry-level can be captured.

The spillover effects seem to be in effect also within firms. According to our estimates, a plant gains some advantage from being a part of a firm that has other high productivity plants in the same 4-digit industry. When the different sorts of spillover effects are controlled, being a part of a multi-unit firm does not seem to be crucial for a plant.

The productivity performance and competitiveness of the manufacturing sector in the future are to some extent dependent on how much and what kinds of plants are created now. At the first steps of the evolution the plants have low labour productivity level and they are usually small. For that reason the new plants have only a marginal effect at the aggregate level. The new plants have, however, a low capital intensity and for that reason they tend to have relatively high total factor productivity. This may be an indication that the new plants make use of advanced technologies. We also obtained some evidence that the total factor productivity growth is particularly rapid among the new plants. This can be explained by the learning by doing, as it may be more important in the first steps in the evolution process than later, when some plant-specific human and organisational capital are already accumulated.

Spillovers from other production units may provide some substitute for learning by doing. We obtained some indication that the high total factor productivity in the other plants operating in the same firm and at the same 4-digit industry is more important for new plants than for the older ones. We noticed also that the new plants were particularly strong since 1988.

Foreign-owned plants (the share of foreign ownership in the firm is at least 20 per cent) appear to be capable of using resources more productively than the domestic-owned ones. This seems to be the case even after controlling for a great variety of plant characteristics or when a plant-specific random term is included in the regression model. It is not clear to what extent good performance leads to foreign ownership and vice versa. On the other hand, it may be expected that the possible positive effect of the foreign effect does not materialise instantly, but it takes some time before the new technology is embodied in a plant's labour input and capital input.

The implicit assumption made in the productivity analysis, that the plants share the same prices, seems somewhat dubious especially when studying the effect of export orientation on the productivity performance. We obtained some indication that export prices differ from domestic prices at the industry-level — especially at the times when the currency is strong. With this in mind it seems evident that the positive effect of exports is underrated. The regression analyses made here provide some evidence that export orientated plants had higher total factor productivity level than less export orientated ones at least in the period from 1985 to 1987 and in 1991 and 1992. On the other hand, the causality may run from the high productivity performance to the export orientation and in this respect the positive effect of exposure to global competition may be overrated.

We have also investigated the relationship between average annual working hours and plant's total factor productivity level. The low annual average hours seem not substantially very favourable for the plant's total factor productivity. This is the case in spite of the fact that the total factor productivity level among the plants that have low average hours may be biased upward due to the measurement errors in the total annual hours.

It would be of a great importance to study the quality aspect of labour input from the productivity perspective. In this study we have explored the relationship between total factor productivity and the composition of a plant's labour force. The pooled regressions and random effect models point out that the total factor productivity level is high in those plants where the share of non-manual workers is large. This is what one would expect, as the non-manual workers are generally well educated. The positive connection between the large non-manual worker share and total factor productivity, however, breaks down when the plant effect is controlled by a constant plant term. High educational level in a plant does not necessarily ensure high productivity performance if it is not accompanied by advanced technology. We found also that those plants that had a high share of male workers in 1984 had also higher productivity performance in the period from 1985 to 1992 than those that had a smaller male share.

This was a first look at the factors of plant productivity in the Finnish manufacturing sector. A great many interesting and important issues are left without consideration. For example, plant dynamics deserve more comprehensive analysis. Furthermore, such econometric loose ends as simultaneity, heteroskedasticity (that was detected briefly), autocorrelation and cross-sectional correlations should be taken into account more carefully. We have plans to study the importance of labour characteristics for productivity in greater detail in the future. This can be done by integrating data on individuals with plant-level data sets. In addition, we aim to take into account R&D and innovations. An issue of a great interest is the importance of such factors as the computer aided manufacturing (CAM) and flexible manufacturing systems for the productivity performance and how these factors are related with the characteristics of the labour force. Information about these factors for a sample of plants is available and we are striving to make use of it in the future.

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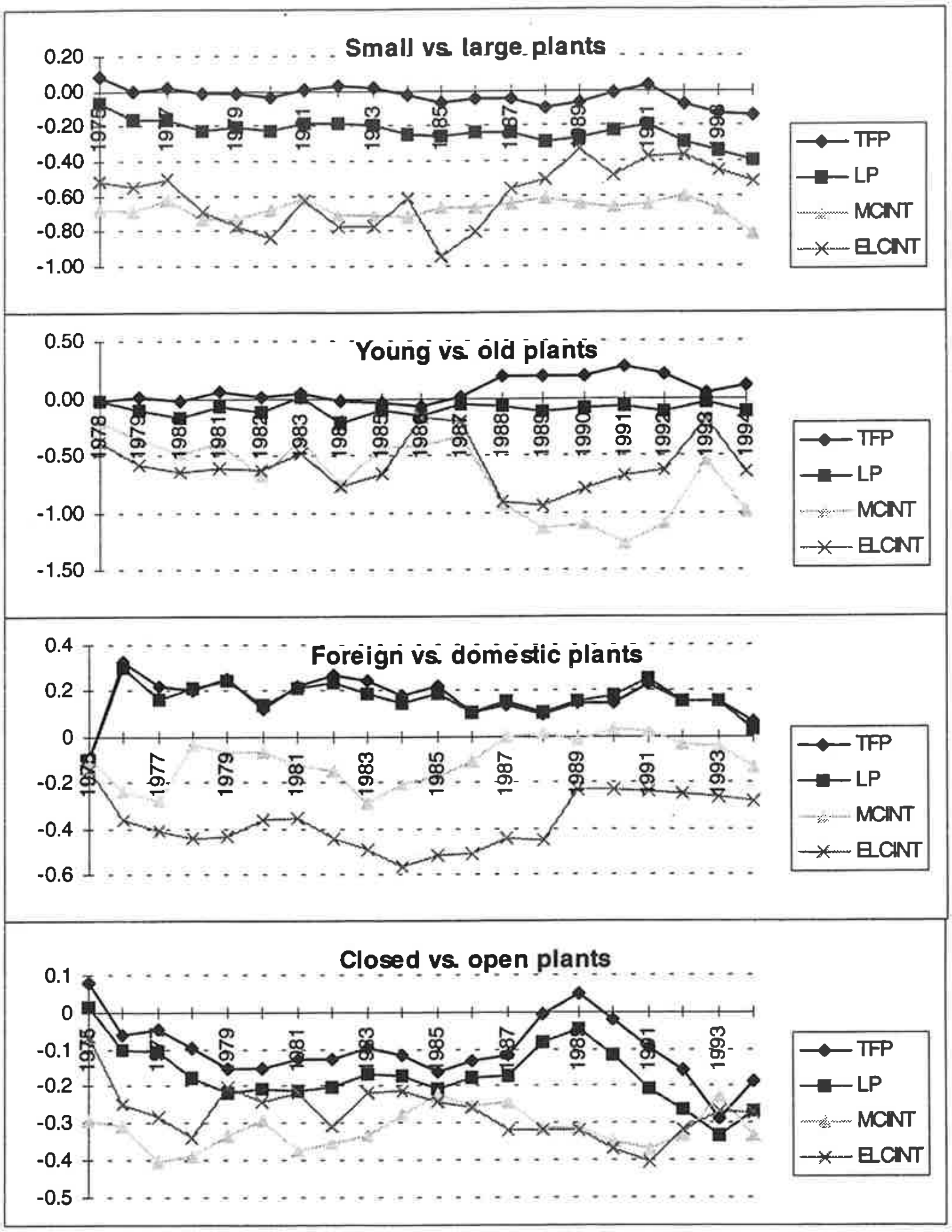
APPENDIX

Graph. Some log-differences between plants at 3-digit industry-level



N.B.: See chapter 4.2.

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