ETLA

ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 358-9-609 900
Telefax 358-9-601 753 World Wide Web: http://www.etla.fi/

Keskusteluaiheita – Discussion papers

No. 757

Mika Maliranta

PRODUCTIVITY GROWTH
AND MICRO-LEVEL RESTRUCTURING

Finnish experiences during the turbulent decades

This research has been supported financially by Tekes, the National Technology Agency, grant DNRA 1312/401/99. Data work and computations have been carried out at Statistics Finland following the terms and conditions of confidentiality. I would like to thank many persons in Statistics Finland for guidance regarding the features of data. Acknowledgements for helpful comments are due to Rita Asplund and Pekka Ilmakunnas. Of course, I am solely responsible for the conlusions and any remaining errors.
.

ISSN 0781-6847 20.04.2001

MALIRANTA, Mika, **PRODUCTIVITY GROWTH AND MICRO-LEVEL RESTRUCTURING. Finnish experiences during the turbulent decades.** Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2001, 67 p. (Keskusteluaiheita, Discussion papers, ISSN 0781-6847; No. 757).

ABSTRACT: The appearance of productivity-enhancing restructuring at the plant level (the so-called between and net entry effects) has contributed substantially to the acceleration of labour and total factor productivity growth in Finnish manufacturing in the period from the latter part of the 1980s up to the mid-1990s. The recent years have witnessed chilling in these components of aggregate productivity growth. We find evidence that increased export-orientation towards the Western markets and increased R&D intensity have generated the productivity-enhancing restructuring. More specifically, R&D seems to have contributed to aggregate total factor productivity through plant level restructuring with a lag of some 3 to 5 years. The chilling in the between-plant component in recent years can be explained by the fact that while the gap to the international technology frontier is narrowing there are less and less needs and opportunities for productivity improvement through micro-structural adjustment. We have found that micro-structural factors of aggregate productivity growth have an important role to play in diminishing productivity and wage dispersion between plants. In the recession years external adjustment through entry and exit and, to a lesser extent, through restructuring among incumbents has improved aggregate productivity performance in some service industries as well. But the recovery period has entailed chill also in many non-manufacturing industries.

Keywords: productivity, total factor productivity, restructuring, R&D, competition, catching up
JEL Classification numbers: L60, L80, O12, O32, O47

MALIRANTA, Mika, **PRODUCTIVITY GROWTH AND MICRO-LEVEL RESTRUCTURING. Finnish experiences during the turbulent decades.** Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2001, 67 s. (Keskusteluaiheita, Discussion papers, ISSN 0781-6847; No. 757).

TIIVISTELMÄ: Tuottavuutta vahvistavan toimipaikkatason rakennemuutoksen (osuusvaikutuksen) ilmaantuminen on edistänyt merkittävästi työn tuottavuuden ja kokonaistuottavuuden kasvun kiihtymistä Suomen tehdasteollisuudessa 1980-luvun jälkipuoliskolta 1990-luvun puoliväliin. Viime vuosina tämä kasvutekijä on alkanut hyytyä. Saadaan näyttöä siitä, että lisääntynyt vientisuuntautuminen länsimarkkinoille sekä lisääntynyt T&K-intensiteetti ovat lisänneet tuottavuutta vahvistavaa rakennemuutosta. Tarkemmin sanottuna, T&K näyttää vaikuttavan aggregaativiseen kokonaistuottavuuteen osuusvaikutuksen välityksellä noin 3-5 vuoden viiveellä. Osuusvaikutuksen hyytyminen viime vuosina selittyy sillä, että samalla kun teknologiakuilu kansainväliseen teknologian eturintamaan on kaventunut, alati vähemmän on tarvetta ja mahdollisuutta tuottavuuden parannuksiin mikro-rakenteiden sopeutuksen kautta. Havaitaan, että aggregaativisen tuottavuuskasvun mikrorakennetekijät vähentävät tuottavuuden ja palkojen hajontaa toimipaikkojen välillä. Lamavuosina ulkoinen sopeutuminen toimipaikkasyntymien ja -poistumien kautta ja vähemmässä määrin myös rakennemuutos toimintaansa jatkavien toimipaikkojen keskuudessa on parantanut aggregatiivista suorituskykyä joillakin palvelutoimialoilla. Myös monilla ei-teollisilla toimialoilla toipumisjaksoa luonnehtii hyytyminen.

1 Introduction

The aim of this study is to seek for ingredients of productivity evolution at the micro-level, as this can help us to understand in depth several phenomena that have recently preoccupied economists. Why was the productivity level in Finland low still in the mid-1980s? Why was there hardly any catching-up of the international technology frontier in the first half of the 1980s? And finally, through which kind of process did the transfer from low to high productivity performance ultimately come out? As a by-product of these considerations we may expect to learn something about the reasons behind the Finnish depression in the early 1990s.

The Finnish economy was hit by an exceptionally severe economic depression in the early 1990s. In a few years' time GDP dropped about 14 per cent. Lots of jobs were destroyed and, as a consequence, employment fell in all main sectors. Unemployment rose from some 3 per cent to 17 per cent. (See Ilmakunnas and Maliranta, 2000a). Industrial production fell by 12 per cent in 1991. Manufacturing employment had shown a downward trend since the early 1980s, but the recession brought about a substantial acceleration in this shrinking tendency; employment in the manufacturing sector fell by almost one fifth from 1989 to 1991. The recovery period started in manufacturing already in 1992 and has lasted up till now. In 1999 manufacturing employment was by and large back on this medium run trend-line.

Several explanations for the recession have been put forward. The Finnish economy had bad luck as the downturn within the OECD area coincided with the collapse of trade with the former Soviet Union in 1991. Furthermore, policy-makers can be argued to have been unsuccessful in the fiscal policy and in the deregulation of financial markets as the indebtedness of the private sector rose substantially and the economy overheated in the late 1980s. A strong currency, especially after the revaluation of the Finnish markka in the early 1989, deteriorated the competitiveness of exporting firms. The defence of the markka against speculative attacks kept interest rates high. (See Honkapohja and Koskela, 1999). This made the financial situation difficult for businesses with high interest payments per cash flow, that is, for new firms that had made large investments.

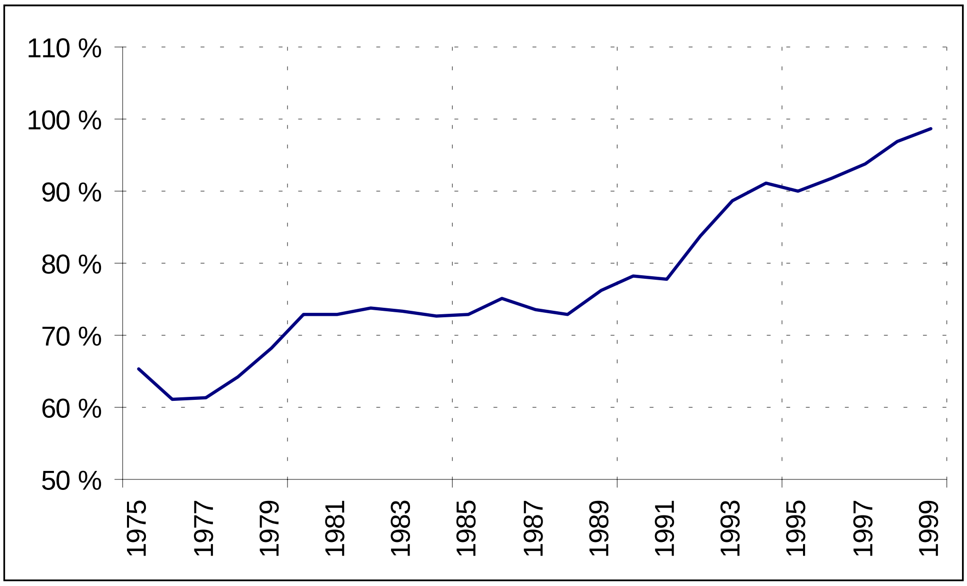
Pohjola (1996 and 1998b) has argued, based on vast empirical evidence, that inefficiency in capital usage made the Finnish economy vulnerable in the presence of free international capital flows and high real interest rates. The inefficiency was a consequence of the long-lasting regulation period from the 1940s up to the mid-1980s.

Indeed, comparisons of manufacturing productivity levels between Finland and the United States seem to provide at least some support for that hypothesis. Figure 1 shows total factor productivity level of Finnish manufacturing relative to that of the United States. Three conclusions can be drawn. First, productivity performance was weak at the onset of the 1980s suggesting a low technology level or inefficient usage of labour and capital inputs. Second, the catching-up process was strikingly slow during the main part of the 1980s. Third, there was considerable acceleration in the catching-up since the late 1980s, and even further acceleration in the recession period 1991-1994. The improved growth performance has pushed the productivity level close to the international technology frontier.

Pohjola also states that the deregulation of financial markets brought to light the underlying weaknesses in real competitiveness, which took the form of surging unemployment figures. The increase in real interest rates made the situation even worse. He argues (Pohjola, 1998) that this triggered the restructuring process that was to lead to a strong increase in labour and capital productivity. Maliranta (1997a and 1997c) provides evidence that the acceleration in labour productivity growth was primarily an outcome of increased restructuring of employment among plants. Most of the jobs that were lost were in low productivity units (for further evidence, see also Ilmakunnas and Maliranta, 2000b and 2000d).

Furthermore, the deregulation of financial markets was accompanied by certain other developments. Business R&D intensity in the Finnish economy had increased at an internationally exceptional speed in the period from the early 1980s to the late 1990s (see Bassini, Scarpetta, and Visco, 2000). We hypothesise that this dractic growth in innovation intensity has conduced productivity-enhancing structural change at the plant level, albeit part of this restructuring at the micro-level can, of course, be expected to show up as changes in industry structures (see Maliranta, 2000). The decrease in exports to the former Soviet Union in the mid-1980s gave further stimulus for increased orientation towards Western markets. Also this may have brought about an allocation shock and a change in the economic environment, both of which are likely to have affected aggregate productivity growth through restructuring.

Figure 1. Relative total factor productivity level of Finnish manufacturing, 1975 to 1999, USA=100 %



Notes. The figure is based on updated results from Maliranta (1996). The productivity comparisons for the base year, that is 1987, have been made by using the same approach as in the ICOP (International Comparisons of Output and Productivity) project at the Groningen university (see van Ark and Pilat, 1993). In this so-called industry-of-origin approach value added figures are converted into a common currency by using unit value ratios. These ratios have been calculated for the binary productivity comparisons by using value and physical quantity information on the products obtained from industrial statistics of the two countries in question. The capital stock estimates needed for the total factor productivity indicator have been calculated from investment series by using the perpetual inventory method by assuming the same depreciation rate for both country. Investments of each country have been converted into dollars by using the purchasing power parities of investment goods. Extrapolation of the series and measurement of capital stock estimates are based on the information obtained from the STAN database of the OECD.

Needless to say, fundamental structural changes in the economy entail accommodation at the individual level as well. As many jobs were destroyed, many unemployed have had to find a new job, possibly involving new kinds of tasks. The new career may have to located in a new plant or in some older plant that has been capable of maintaining jobs or of creating new ones. Finding a job during a recession, when the number of open vacancies is low, is difficult. It is extremely difficult if skills do not match with current requirements in the workplaces. Many were forced to join and many were stucked in the ever-expanding pool of unemployed. Despite the very strong and long-lasting recovery period, a great deal of production potential is still wasted as almost one tenth of the labour force is still unemployed.

The focus of this study is to investigate the restructuring process from the productivity evolution perspective. We try to evaluate whether the changes in the economic environment in general and during the recession in particular have had an impact on productivity performance at the aggregate level, as a casual look at aggregate productivity indicators might suggest. If there were inefficient units before the recession, protected by a 'soft' economic environment, for example, we might expect that the depression would have done the job of 'cleansing'.

Destruction is not 'creative' in a sensible meaning of the expression unless it is not accompanied or followed by creation of high productivity jobs among new or incumbent plants. Therefore the recovery period deserves special attention. The productivity of an individual is dependent on his or her skills as well as on the characteristics of the workplace.[1] The acceleration of productivity growth is of low value if the increased average productivity is 'created' by setting low-skilled individuals aside into unemployment or by pushing them into early retirement.

A strong focus on the manufacturing sector has characterised the analyses of both productivity and job flows leaving the service sector with less attention. This study attempts to provide at least some improvement to this grievance by including service industries into the analysis as well.

The rest of the paper is organised as follows. In section 2 we present some theoretical considerations regarding micro-structural change and productivity growth. In section 3 we discuss the methodology of productivity decomposition, which is the main analytical tool used in this study. Data sources are described in section 4. The empirical analysis is presented in section 5 and section 6 concludes.

2 Theoretical perspectives on resource reallocation

The idea that the nature of competition and resource reallocation are crucial elements of economic growth traces back to the work of Joseph A. Schumpeter. In 1942 (page 83) he introduces the notion of 'Creative Destruction'. He states that 'The fundamental impulse, that sets and keeps the capitalist engine in motion comes from the new consumer's goods, the new methods of production…' He argues that this process incessantly creates new and destroys old.[2]

Creative destruction models of economic growth point out that the process of adapting new products and new methods requires the destruction of old products and methods. To take an example, a process innovation may require constructing a brand new machine, because the old one cannot be retooled. Old vintage capital becomes obsolete. It is said that technology is embodied in capital (see for example Hulten, 1992). The same may hold true for skills, too. When new knowledge becomes eventually embodied in labour through learning and training, turning to new human capital, it is possible that some of the older skills become obsolete from the point of view of best-practise conduct.

[1] See Ilmakunnas, Maliranta, and Vainiomäki (1999) for the roles of plant and worker characteristics for productivity and wages.

[2] Böckerman (2000) provides a survey on the Schumpeterian insights.

Schumpeter viewed the competitive struggle among firms as one that sustains economic progress. Firms make investments, which involve sunk costs, to create superior technology. The incentive to make innovations comes from the expectation that it will be able to capture monopoly rents in the future.

2.1 Elements of creative destruction

Aghion and Howitt (1992) develop a model that formalises the Schumpeterian idea that progress creates losses as well as gains. A firm makes investments in R&D in order to create a new innovation. When a new innovation is adopted, the monopoly rents of the previous innovator are destroyed. The firm receives monopoly rents until the knowledge underlying the rents becomes obsolete as a result of new and better innovation made by a competitor. This model points out that the incentives for investment in R&D and thus the economic growth are influenced by the process of creative destruction. There is a race for rents associated with technological advancements among firms and the struggle generates turbulence.

An essential point of the creative destruction argument is that heterogeneity in technological (and productivity) levels is systematically associated with reallocation, which is the outcome of dispersed growth rates. The greater the dispersion of technologies and the tighter the relationship between growth and performance levels at the firm- or plant level, the greater is the role of creative destruction for productivity growth and economic progress.

Davis and Haltiwanger (1999) present a model that they use for considering the productivity-enhancing role of factor reallocation. Their model suggests that unleashing the creative destruction process is likely to bring about a lot of losses in the short-term in terms of unemployment and consumption. However, they show that the longer-term gains to allowing the creative destruction may be enormous. This model describes the one-shot cure (unleashing creative destruction) to the inefficiency originating from distorted micro-structures. As such it is suitable for the analysis of that type of cases, where the business environment has experienced a radical change for example due to some policy reform. Davis and Haltiwanger consider especially the case of transition countries.

In their model, the technological level and technological progress of the firms are taken as given. Productivity grows within plants at equal rates. At times there are two types of firms in terms of productivity levels and all what happens subsequently is reallocation of the labour force between them. While in the long run the aggregate productivity growth is dominated by the technological progress, there is little role for other factors, e.g. job creation and destruction.[3]

Of course radical changes in the business environment are exceptional. In many cases a more useful framework would include modelling incessant technological steps and heterogeneity as an outcome of continuous innovation activity made in profit maximising firms, as is the case, for example, in Aghion and Howitt's (1992) model (and in many others).

---

[3] Several authors, e.g. Färe, Grosskopf, Norris, and Zhang (1994), Pohjola (1996) and Koop, Osiewalski, and Steel (1999) have used an approach where productivity growth is divided into two distinct components. The first is the shift of the production frontier, which indicates the maximum technically feasible output with given inputs. This component shows the speed of technological progress. The second component, the change of the distance from the frontier, indicates the change of (in)efficiency. While the source of curing the inefficiency will eventually be exhausted, in the long run there is no role for factors cleansing inefficiency, unless the continuous emergence of new inefficiencies is an unavoidable consequence of technological progress.

The identification of the sources of plant level dispersion in technology and productivity levels can be started from the firm level. Klette and Griliches (2000) present a model of endogenous firm growth with R&D investments and stochastic innovations that draws on the quality ladder models in the macro growth literature. In this model product innovations are created by R&D investments that are treated as non-rival input in production.[4] The higher the R&D intensity is, the higher are the ladders that will be constructed for the industry within a given period of time. As typically in the quality ladder literature, they assume that a firm's sales (or market share) increase with its product quality, which is a cumulative outcome of innovative steps made in the past. They extend their basic model to a simultaneous study of several heterogeneous firms competing within an industry with vertically and horizontally differentiated products.

One of the numerous implications that their framework is able to yield is that the variance of firm growth rates is higher in industries with a higher rate of innovation. They point out that this proposition is consistent with Klette and Førre's (1998) finding that more R&D intensive industries have higher rates of job reallocation in Norway. Vainiomäki and Laaksonen (1997 and 1999) find similar results for Finnish manufacturing. Also Maliranta (2000) shows that job reallocation is strongest among R&D intensive firms.[5]

The model presented by Klette and Griliches neglects, as they remind us, the stylised fact that there exist persistent differences in R&D intensities even within narrowly defined industries. Firms may have ended up to different technology choices, R&D efforts and strategies when endeavouring maximum present value of profits. They may have different ability to adopt and develop new technologies (see for instance Hobijn and Jovanovic, 2000). Lambson (1991) states that uncertainty about future cost or demand conditions encourages firms to differentiate their choices. Some firms may carry on their profitable activities with less advanced technology, which was adopted once in the past with some sunk costs. As Hjalmarsson (1973) puts it: as long as firms find themselves having non-negative quasi-rent, they have their raison d'être with their past choice.

Since technology is a non-rival good, and to at least some extent excludable, a firm is usually unable to reap all fruits of its R&D effort. Seeing from the other side, instead of creating technology for itself by itself, it can also absorb technological knowledge that is spread from other innovative firms. Knowledge spillovers among firms, from best practise firms to low productivity firms, can in itself be expected to bring about convergence in technology levels (internal adjustment) and thus to mitigate the need for structural change among firms (external adjustment).

However, the utilisation of knowledge spillovers is not costless and the ability to adopt new technological knowledge may vary between firms. Moreover, the diffusion of knowledge is not instant. Nasbeth and Ray (1974) and Rogers (1983) document multi-year lags in the diffusion of knowledge about new technologies among firms producing related products. Therefore, it is also possible that the new knowledge does not reach all firms equally fast because of having different networks or geographical locations. For these reasons, the diffusion of technological knowledge from abroad may generate heterogeneity in terms of technological knowledge among domestic firms.

---

4 This is to say that once a new type of product is developed, no additional costs are involved in the production. This is a distinctive feature of technological knowledge. Once you possess a piece of information about how to produce a certain product in a better way, you can make use of this knowledge repeatedly without extra costs.

5 It should be noted that the widely used ‘excess reallocation’ or ‘gross reallocation’ measures (see Davis, Haltiwanger and Schuh, 1996) do not necessarily provide reliable indication of changes in the market shares (i.e. reallocation). For example, ‘excess reallocation’ is typically procyclical, but according to our calculations, the divergence of employment growth rates measured by the employment weighted standard deviation appears to be counter-cyclical rather than procyclical in Finnish manufacturing.

Next we move to the plant level, which will be the level of our primary consideration. Achieving productivity gains with some new technological knowledge requires implementation and embodiment at the plant level. One form of vintage capital models states that only new establishments can adopt new technology. This approach emphasises the role of entry and exit. However, even though new technology is embodied in new capital, it can be implemented also among existing plants through retooling (see Cooper, Haltiwanger, and Campbell, 1997). The ability to extend existing technology with a more modern one may, however, vary across different types of plants. Given the cumulative nature of technological progress, as outlined for instance in the model of Klette and Griliches, one would nevertheless expect modern technology to be more easily integrated with relatively new technologys vintage and equipment capital than with ancient ones.

This would have some implications to the ways in which multi-unit firms can be expected to adjust their operations.[6] Expansion of operations can, in turn, be expected to concentrate on newer production sites with higher performance level and/or greater expected opportunities to be retooled when new technological advancements emerge in the future. This notion gains empirical support from the results by Ilmakunnas and Maliranta (2000b, 2000c, and 2000d) for Finnish manufacturing and the private sector as a whole. Relatively new plants had higher job creation rate and net employment growth compared to older ones. On the other hand, they have also had higher job destruction rates. This all seems to suggest that there is a selection process in operation, especially among relatively new units.

Davis, Haltiwanger, and Schuh (1996) report similar results for job creation and destruction in US manufacturing. Campbell and Fisher (1998) point out that job creation, destruction and net employment rates of young plants are more volatile than those of older ones, i.e. young plants are more responsive to aggregate disturbances. They argue that this reflects greater organisational flexibility in young plants, indicating that new plants are more able to rearrange production. However, the updating of the technology may have to be supported by new workers with modern skills and changes in the workforce composition. This is in agreement with the findings on worker flows by Ilmakunnas and Maliranta (2000c). Worker inflow and churning[7] (i.e. excess worker turnover) are shown to be especially voluminous among relatively new plants, when various factors are controlled (e.g. plant size, educational level of employment, average age and seniority of employment, etc.)

2.2 *Inefficiency*

Productivity dispersion at the plant level may reflect differences in disembodied technological knowledge between owner-firms as well as differences in the technological knowledge that is embodied in the capital, labour force and local managers. Leibenstein (1966), in contrast, argues that units similar in all relevant aspects might have different productivity due to differences in X-inefficiency. As has frequently been pointed out, a sharp distinction between low relative technological levels and X-inefficiency is difficult to draw, and this is especially the case when technology is given a broad interpretation including, for example, managerial skills. The difference is important to keep in mind, however. Borenstein and Farrell (2000) put it strongly: 'X-inefficiency is surely among the most important topics in microeconomics'. They (1999) argue that organisations do not generally minimise costs or maximise value. There is sheer inefficiency and rent dissipation.

---

6 Multi-unit firms account for about 2/3 of Finnish manufacturing employment.

7 The churning rate is defined as worker inflow rate + worker outflow rate - job creation rate - job destruction rate (see Burgess, Lane, and Stevens, 2000).

From the standpoint of aggregate productivity evolution, the part of measured inefficiency that can be attributed to 'remediable defect' (see Torii, 1992) or 'fat' (see Borenstein and Farrell, 1999) is of special interest. If there exists such inefficiency among plants that is not inevitable and changeless, it would be important to know, by which policy action the factors lying behind this type of waste of resources can be renovated. Actions designed for alleviating inefficiencies may have high returns. The fat hypothesis states that a firm is most apt to cut costs to reduce X-inefficiency when it is under financial pressure (see Jensen, 1986). Nickell (1996) provides some evidence that competition improves corporate performance. He also mentions that competition may affect aggregate performance through a selection and restructuring process. When considering the selection bias toward overstating the positive effect of competition on productivity that will occur when only those with a positive productivity shock survive, Disney, Haskel, and Heden (2000) conclude that competition raises both the level and the growth rate of total factor productivity in the plant. In other words, competition appears to boost overall productivity performance through, what they call, internal restructuring[8] such as new technology and organisational change.[9] Exists and entries appear to have outstanding contribution to aggregate productivity performance especially during recessions. How competition affects aggregate productivity through restructuring among incumbents is not considered in their study.

Let us now go back to a multi-unit firm that feels the need for trimming, say, due to a negative wealth effect it has experienced because of a fall in prices in its product market. One would expect that the firm tries to seek opportunities to cut the costs with the least amount of losses in output. This would lead to downsizing of labour in its most inefficient units. If the inefficiency is prevalent and differences in the extent of inefficiency are substantial, hardening competition is likely to bring about micro-structural changes at the plant level. There is, however, one important difference in the consequences compared to those resulting from the cleansing of lower technology units incapable to yield positive quasi-rents anymore. If the low productivity is due to inefficiency rather than low-level technology, we would expect that downsizing is more likely associated with extra productivity growth within low-productivity plants. We would expect to find convergence in the plants' productivity levels.

Haskel and Sanchis (2000) present a bargaining model for explaining productive inefficiency. Their theory builds on the idea that workers can bargain over low effort if they and the firm have some monopoly power. Their model provides a theoretical explanation of why competition can be expected to alleviate technical inefficiency. The lower amount of surplus to be bargained on may lead to higher effort. They point out, however, that this outcome is by no means inevitable. Union preferences might be so strong over effort that they would choose lower effort even thought it would mean even a larger decrease in (gross) wages. We would expect that this outcome is the more likely to occur, the higher is the marginal income tax rate.[10]

Cappelli (2000) distinguishes downsizing from layoffs, the latter traditionally associated with shortfalls in demand and economic downturns. The distinctive feature of downsizing is that it is driven by the search for operating efficiencies (or endeavour to heal existing inefficiencies). While traditional layoffs were typically temporary Cappelli states that a characteristic feature of downsizing related layoffs is that they are permanent. As only some firms have performed downsizing actions and with different rates,

---

8 Levinsohn and Petrin (1999) call this the 'real productivity case'.

9 See also Stennek (2000).

10 The marginal income tax rate may be relevant not only from the perspective of internal adjustment (i.e. lowering technical inefficiency in plants), but also from the point of view of external adjustment. The higher the marginal tax rate, the less workers have incentives to seek for higher wage and higher productivity jobs. In firm level wage formation, the staff of firms with declining relative productivity may be more apt to declining relative gross income in order to sustain non-pecuniary and non-taxable compensation. In the Finnish system, workers are not generally allowed to accept below norm wage levels or even below norm wage raises. The norms are determined in the agreements negotiated in the collective bargaining (see below).

those factors causing downsizing can be expected to generate permanent re-structuring at the plant level with likely positive aggregate productivity consequences. The articulated aim of Cappelli's empirical work was to identify those factors. He finds that profit sharing for managers and technicians as well as stock options are associated with job losses (i.e. job destruction) and downsizing, which is defined in the study as job destruction in the case where a plant is operating at or above its normal capacity. Of course, an interesting question would be why profit sharing and stock options have been adopted in some firms and what might be the ultimate reasons for the increasing popularity of these tools (and downsizing).

2.3 Nature of competition

Baldwin (1993) stresses the differences between two conceptual approaches to the notion of competition. The more traditional and widely adopted approach is to see competition as a state of affairs. An alternative and complementary view, that follows the trails marked out by Schumpeter, Hayek and the Austrian school, sees competition as a dynamic process.

The intensity of competition in its traditional meaning is typically evaluated with indicators such as the number of firms, concentration, advertising ratios, etc. If these measures can be shown to be related to cross sectional differences in profitability, one could argue that they can be used for assessing the intensity of the competitive process.

However, as it comes to productivity and economic development, one should have a long term view (see for example Baumol, Blackman, and Wolff, 1989). Firms are maximising the present value of their future cash flows. Technological advancements that are anticipated to open profit opportunities are usually outcomes of sustained costly development efforts. The presence of high profits found at one point in time does not necessarily mean that these firms are having excessive profits over their whole life cycle. These considerations lead us to seek some complementary indicators that better characterise the dynamics of competition.

Mobility measures provide us with an alternative way to evaluate the intensity of competition. Simultaneous occurrence of declines and rises within an industry suggests that there is competitive struggle taking place. The fact that someone seems to win over others straight up does not mean that the competitive pressure is missing. On the other hand, as Baldwin points out, the lack of changes in the relative positions does not preclude the possibility that there is hard struggle. It should be noted that even when the market shares of the firms are relatively stable there might be a substantial amount of restructuring taking place within multi-unit firms, as firms are trying to make best use of their resources. Disney, Haskel, and Heden (2000) find that much of the restructuring effect in UK manufacturing has come from multi-unit firms closing down poorly-performing plants and opening better-performing new ones.

It is useful to consider some factors that may affect the intensity of competition in its dynamic meaning. Bertin, Bresnahan, and Raff (1996) find that the Great Depression in the United States did not have a cleansing effect in blast furnace operations despite the presence of very substantial interplant heterogeneity and dramatic changes in demand. They argue that the economic explanation of this lies in the poor short-run substitutability of one plant's output for another's. Therefore we would not expect the policy action. For instance, the presence of domestic monopolies may be due to regulation and subsidies.

Increased exposure to global competition through export, import or foreign ownership can be expected to affect restructuring in various ways. Business contacts with foreign suppliers or customers may create a channel for technological transfer that in turn may tend to increased heterogeneity in technologies among incumbent domestic producers (learning by exporting). Foreign ownership can be expected to generate a technology transfer effect in the form of building new transplants and diffusion of knowledge; a mechanism emphasised by, for instance, McKinsey Global Institute (1993).

Bernard, Eaton, Jensen and Kortum (2000) state that international economy plays an important role in determining which firms are capable to survive and expand. Lowering trade barriers are apt to filter low productivity plants out while giving opportunities to high productivity plants to sell more abroad. This is to say that the increased outward-orientation is likely to bring about productivity-enhancing restructuring. For example, Tybout and Westbrook (1995) find that the open sectors in Mexican manufacturing did relatively well in terms of shifting market shares toward the more productive plants.

Okamoto (1999) provides evidence that the positive effect of multinationals comes through increased competitive pressure rather than technology transfer. Increased competitive pressure may induce improvements in X-efficiency or productivity-enhancing external adjustment (see also Caves, 1974). The analysis by Okamoto (1999) focused on the role of Japanese multinationals in the US auto parts industry. Hardening competition may compel domestic firms to seek for operational inefficiencies (see Okamoto, 1999). To make sure that managers do their best to guarantee profits and survival in the global markets, owners may try to find incentives in order to encourage sound conduct (see Richards, 1998) and also carry out downsizing if needed.

Empirical results concerning the role of 'outward-orientation' for job flows and restructuring are somewhat mixed. Davis, Haltiwanger, and Schuh (1996) did not find any systematic relationship. However, Levinsohn (1999), Salvanes and Førre (1999), and Gourinchasin (1999) find evidence that the openness fuels restructuring of jobs. Thus, the latter studies give some grounds to suspect that 'outward-orientation' may affect aggregate productivity performance through external adjustment.

Clerides, Lach, and Tybout (1996) do not find evidence that the presence of exporters reduces the unit production costs of neighbouring firms. On the other hand, they observe some indication that the presence of other exporters might make it easier for domestically-orientated firms to expand to foreign markets. Moreover, they argue that the productivity gap between exporters and non-exporters is mainly due to self-selection rather than learning by exporting.

McKinsey Global Institute (1995) argues that Sweden's overall low performance is primarily a result of an unusually low level of competitive intensity in most parts of the economy. The low competitive pressure has deprived corporations' incentives to adopt global best practises and to innovate continuously. Retailing, construction, and food processing provide the best illustrations of the negative causal chain between competition and performance. The Institute also lays stress on the fact that Sweden's successful industries, like heavy trucks, computer software and the deregulated banking sector, demonstrate the benefits of competition. The paper industry should also be mentioned in the argument, as it certainly has been relatively exposed to global competition and has had (just like Finland) a high productivity level according to the results of Maliranta (1996).

2.4 Recessions and Crises

Sometimes an economy confronts a widespread, abrupt and dramatic change in the economic development. That type of episodes were experienced in the United States in the 1930s, and in Finland, Sweden, Eastern European transition countries as well as in many Asian countries in the 1990s.

In their pioneering work Caballero and Hammound (1994) investigate industry response to cyclical variation in demand in the framework of a vintage model. They state that cyclical variation in demand is likely to cause 'creative destruction', as outdated units are the most likely to turn unprofitable and be scrapped in a recession. However, they call also attention to the possibility that incumbents can be 'insulated' from the fall in demand by a reduction in creation. Considering empirical evidence in US manufacturing, they find that the former aspect has dominated and conclude that recessions can be characterised as times of 'cleansing'.

In more recent works Caballero and Hammour (1999 and 2000) have, however, taken a longer perspective to the role of recessions in the economic development. They argue that when one considers the cumulative effects of a recession, the 'liquidationist' thesis about the constructive effects of recessions is likely to be reversed. Their time-series analysis of gross job flows in US manufacturing over the period 1972-93 provides evidence that there has been a reduction in cumulative factor reallocation following a recession. A recession is followed by a 'chill' characterised by reduced job destruction as well as job creation. They argue that this chill is costly, and that it adds about 40 percent to the traditional unemployment costs of recessions. It is important to note that contrary to the traditional wisdom that recessions are harmful because of increased separations, according to their insight the recessions have negative welfare consequences because decreased cumulative restructuring (e.g. less separations) hampers long term economic growth.

They identify two separate mechanisms that would predict a cumulative chill, rather than increased cumulative turbulence of a recession. Imperfections in the financial markets may lead to an insufficient amount of creation. As there is less creation, some incumbents are 'insulated' from destruction during the recession and recovery. The second effect works through the productivity selection mechanism. The recession materialises through both an increase in destruction and a decrease in creation. If potential entrants are heterogeneous in terms of productivity levels and the selection is selective, the average productivity of the entrant pool rises with lowering creation. In other words, after the recession there should be less than a normal amount of low productivity newly established units.[11] The absence of relatively low productivity entrants reduces destruction in the ensuing recovery. Caballero and Hammour (2000) further claim that scarcity of financial resources during the recovery limits the socially useful transfer of resources from low to high productivity units.

The crux of several works by Caballero and Hammour is that recessions are times when it becomes too expensive to maintain the least productive units. Other type of reasoning is provided in models by Aghion and Saint-Paul (1991), Hall (1991), and Cooper and Haltiwanger (1993). These are based on the idea that during the slowdown it is relatively cheap to innovate and reorganise. This can be called the "pit-stop" or "opportunity cost" view (see for example Caballero and Hammour, 1994, and Schuh and Triest, 1998). A common feature of both types of theories is that changes in demand can affect restructuring. The mechanism may involve an 'insulation' element or changes in the relative costs of different types of activities.

Of course, business cycles and restructuring may be mutually entangled also in other ways. Schuh and Triest (1998) consider the possibility that the restructuring of production technology causes business cycle fluctuations. They identify the type of theories of countercyclical reallocation stressing the role of allocative forces that induce reallocation across units and sectors. While reallocation is costly and time-consuming, aggregate demand and output decline. A few couple of factors were already mentioned above that can be expected to affect reallocation, such as a change in the economic environment entailed with, for example, increased international competition and increased innovation activity.

[11] According to this view, greater business fluctuations would generate less experimentation.

Schuh and Triest (1998) mention oil prices and swings in exchange rates (which can be related with exposure to internal competition). Also, divergent development in different (export) markets may cause divergent employment growth and investment rates among plants orientated to different markets. Pohjola (1998b, 309-314) presents a model where a change in relative prices due to deregulation leads to an allocation shock in the economy. A recession is an immediate outcome due to the specificity of capital and the fact that labour and capital are complements. The analysis by Gourinchas (1999) provides empirical evidence from France that shocks in exchange rates affect job flows, but most of the variation takes place in those industries that compete with imports.

Caballero (1998) is suspicious about whether reallocation shocks can explain the behaviour of economic cycles in a modern developed country such as the United States. However, when a country is taking some important steps, e.g. deregulation, to encourage long-term economic progress, short-term pain due to micro-level restructuring may not be avoided. This may be the case in the Eastern European transitory countries or less developed countries trying to catch up the leader countries. The failure of institutions to accommodate reallocation may prevent or hamper the materialisation of catching up opportunities (see Caballero and Hammour, 2000).

2.5 Institutions and policy considerations

The idea that the functioning of the economic and political institutions may be important for the static and dynamic efficiency[12], which determines the current and future productivity, is by no means new. Olson (1982) states that institutional sclerosis may stifle economic progress. As mentioned above, more recently Caballero and Hammour (2000) have emphasised the role of institutions in resource reallocation.

Product markets

We have pointed out above the potentially important role of competition in the product markets in the context of inefficiency. Reforms that lead to increased competitive pressure in the product markets among firms and plants can be expected to lead eventually to more productive use of resources and increased living standards. This may come in the form of internal adjustment (e.g. firms and plants eliminate inefficiencies that may occur in their operations) or in the form of external adjustments[13] (the share of firms and plants incapable to use resources efficiently is diminished). As shown by Olley and Pakes (1996), the regulatory process in the manufacture of telecommunications equipment appears closely related with factor reallocation and productivity movements in the United States. McKinsey Global Institute (1996) stresses the importance of encouraging product market competition, lowering barriers to entry and prune regulations.

Capital markets

On the other hand, Börsch-Supan (1998) argues that without capital market pressure, unproductive firms will not exit even in the face of hard product market competition. If investors allow bad capital management in a firm, the lack of capital market pressure is likely to lead to bad conduct in operations' effectiveness, product-line management, pricing, capital purchasing decisions, and industry chain management (see Börsch-Supan, 1998). At the nation-wide this means that some resources are

[12] Wihlborg (1998) discusses properties and requirements of static and dynamic (or 'Schumperian') efficiency.
[13] Levinsohn and Petrin (1999) denote this the 'rationalisation case'.

wasted because of bad management. This issue is important, for example, from the point of view that different countries have had quite different institutions for capital markets.

McKinsey Global Institute (1996), Börsch-Supan (1998), and Baily and Zitzewitz (1998) have compared capital productivity and financial rates of return on capital between countries for various sectors. The results suggest that generally capital is used much more efficiently and profitably in the United States as compared to Germany, Japan or South Korea. Pohjola (1996) blames the Finnish economy for inefficiency in capital input usage. Maliranta (1996) finds that capital productivity in Finnish manufacturing was some 3/4 of that in the United States in the late 1980s, when capital input was measured with the machinery and equipment stock, and somewhat lower when all tangible assets were included. According to Maliranta (1995) capital productivity relative to the United States was 56 percent for the Finnish economy as whole in 1990 (see also Pohjola, 1996).[14] According to a recent study by Walton (2000), the increase in the ratio of profits to capital has been exceptionally fast in Finnish companies after the recession. In the service sector (excluding financial companies) the United States has been the leader, but Finland is next before the United Kingdom and Norway. The return on capital for US manufactures was over 20 percent in 1999, which was the highest return rate after Singapore. Nowadays also Finnish manufacturing companies do well in international comparisons with a return on capital of 16 percent.

Richards (1998) stresses that active owners are needed in order to encourage corporate efficiency in the usage of capital and the allocation of resources to those with the best ability. Institutions are likely to have a decisive role in how well the interests of the owners are taken into account. Ramey and Shapiro (1998) find evidence that there was a significant increase in capital reallocation across firms and industries during the 1980s and 1990s with significant economic consequences. In particular, their results seem to indicate that increased capital reallocation has increased labour productivity growth.

Sometimes US financial markets are blamed for focusing on the short-term. Empirical evidence, however, seems to suggest that excessively passive patience is more likely to jeopardise long-term economic performance.

Labour markets

Labour is another important factor of production. For some reason, the functioning of labour markets has attracted more notice than that of capital markets in the context of assessing the economic performance of nations. Rigidities in labour markets have often been seen as one of the predominant factors behind recent economic problems in many European countries.

It is, however, worth noting that restrictions in the labour markets (e.g. firing cost policies) are usually implemented together with wage compression policies (see Bertola and Rogerson, 1997). Wage compression as such is apt to lead to greater job flows and greater job reallocation. But in the absence of wage differentials across 'good' and 'bad' firms there are no incentives for mobility from the workers' part. Acemoglu and Shimer (2000), for example, argue that when there is no wage dispersion, workers do not search enough, and there is a less than optimal amount of competition for labour. On the other hand, if wages are compressed by, for example, collective agreements, the greater mobility is a result of the fact that there is no 'extra tax' for plants capable of using resources efficiently and no 'allowance' for the inefficient ones. In this type of environment workers try to find a new job because they have been laid off or feel a threat of loosing their jobs shortly.

---

[14] This is about the same level as in Germany and Japan, for example.

Determination of wages in the 'Scandinavian' model within the 'framework wage agreements' that are being negotiated between government, employers and major trade unions differs considerably from that of the USA. Uniformity in wage increases or even efforts to compress wages have obtained more emphasis at the cost of the viewpoint of the firm's or industry's profitability or 'ability to pay'. Hibbs and Locking (2000) point out that the central union pay policy may explain at least partly why wage levels across firms and industries in Sweden exhibit no 'non-competitive' correlations with profitability, average productivity and capital intensity. This would mean that identical workers (with identical working conditions) receive the same wage irrespective of the provitability, productivity or capital intensity of the industry or the firm.[15]

The analysis of US manufacturing by Dunne, Foster, Haltiwanger, and Troske (1999) demonstrates that the dispersion both in wages and in labour productivity exhibits a sustained increase over the period 1975-1993. They point out that there exists a positive cross-plant relationship in the level of wages and productivity as well as in the changes in wages and productivity. They argue that there is a link between wages and productivity that explains the co-movement of the dispersion.

They refer to the work by Caselli (1999), where it is argued that technological revolution which occurs in the form of appearance of new types of machines can be expected to lead to segregation. When a skill-biased revolution comes into being, high skill (and high wage) workers occupy high productivity plants that have new generation machines. Low skilled workers (or those uninformed about technology possibilities, see Acemoglu and Shimer, 2000) continue to use the old machines. An alternative explanation is that the widening dispersion in plant productivity levels leads to an increase in between plant wage dispersion because of rent sharing (or differences in "ability to pay"), for instance.[16]

When viewed from the framework outlined by Caselli (1999), we would expect that in the 'Scandinavian model' workers using old machines have to leave their jobs sooner after a technological revolution, because of shut-down of unprofitable production units. Of course, if these workers were using old machines because of inferior (or old dated) skills, some problems in the adjustment are likely to occur especially if the upgrading of skills is costly and time-consuming. It is possible that some become unemployed at least for a while in the course of the process of reallocation (see Aghion and Howitt, 1994, and Hall, 1995).[17]

So, during rapid technological progress worker mobility may be worthwhile as the greater exposure to modern technology in modern high productivity plants may fuel a faster upgrading of modern skills through learning. 'Creative destruction' among low productivity plants incapable of paying high wages may hamper the segregation process with the provision that these workers do not become permanently unemployed. Cross-matching of (initially) low skill and high skill workers in high productivity plants may promote the increase of the average skill level in the nation. This can be expected to occur if the lower-skilled are able to learn from higher-skilled co-workers. On the other hand, Kremer's (1993) so-called O-ring theory emphasises that the effectiveness of an entire production operation is limited by the least-efficient input. So, according to this view cross-matching might lead to losses in production in the plants, if the upgrading of low skills is not quick enough.

---

[15] The role of collective bargaining, institutional wage compression and growth is discussed also in Flanagan (1999, see especially pages 1163-1164).

[16] Aghion, Caroli, and Garcia-Penalosa (1999) provide a comprehensive survey on the literature concerning inequality and economic growth.

[17] In fact, there do not seem to be very large differences in job reallocation between European and US economies. Worker flows into unemployment and from unemployment are, in effect, much more voluminous in the United States (see Pohjola, 1998a, 31-36).

Hibbs and Locking (2000) argue that the reduction of inter-industry wage differentials in Sweden has contributed positively to aggregate output and productivity growth. Unemployment records of Sweden, Finland and other Scandinavian countries, at least up to the early 1990s, suggest that the rise in the unemployment rate is not an inevitable consequence of the greater external adjustment that wage compression is likely to generate. On the other hand, it is possible that until the early 1990s the Scandinavian countries have not confronted such abrupt technological revolutions or allocation shocks that could not have been handled with active labour marker programmes.

The match of institutions

Of course, in practise the management of labour and capital input is so intrinsically interwoven that there is no point to deliberate which one to blame if the overall productivity performance is lagging behind the benchmark conduct. Capital productivity is affected by work practises (Börsch-Supan, 1998, 209) that in turn may be subject to bargaining (Haskel and Sanchis, 2000). Efficient labour markets may be needed so that managers are able to make sound investments and to make best use of the available assets (Richards, 1998).

Caballero and Hammour (1998) argue that the failure of European labour institutions to operate in the presence of appropriability of specific quasi-rents explains recent trends in unemployment, labour share, profit rates and capital productivity. In the long run firms are able to substitute capital for labour. Attempts to appropriate capital have induced substitution of capital for labour. They state that deregulation and the integration of EU product and financial markets may have, in the absent of commensurate labour market reforms, sharpened the unsound tendencies. This is because those steps that have been taken have probably enhanced factor substitution possibilities.

Policy-making

Caballero and Hammour (1998) recommend deregulation in the labour markets (see also Caballero and Hammour, 1996). But as we are reminded by Pohjola (1998b, 314) it is hard to see, what type of reforms would be needed to mitigate the hold-up problems underlying the failure of institutions to generate efficient outcomes regarding investments and employment. As noted above, the centralised bargaining system in Sweden until the early 1980s appears to have diminished the appropriation of quasi-rents in firms and industries. McKinsey Global Institute (1996) draws as a conclusion from their aggregate- and micro-level evidence that labour market factors may have played some role in some industries but they are not the primary cause of the low productivity performance in Sweden.

Stabilisation policy may have not only short-term effects but may affect long-term growth as well. While the latter is particularly essential from the standpoint of welfare considerations, it is worth considering some elements of sustained growth. It is pointed out that as recessions are the periods in which opportunities to cumulate experience through learning by doing are wasted, one may expect that counter-cyclical fiscal policy to have favourable long-term consequences (see Martin and Rogers, 1997). As discussed above, Caballero and Hammour (2000) claim that the cumulative effect of recessions is likely to decrease restructuring, and thus may have negative effects on long-run productivity and growth. A model by Ewijk (1997) suggests that mild fluctuations may be beneficial for growth, but severe fluctuations will be harmful. The argument goes much along the line of the 'pit-stop' view. Business cycles change the relative costs of innovating and producing, which brings about intertemporal substitution between production and productivity improving activities with positive overall long-term consequences. Severe recessions are harmful, because of a decline in learning-by-doing.

Empirical findings on worker mobility suggest that churning (i.e. simultaneous hirings and separations in firms) in the labour markets diminishes during recessions. This would lead to negative productivity consequences in the long run if matching of employers and employees is an important element of productivity growth. For example, Ilmakunnas, Maliranta, and Vainiomäki (1999) provide evidence that a high worker churning rate is positively associated with high productivity growth rate. Maliranta (2000), in turn, shows that the churning rate is typically highest among firms with a high R&D intensity, which may reflect the fact the innovations increase the need for matching of jobs and persons. Hassink (2000) finds that quits are frequently used in job destruction. The freeze in labour markets and a lower number of open vacancies during recessions discourage voluntary quits, which would be useful for plants having a need to make downward adjustments in employment. This is because firms prefer strongly natural attrition over costly layoffs as a tool for reducing employment (Davis and Haltiwanger, 1999). Therefore the more silent life in the labour markets during recessions may hamper job reallocation, which may in turn stifle productivity growth.

All in all, there are various of reasons why stabilising policies may have desirable long run consequences. However, if stabilisation policy means that incumbents are rescued in times of economic hardship, and incumbents anticipate this, stabilisation policy may diminish the incentives for incessant trimming of firm's operations.[18] We might expect that if technology and allocation shocks play an important role, stabilisation policy may be less successful. Bentolila and Bertola (1990) state that higher firing costs are likely to have positive consequences from the standpoint of a more stable labour demand by a given firm. They point out, however, that desirable employment stabilisation has to be traded off against the undesirable productivity inefficiency that it may have. Hopenhayn and Rogerson (1993) have carried out an analysis of the long run effects in a general equilibrium framework, which suggests that a tax on job destruction at the firm level entails a sizeable welfare loss caused primarily by a substantial decrease in average productivity. This outcome is in agreement with that obtained from a model by Davis and Haltiwanger (1999) that was introduced in Section 2.1 above. They point out that there may be a serious conflict between short-run stabilisation needs and long-run goals. Unleashing the reallocation process leads initially to a sharp decline in output and consumption and a rise in job destruction and unemployment. However, despite the short-term pain, welfare gains in the longer term may be enormous, if there was initially a serious distortion in the micro-structures. But as it is argued above, sound institutions will be needed to carry out the transition successfully.

2.6 A brief summary of theoretical considerations relevant for this study

Our theoretical considerations presented above suggest that to reap the fuits of R&D efforts fully may require plant level reallocation of inputs. This is likely to be the case especially if the innovations produced by R&D need to be embodied into some inputs (e.g. capital) by irreversible investments. This means that technological progress of an industry entails restructuring through simultaneous job creation in some plants and destruction in others. Also capital input needs to be reallocated into such plants capable of using it efficiently. We would expect that (relatively) new plants play a central role in this creative destruction process, because they are likely to be more adaptive as it comes to new technology. Moreover, we will expect to find a lag between R&D and productivity improvement not only because it takes time to build and to learn to use new production possibilities within plants but also due to the need for reallocation of many inputs among plants.

[18] It is sometimes argued that repeated devaluations led to dissipating behaviour among Finnish forest companies, for example.

Exposure to global competition should also be important for productivity-enhancing structural change. It may enhance technology transfer from abroad generating possibly need for restructuring at the firm- and plant-level. Outward orientation will also increase competitive pressure that may give stimulus for input reallocation by eating quasi-rents of low technology and/or inefficient plants and firms.

The level of technology and productivity compared to the international frontier may be relevant since catching up the benchmark technology may require divergent development at the micro-level, i.e. restructuring at plant level.

Institutions may play a decisive role in creative destruction process as well. Wage compression resulted in a centralised bargaining system, for example, may promote cleansing of low productivity plants.

3 Methodology of productivity decomposition

There is a wide variety of decomposition formulations for distinguishing different elements of aggregate productivity changes. Foster, Haltiwanger, and Krizan (1998) provide a survey on different methods and investigate their properties with plant level data. Before introducing methods to be used in the present study, it is worth taking a brief look at some properties of the available methods. [19] In the view of the points brought up in the previous chapter, we would find such methods useful that distinguish between the role of productivity growth within plants and external restructuring (productivity increase due to restructuring between plants). Moreover, when thinking of the fat hypothesis and X-inefficiency, it seems important also to consider the role of catching up among low productivity production units and the convergence in productivity levels among plants.

Usually researchers have access to aggregated data sets only, which can be thought to be constructed by taking sums over all units belonging to the industry or sector in question. For example, a sector or total economy level output in year t can be calculated from industry-level aggregates[20] that, in turn, are obtained by summing over all plants in the industry in question, i.e.

(1) $$Y_t = \sum_{st} Y_{st} = \sum_s \sum_{i \in st} Y_{it} ,$$

where Y is output and s and i denote industry and plant respectively.

Values of a certain type input X_{gt} is obtained in a similar manner

(2) $$X_{gt} = \sum_{st} X_{gst} = \sum_s \sum_{i \in st} X_{git} ,$$

[19] Empirical analysis of micro-level sources of aggregate productivity change with some decomposition method include for instance Baily, Hulten, and Campbell (1992), Baily, Bartelsman, and Haltiwanger (1997), and Foster, Haltiwanger and Krizan (1998) using plant-level manufacturing data from the U.S.; Aw, Chen, and Roberts (1997) using firm-level data from Taiwan; Tybout (1996), Liu and Tybout (1996) using data from Columbia, Chile, and Marocco; Griliches and Regev (1995) using data from Israel. Plant-level data from manufacturing is used by Maliranta (1997) for Finland, Andersson (1999) for Sweden, and Disney, Heden, and Haskel (2000) for the United Kingdom.

[20] In this study we focus on manufacturing sector and its 2- or 3-digit industries. It should be noted that it is quite common to use aggregate time series of total manufacturing or total economy in analyse of productivity in the context of cross-country comparisons, for example. So growth rates in that type of analyse are affected by structural changes at the sub-industry level as well as at the plant level within sub-industries. See also footnote 31.

where g denotes the type of input, e.g. labour or capital input. Usually aggregate productivity measures are calculated by using this type of aggregate values. For example, a single productivity measure for the g type of input at the sectoral level (P_{gt}) can be calculated from industry-level values or from plant level values as

$$(3) \qquad P_{gt} = \frac{Y_t}{X_{gt}} = \frac{\sum_s Y_{st}}{\sum_s X_{gst}} = \frac{\sum_i Y_{it}}{\sum_i X_{git}}$$

In order to have a more comprehensive indicator of productivity, it is useful to consider all (or the most important) inputs at one blow; that is, different types of inputs should be aggregated in some reasonable way in single input index. Multi-factor productivity may be calculated as

$$(4) \qquad P_t = \frac{Y_t}{f(X_{1,t}, X_{2,t}, \ldots, X_{N,t})},$$

where $f()$ is a function of N different types of inputs. Many studies have addressed the question to what extent aggregate productivity growth measures are biased due to insufficient narrowness in distinguishing different types of inputs, e.g. summing the hours worked by low skilled and high skilled without taking into account the fact that different items may have different efficiency (see, for example, Jorgenson, Gollop, and Fraumeni, 1987; Jorgenson, 1990; and Gunnarsson and Mellander, 1999). In this study we focus, instead, on the possibility that aggregate productivity measures are distorted due to aggregation over units.

The aggregate level single indicator productivity measure, as defined in (3), can be expressed in terms of plant level productivity

$$(5) \qquad P_{gt} = \sum_i w_{git} P_{git},$$

where P_{git} is a single input productivity indicator in plant i (Y_{it}/X_{git}) and w_{git} is the input weight of that plant:

$$w_{git} = \frac{X_{git}}{\sum_i X_{git}}.$$

Analogously, the aggregate multi-factor productivity indicator introduced in (4), which distinguishes N types of different inputs, can be derived from plant level information in the following way

$$(6) \qquad P_t = \sum_i w_{it} P_{it},$$

where P_{it} is an index of multi-factor productivity in plant i, $Y_{it}/f(X_{1,it}, \ldots, X_{N,it})$, and w_{git} is the input index weight of plant i:

$$w_{it} = \frac{f(X_{1,it}, \ldots, X_{N,it})}{f(\sum_i X_{1,it}, \ldots, \sum_i X_{N,it})}$$

Quite commonly plant level productivity indicators are aggregated by using output weights (see Baily, Hulten, and Campbell, 1992; Foster, Haltiwanger, and Krizan, 1998). In this case, however, the direct relationship with such productivity indicators, which can be calculated from aggregated data sets, is lost. Therefore, from now on we focus on input-weighted productivity decomposition methods. Another motivation for this choice is due to our aspiration to examine productivity-enhancing restructuring processes from the standpoint of job creation and destruction (or varying employment growth rates in different plants, to be more specific) as well as investment decisions made by plants that are heterogeneous in terms of ability to use inputs in a productive manner.

In a vast majority of studies aggregate productivity is calculated by aggregating the logs of the plants' productivity indexes using input or output weights, i.e.

$$(7) \qquad \underline{\ln P_{gt}} = \sum_i w_{git} \ln P_{git} \, .$$

It should be noted, however, that generally

$$\underline{\ln P_{gt}} \neq \ln \frac{\sum_{it} Y_{it}}{\sum_{it} X_{git}} = \ln P_{gt} \, .$$

The multi-factor productivity version of (7) is the following

$$(8) \qquad \underline{\ln P_t} = \sum_i w_{it} \ln P_{it} \, ,$$

where P_{it} and w_{it} are defined above.

The purpose of the decomposition exercise is to study the productivity growth rate at some aggregate level. When annual changes of productivity, as defined by (6), are studied, we can derive the following equation[21]:

$$(9) \qquad \frac{\Delta P_t}{\overline{P}_t} = \sum_i w_{it} \frac{P_{it}}{\overline{P}_t} - \sum_i w_{i,t-1} \frac{P_{i,t-1}}{\overline{P}_t} \, .$$

In order to have a change rate, all terms in the above equation must be divided by some appropriate productivity level measure. Usually the initial productivity level, P_{t-1}, is used as the denominator (see, for example, Baily, Bartelsman, and Haltiwanger, 1997). However, this kind of procedure does not render symmetric rates as it is the case when log-differences are used. One convenient solution to this problem is the one used in formula (9), where we use the average productivity level in year t and t-1, i.e. $\overline{P}_t = (P_{t-1} + P_t)/2$. This way of measuring growth rates yields a very close approximation to the log-differences of productivity indicator, given that changes are relatively mild. Using the average level as the denominator yields growth rates that can, in principle, vary in the interval (- 200 %, 200 %).

When productivity is defined in log-form, as in (7), the productivity growth rate can be measured as:

$$(10) \qquad \Delta \underline{\ln P_t} = \sum_i w_{it} \ln P_{it} - \sum_i w_{i,t-1} \ln P_{i,t-1} \, .$$

Generally formulations (9) and (10) do not provide identical values for productivity change, i.e.

[21] For convenience we express the equations without the subscript g denoting a single factor of production. It should be noted, however, that the multi-factor and single-factor cases are analogous.

$\frac{\Delta P_t}{\overline{P}_t} \neq \Delta \underline{\ln P_t}$. Baily, Hulten, and Campbell (1992) argue that industry growth rates in US manufacturing industries calculated as in (10) (with output weights) agree reasonably well with the growth rates calculated from aggregate industry data.

However, it is interesting to note what may bring about a deviation between values obtained from the two different ways of aggregating micro-level occurrences. Namely, $\Delta \underline{\ln P_t}$ does not reflect solely the contributions of average plant productivity growth and changing plant shares, but also of changes in the variance of log productivity levels. The latter can be used as a simple indicator for changes in (in)efficiency (see, for instance Maliranta, 1997b). When log-productivity levels are converging (diverging), formula (10) overestimates (underestimates) the productivity growth rates that are obtained with sum-aggregates of output and inputs. This is unfortunate, as changes in (in)efficiency at the plant level may be an important element of the evolution of productivity performance in a sector or country, especially when the competitive environment has changed.

3.1 Components among continuing plants

3.1.1 Two basic types

If the decomposition exercise is carried out based on the continuing plants only, i.e. by excluding those plants in year *t*, which did not exist in *t*-1 (entry) and those plants in *t*-1, which do not live in *t* (exit), the aggregate change of productivity is typically decomposed into two or three components. We will also introduce some new modified versions of these methods, which have an additional term with some potentially attractive properties.

First we consider the type of methods where the aggregate productivity change rate among continuing plants is decomposed by using weights of the initial year or weights obtained by averaging shares in the initial and the end year. Later we discuss methods used for analysing the role of turnover of plants through entry and exit.

Weights of the initial year

The first type of decomposition method we consider here is one that bears a lot of resemblance with the one used by Baily, Bartelsman and Haltiwanger, BBH, (1997). In this case productivity is defined by (6) and we have the following formula:

$$(11) \qquad \frac{\Delta P_t}{\overline{P}_t} = \sum_{i \in C} w_{i,t-1} \frac{\Delta P_{it}}{\overline{P}_t} + \sum_{i \in C} \Delta w_{it} \frac{P_{i,t-1}}{\overline{P}_t} + \sum_{i \in C} \Delta w_{it} \frac{\Delta P_{it}}{\overline{P}_t}, \quad \text{(BBH)}$$

where C denotes continuing plants. The average aggregate productivity level, the denominator in the formula, is calculated as[22]

$$\overline{P}_t = \left(\frac{\sum_{i \in C} Y_{it}}{\sum_{i \in C} X_{it}} + \frac{\sum_{i \in C} Y_{i,t-1}}{\sum_{i \in C} X_{i,t-1}} \right) \Big/ 2 .$$

[22] BBH (1997) and Maliranta (1997) use the industry productivity level in the initial year as the denominator.

In an important paper Baily, Hulten and Campbell (1992) introduced a formula where the productivity index of a plant is given in the log-form. Foster, Haltiwanger, and Krizan (1998) have modified it into:[23]

$$(12) \qquad \Delta \ln \underline{P_t} = \sum\nolimits_{i\in C} w_{i,t-1} \cdot \Delta \ln p_{it} + \sum\nolimits_{i\in C} \ln p_{i,t-1} \cdot \Delta w_{i,t} + \sum\nolimits_{i\in C} \Delta \ln p_{it} \cdot \Delta w_{i,t} \,. \qquad \text{(FHK)}$$

The first term in (11) and (12) represents the so-called within plant component (WITH) based on plant level changes, weighted by initial input shares. The second term represents the between-plant component (BETW) which reflects the contribution of changing shares to aggregate productivity change. The weights for changes in input usage shares are in (11) and (12) based on initial productivity levels that are proportioned to average aggregate productivity level in years t and t-1.[24] The third term in (11) and (12) represents a cross (i.e. covariance-type) term (CROSS). It is negative if high productivity growth is typically associated with decreasing input shares.

The productivity growth rate in (11) is calculated by using the industry productivity level as the denominator. Consequently it is not a very good measure of a plant's productivity growth rate and does not generally provide a reasonable approximation for the difference in a plant's log productivity, i.e. $\Delta \ln P_{it}$. However, some further rearrangement of the terms in (11) yields an expression with an intuitive economic interpretation

$$(13) \qquad \frac{\Delta P_t}{\overline{P}_t} = \sum\nolimits_{i\in C} w_{i,t-1} \frac{\Delta P_{it}}{\overline{P}_{it}} + \sum\nolimits_{i\in C} w_{i,t-1} \left(\frac{\overline{P}_{it}}{\overline{P}_t} - 1 \right) \frac{\Delta P_{it}}{\overline{P}_{it}} + \sum\nolimits_{i\in C} \Delta w_{it} \frac{P_{i,t-1}}{\overline{P}_t} + \sum\nolimits_{i\in C} \Delta w_{it} \frac{\Delta P_{i,t}}{\overline{P}_t} \,. \qquad \text{(MBBH)}$$

This is a modified version of the method used by BBH (1997). The first term is the within effect. It differs from the within effect appearing in (11) in that the term measuring the industry productivity level is replaced by a more reasonable plant productivity indicator. The within effect obtained from (13), MBBH, provides a very close approximation for the within term appearing in (12), FHK, with its useful properties. The second term on the right-hand side of (13) can be called the catching-up term (CATCH), which is apt to have low values when initially low productivity plants tend to have high productivity growth rate.

As pointed out by Maliranta (1997c) and Foster, Haltiwanger, and Krizan (1998), this type of decomposition method, with input (or output) shares in the initial year used as weights, may render a distorted view on the micro-level sources of aggregate productivity growth because of temporal measurement errors in input (or output) values. The observed productivity of a plant may deviate from the long run trend as is determined by a more persistent technological competence in the plant. This kind of behaviour can be explained, for example, by a model by Jovanovic and Stolyarov (2000), where lumpy investments are made into some factor of production while another input is adjusted smoothly even when these two inputs are complements. Generally, irreversibility and non-convex adjustment costs of inputs can be expected to yield short run fluctuations in relative productivity levels, obscuring the true productive performance level in plants when using cross-section data.

When input weights are used, the temporary measurement errors in input values and the temporary deviations from the static ex-post optimal input level are troublesome from the standpoint of economic

---

[23] In fact, FHK also include one additional term, the initial industry index. However, in the present context that term is not needed. This is because we are considering only continuing plants (Foster, Haltiwanger, and Krizan, 1998). See Equation (25) below.

[24] This can be argued to be an unfounded term as it is expected to be less than one more often than above one because of the general tendency of productivity to grow over time:

interpretation. In this case the within component is likely to be biased upward. This is because the measurement error in w_{it-1} leads a spurious positive correlation between $w_{i,t-1}$ and ΔP_{it}. The between effect is also biased upward because a spuriously high initial productivity (spuriously low input value) is positively correlated with subsequent labour input growth (Δw_{it}). The role of the cross term is to capture the remaining downward bias in this type of decompositions, which originates from a spurious negative relationship between Δw_{it} and ΔP_{it}.[25] On the other hand, a negative cross term can be argued to indicate a productivity inducing role of downsizing. As downsizing is likely to be used in order to eliminate inefficiency (that is, downsizing is common in low productivity plants), we would expect that there is a correlation between the catching up term and the cross term. Indeed, we have found substantial co-movement in these two terms (see Appendix 2).

One might accept the systematic bias in components and focus instead on analysing changes in components over time or on comparing components across industries in order to 'cancel out' these biases. However, it is possible that there are differences in the severity of the errors-in-variable problem over time and across industries (not to say across countries). Alternatively one could use longer periods where larger changes in inputs are dominated less by errors or temporary variations. Still another alternative is to choose such methods that are not as vulnerable to problems in the data.

Use of average weights

The aggregate productivity growth rate among continuing plants can be decomposed into two elements. Bernard and Jones (1996) use the following type of formula when decomposing aggregate productivity growth rates into a within sector and a between sector component:

(14) $$\frac{\Delta P_t}{\overline{P}_t} = \sum_{i\in C} \overline{w}_{it} \frac{\Delta P_{it}}{\overline{P}_t} + \sum_{i\in C} \Delta w_{it} \frac{\overline{P}_i}{\overline{P}_t},$$ BJ

with productivity is defined as in (5) or, as Griliches and Regev (1995)

(15) $$\Delta \underline{\ln P_{it}} = \sum_{i\in C} \overline{w}_i \cdot \Delta \ln P_{it} + \sum_{i\in C} \overline{\ln P_i} \Delta w_{i,t},$$ GR

when productivity is defined by (7). As before, a bar over a variable indicates the average of the variable over the initial and the end year, which makes a slight difference between the formula shown here in (14) and the one proposed in Bernard and Jones (1996). In this type of decompositions, only the within-plant and between-plant components are distinguished.

Foster, Haltiwanger, and Krizan (1998) and Caballero and Hammour (2000) argue that one problem with this sort of decompositions is that they do not separate out cross/covariate effects. As stated above, the use of initial input shares as weights produces an upwardly biased within component. By similar reasoning, we may anticipate the use of input shares in the end year to yield a downwardly bi-

---

[25] When output weights are used instead of input weights, the direction of the bias in the different components is reversed. We have reason to believe that errors-in-variable problems or short run deviations from the long-term level are more serious for output values than for input values. Thus the magnitude of the bias is likely to be graver. Especially when a combination of several inputs is used as weights, as is the case when input weights are used in the decomposition of multi-factor productivity growth, the bias due to random error can be expected to be more moderate. Empirical results reported by Foster, Haltiwanger, and Krizan (1998) are in keeping with all predictions expressed here and in Maliranta (1997c): the within effect as well as between effect is higher when input weights are used (the between effect is negative when output weights are used) and the cross term is positive when output weights are used (the cross term is negative when input weights are used).

ased within component. Thus the use of average input shares seems to have some appeal. Moreover, the between component in this type of methods has the attractive property of comprising a term that captures a more persistent relative productivity level.

BJ-method can be modified into a form that includes one additional term which captures possible catching up tendency in a similar manner as the BBH-method described above.

$$(16)\qquad \frac{\Delta P_t}{\overline{P}_t} = \sum_{i \in C} \overline{w}_i \frac{\Delta P_{it}}{\overline{P}_{it}} + \sum_{i \in C} \overline{w}_{it} \left(\frac{\overline{P}_{it}}{\overline{P}_t} - 1 \right) \frac{\Delta P_{it}}{\overline{P}_{it}} + \sum_{i \in C} \Delta w_{i,t} \frac{\overline{P}_i}{\overline{P}_t}. \qquad \text{MBJ}$$

In addition to the within component (the first term on the right hand side of the equation) and the between-plant component (last term), this formulation the includes the catching-up term

$$\sum_i \overline{w}_{it} \left(\frac{\overline{P}_{it}}{\overline{P}_t} - 1 \right) \frac{\Delta P_{it}}{\overline{p}_{it}}.$$

If there is a systematic tendency of (persistently) low productivity plants to have high productivity growth rates (the term inside brackets is negative), this term should take a low value. On the other hand, it is apt to be positive, if high productivity plants are usually large (and have a high productivity growth rate).

Let us go back for a moment to the issue of using initial productivity in the decomposition. Assume that as a starting point for the further development of the decomposition method we had decided to use the original formulation of BBH (1997), where growth is measured by the productivity level in the initial year. In that case we would have a catching-up term of the following kind:

$$\sum_i \overline{w}_{it} \left(\frac{P_{i,t-1}}{P_{t-1}} - 1 \right) \frac{\Delta P_{it}}{P_{i,t-1}}.$$

In other words, there is a term within brackets indicating the relative productivity level in initial year. We would expect this component to be apt to have negative values because of the regression-towards-mean problem.[26] Friedman (1992) suggests that one should use the relative productivity level in the end year to examine whether or not there is a convergence process in operation. Cannon and Duck (2000) demonstrate that if a test of convergence obtained by using this strategy suggests the presence of convergence, this should be interpreted as strong evidence. However, even with a positive correlation between the productivity level in the end year and preceding productivity growth, one cannot reject the hypothesis of convergence. This is because a test based on initial productivity levels is biased in the direction of suggesting convergence, when none is actually prevailing, whereas a test based on productivity levels in the end year is biased in the direction of not suggesting convergence even when this is actually occurring. Again, our approach of choosing the intermediate alternative seems natural.

[26] A negative (conditional) correlation between initial productivity level and subsequent productivity growth is commonly called β-convergence as distinct from σ-convergence, which is defined as a narrowing of the dispersion in productivity levels (see Barro and Sali-i-Martin, 1995).

3.2 Use of total factor productivity index

We are especially concerned with the efficiency of usage of the two most important factors of production in the economy, i.e. labour and capital. By assuming constant returns to scale we may define total factor productivity at the plant, industry or sector level in year *t* as:

$$(17) \qquad TFP_t = \frac{Y_t}{L_t^{\alpha_t} K_t^{1-\alpha}},$$

where *Y* refers to output, *L* labour and *K* capital input, and α denotes labour input elasticity. For calculating the input index $L_t^{\alpha} K_t^{1-\alpha}$ we estimate, as is quite usual, the labour input elasticity by using nominal factor shares defined at the industry- or the manufacturing level as the case may be. The manufacturing total factor productivity level in year *t* can be expressed as (see Bernard and Jones, 1996)

$$(18) \qquad TFP_t = \frac{\sum_i Y_{i,t}}{\left(\sum_i L_{i,t}\right)^{\alpha} \left(\sum_i K_{i,t}\right)^{1-\alpha}} = \sum_i \frac{Y_{i,t}}{L_{i,t}^{\alpha} K_{i,t}^{1-\alpha}} \cdot \left(\frac{L_{i,t}}{L_t}\right)^{\alpha} \left(\frac{K_{i,t}}{K_t}\right)^{1-\alpha} = \sum_i TFP_{i,t} \cdot w_{i,t} \ .$$

Following, for instance, MBJ, the total factor productivity growth rate can be decomposed as:

$$(19) \qquad \begin{aligned} &\frac{TFP_t - TFP_{t-1}}{\overline{TFP_t}} = \\ &\sum_i \overline{w}_{it} \cdot \frac{\Delta TFP_{it}}{\overline{TFP_i}} + \\ &\sum_i \overline{w}_{it} \left(\frac{\overline{TFP}_{it}}{\overline{TFP}_t} - 1 \right) \cdot \frac{\Delta TFP_{it}}{\overline{TFP}_{it}} + \\ &\sum_i \Delta w_{it} \cdot \frac{\overline{TFP}_{it}}{\overline{TFP}_t} \end{aligned}$$

which distinguishes between within, catching-up and between components of the aggregate total factor productivity growth rate. For measuring this decomposition for each period it is natural to determine the labour input elasticity by taking the average of the factor share in the initial year and the end year, i.e.

$$\overline{\alpha} = \frac{\alpha_t - \alpha_{t-1}}{2}.$$

The properties of different methods are illustrated in Appendix 1. We have provided three different types of demo data called 1) 'errors in labour input values', 2) 'systematic structural change', and 3) 'catching up with structural change', for which we have applied different decomposition methods. This demonstration indicates some important differences in the methods that will be seen also in the analysis of the role of structural change in Finnish manufacturing (Section 5).

3.3 Entry and exit

So far we have considered productivity growth and structural change among incumbents only. Next we would like to take into account the extreme cases of the rise and decline of plants, i.e. entries and exits.

First, we define the net entry component (NETENT) as the difference in productivity growth rates among all plants and among continuing plants only:

$$(20) \qquad NETENT = \frac{\dfrac{\sum_{it} Y_{it}}{\sum_{it} f(X_{it})} - \dfrac{\sum_{i,t-1} Y_{i,t-1}}{\sum_{i,t-1} f(X_{i,t-1})}}{\left(\dfrac{\sum_{it} Y_{it}}{\sum_{it} f(X_{it})} + \dfrac{\sum_{i,t-1} Y_{i,t-1}}{\sum_{i,t-1} f(X_{i,t-1})} \right) \Big/ 2} - \frac{\dfrac{\sum_{i\in C,t} Y_{it}}{\sum_{i\in C,t} f(X_{it})} - \dfrac{\sum_{i\in C,t-1} Y_{i,t-1}}{\sum_{i\in C,t-1} f(X_{i,t-1})}}{\left(\dfrac{\sum_{i\in C,t} Y_{it}}{\sum_{i\in C,t} f(X_{it})} + \dfrac{\sum_{i\in C,t-1} Y_{i,t-1}}{\sum_{i\in C,t-1} f(X_{i,t-1})} \right) \Big/ 2},$$

where X is a vector of input quantities. Henceforth we use a more convenient notation:

$$(20') \qquad NETENT = \frac{\Delta P_t}{\overline{P}_t} - \frac{\Delta P_t^C}{\overline{P}_t^C}$$

where superscript C denotes that only those plants that appear both in the initial and in the end year are included in the aggregate measure. Net entry component (*NETENT*) shows the effect arising from the turnover of the plants during the period in question. However, the sign and magnitude of this component are dependent on several factors, as can be seen in the following decomposition. At this point it is useful to move to log-differences (see Maliranta, 1997a and 1997c). Net entry effect measured by log-difference is indicated by using lower cases:

$$(21) \qquad \begin{aligned} netent &= \Delta \ln P_t - \Delta \ln P_t^C = \ln\left(\frac{P_t}{P_{t-1}}\right) - \ln\left(\frac{P_t^C}{P_{t-1}^C}\right) \\ &= \underset{\text{(I)}}{\ln\left(\frac{P_{t-1}^C}{P_{t-1}}\right)} + \underset{\text{(II)}}{\ln\left(\frac{P_t}{P_t^C}\right)} \end{aligned}$$

The term (I) — the exit component — can be developed further by noting that

$$(22) \qquad P_{t-1} = (1-w^D)\cdot P_{t-1}^C + w^D \cdot P_{t-1}^D$$

where $w^D = \dfrac{f(X_{t-1}^D)}{f(X_{t-1})}$, $0 \le \text{w}^\text{D} \le 1$.

D denotes that only those plants are included that are to disappear by year t. By inserting (22) into term (*I*) we obtain

$$(23) \qquad \text{exit effect} = -\ln\left(1 - w^D\left(1 - \frac{P_{t-1}^D}{P_{t-1}^C}\right)\right) \qquad \text{(EXIT)}.$$

We would expect that the (nominal) productivity level is low among those plants disappearing in the near future, thus usually $P^D/P^C < 1$. Under these circumstances, the lower P^D or the higher w^D, the greater is the positive effect of exit for aggregate productivity growth. In a similar way we can render the term (II) in (21) — the entry effect — into the following formula:

$$(24) \qquad \text{entry effect} = \ln\left(1 - w^E\left(1 - \frac{P_t^E}{P_t^C}\right)\right) \qquad \text{(ENTRY)},$$

where E refers to those plants that exist in year t but not in year t-1 and $w^E = \frac{f(X_t^E)}{f(X_t)}$ ($0 \le w^E \le 1$) is the input share of these new plants in year t. The entry effect is positive if new plants are more productive than incumbent plants in year t. The magnitude of the impact is dependent on the input share.

Foster, Haltiwanger and Krizan (1998) propose a version of the productivity decomposition formula, which is useful for measuring the impact of entry and exit on aggregate productivity growth. It is a slightly different version of the equation (12) introduced above[27]:

$$\text{(25)} \quad \Delta \underline{\ln P_t} = \sum_{i \in C} w_{i,t-1} \cdot \Delta \ln P_{it} + \sum_{i \in C} \left(\ln P_{i,t-1} - \ln P_{t-1}\right) \cdot \Delta w_{it} + \sum_{i \in C} \Delta \ln P_{it} \cdot \Delta w_{it} + \sum_{i \in N} w_{it} \left(\ln P_{it} - \ln P_{t-1}\right) - \sum_{i \in X} w_{i,t-1} \cdot \left(\ln P_{i,t-1} - \ln P_{t-1}\right) \quad \text{(FHK2)}$$

where N denotes entering plants, and X denotes exiting plants. Formula (25) differs from (12) in two respects. Now we are including also entrants and exits. Secondly, this formula contains an industry index term.

There is also an analogous modification of the GR-method available:

$$\text{(26)} \quad \Delta \underline{\ln P_{i,t}} = \sum_{i \in C} \overline{w}_i \cdot \Delta \ln P_{it} + \sum_{i \in C} \left(\overline{\ln P_i} - \overline{\ln P}\right) \cdot \Delta w_{,t} + \sum_{i \in N} w_{it} \left(\ln P_{it} - \overline{\ln P}\right) - \sum_{i \in X} w_{i,t-1} \cdot \left(\ln P_{i,t-1} - \overline{\ln P}\right) \quad \text{(GR2)}$$

In addition to the fact that FHK2 and GR2 can be used conveniently with unbalanced data, they are useful when investigating what role different types of plants play in different components of aggregate productivity change.

3.4 Groups of plants

In the previous methods the value of a particular component is calculated by summing over all continuing or entering or exiting plants. Each group of plants can be further broken down into subgroups according to given characteristics of the plants. Methods (25) and (26) are particularly useful for that type of investigation. Plant contributes positively to aggregate productivity growth in two circumstances; if plant with above-average productivity level increases its input share, or if plant with below-average productivity level decreases its input share. In the other two remaining cases the contribution is negative.

3.5 Prices and quantities

Ideally output Y should be measured in (quality adjusted) physical quantities (in kilos, litres, metres, etc.). Of course, normally this is not possible. Usually output is measured by deflating revenues by some industry specific price index, and output is expressed in fixed base year prices. For convenience,

[27] This formula is, in fact, the one they presented originally. But as stated in footnote 23, the industry index makes no difference when entrants and exits are excluded. This is why we decided to drop it from equation (12). To put it differently, FHK and FHK2 yield exactly the same result for the within, between and cross components, when applied to a balanced panel data set.

let us assume that each plant is producing only one type of product.[28] When output is measured in base year (b) prices, aggregate output in year t can be given as

(27) $$Y_t = \sum_{it} p_{ib} q_{it}$$

and the change of aggregate output can be calculated by

(28) $$\frac{Y_t}{Y_{t-1}} = \frac{\sum_{it} p_{ib} q_{it}}{\sum_{it} p_{ib} q_{i,t-1}}$$

If the base year is chosen so that $b = t$-1, this index is the familiar Laspeyres quantity index. The Paasche quantity index, in turn, is obtained when b = t.

Using base year prices is convenient when one wants to compare several years at a blow. A problem, however, is, which year to choose as the base year. This is a relevant question while economic evolution also entails changes in relative prices and quantities.

In this study we need not compare the volumes of output levels (or productivity levels) in several years simultaneously but the rates of change at different points in time. To put it differently, we want to compare ratios in different periods, say Y_t/Y_{t-1} with Y_{t+5}/Y_{t+4}, as we would like to know whether or not there has been acceleration in output (or productivity) growth rate. It may not be appropriate to use one single base year for measuring productivity growth rate in t and t+5. This is because of a possible systematic relationship between unit price change and quantity change at the product level (or plant level). We would expect their correlation to be negative. This being the case, there would be an upward bias in Y_{t+5}/Y_{t+4} if the quantity index is calculated by using t as the fixed base year. The reason for this is that the products with an exceptionally high growth rate in volumes have excessively high weight because of relatively high prices in base year in the past. For example, industries with rapid productivity and output growth tend to experience a below-average price change (or an even negative price change, as has been the case with telecommunication equipment in Finland in recent years) and by this means they tend to curtail inflation.[29] With a similar reasoning one could predict that growth rates in the past, e.g. Y_{t-4}/Y_{t-5}, are apt to be downwardly biased. All in all, using fixed base year prices in the analysis of long-term growth performance may lead to an incorrect conclusion of accelerating growth rate solely because of the method that is applied. It seems recommendable to use 'rolling base years' when investigating aggregate productivity growth over a long period.

In practise, researchers usually have information on the total nominal value of output. In other words, we observe nominal output $NY_{it} = p_{it}q_{it}$ and $NY_{i,t-1} = p_{i,t-1}q_{i,t-1}$. We assume that the industry-specific index reflects unit price changes in the plant and consequently $\tilde{p}_{it} = p_{it} / p_{i,t-1}$ is available to us. We may derive Laspeyres quantity index, where outputs (Y) are expressed in year $t-1$ prices.

(29) $$Q_L = \frac{Y_t}{Y_{t-1}} = \frac{\sum_i p_{i,t-1} q_{it}}{\sum_i p_{i,t-1} \cdot q_{i,t-1}} = \frac{\sum_i NY_{it} / \tilde{p}_{it}}{\sum_i NY_{i,t-1}} = \frac{\sum_i Y_{it}}{\sum_i Y_{i,t-1}} .$$

[28] Or alternatively, we assume that price differences between different makes of a certain plant reflect quality differences, and that all product varieties within a certain plant share the same rate of change.

[29] Through this process, the fruits of new technology developed in a certain industry are spread to all consumers.

For the sake of comparison, output growth in the period from t+4 to t+5 in base year t prices is calculated by

$$(30)\quad Q_B = \frac{Y_{t+5}}{Y_{t+4}} = \frac{\sum_i p_{it} q_{i,t+5}}{\sum_i p_{it} q_{i,t+4}} = \frac{\sum_i NY_{i,t+5} / \tilde{p}_{i,t+5}}{\sum_i NY_{i,t+4} / \tilde{p}_{i,t+4}} = \frac{\sum_i Y_{i,t+5}}{\sum_i Y_{i,t+4}},$$

where

$$(31)\quad \tilde{p}_{i,t+5} = p_{i,t+5} / p_{it} \text{ and}$$

$$(32)\quad \tilde{p}_{i,t+4} = p_{i,t+4} / p_{it}.$$

Next we relate these considerations with our decomposition exercise applied, for example, at the total manufacturing level. As we assume that each plant produces only one type of product, it does not make any difference, which one of the years has been chosen as the base year as far as the within component is concerned. But as regards the between and catching-up components these considerations become relevant. In particular, it is natural to expect that the decision whether to increase or to decrease inputs, and by how much, is dependent on current nominal productivity (or expected nominal productivity in the future) rather than on output per input expressed in the prices of some arbitrary base year in the past, for example. This is because nominal productivity is likely to be closely associated with the profitability measure, which, of course, is of ultimate concern of a profit maximiser. Therefore we would prefer to use such a measure of productivity, where output is measured in end year or initial year prices (Paasche index or Laspeyres). In this study we use Laspeyres index. In practise, it makes no difference, which one of these two is used, as long as the base year is rolling.

4 Data

Our main data source is the Longitudinal Data on Plants in Manufacturing (LDPM), which is constructed especially for research purposes from annual Industrial Statistics. In principle, the plant is defined in the Finnish Industrial Statistics survey as a local kind-of-activity unit. In other words, it is a specific physical location, which is specialised in the production of a certain type of products or services. A single local unit may consist of several plants that have activities in different industries. In some special cases a plant is delineated so that it includes parts that are located geographically detached. It is, however, required that the units locate within the same municipality. This solution seems to be well justified especially when the geographically separated units are closely attached to each other operationally. This way of grouping plans may help the firm to provide more accurate information on its activities within a certain specific industry.

The Industrial Statistics compiles, by annual surveys, comprehensive information on the economic activity of industrial plants. This electronic database contains information from 1974 to 1998. Up to 1994 it includes basically all plants with at least 5 persons. Since 1995 all plants owned by an enterprise with at least 20 persons are included in the survey. As there is a relatively large number of single unit firms employing less than 20 (but more than 5) persons, the number of plants drops by almost one half due to this change in the applied criteria. However, the number of persons diminishes only moderately, by a few per cent. Thus, there is a break in the series between 1994 and 1995 that needs to be taken into account in handling and interpreting time-series. In particular, there may appear some artificial exits in 1995. One possible way to generate continuous time series would be to exclude all units that have less than 20 persons engaged.[30] Our analysis covers all production units that have positive value added.

Output can be measured by value added or total production. An attractive property of the value added measure is that it is additive across plants and industries. The production of a plant may be very much dependent on the amount of intermediate inputs used in the production process. High gross output per labour input may reflect, among other things, large-scale outsourcing. An ideal measure would be a multi-factor productivity measure calculated by using a gross output measure, which takes into account the efficiency in the usage of labour, capital and intermediate inputs. Unfortunately, for the time being appropriate price indexes are not available for the intermediate inputs. Similarly, we do not have an appropriate price index for the value added measure, either. In the absence of anything better, we convert nominal value added figures into real terms by using industry-specific producer's price index. However, this type of productivity indicator may yield strongly varying productivity growth rates in the short run. In the Finnish National Accounts the change of real valued added is assumed to equal the change of real gross output at the detailed industry level. That procedure provides more stable productivity growth rates.

Labour input is measured by the total number of hours worked without any distinction by quality characteristics. Productivity growth rates may thus reflect skill upgrading to some extent. This issue deserves separate analysis (see Ilmakunnas, Maliranta, and Vainiomäki, 1999). Capital input is measured with a capital stock estimate that is calculated by the use of perpetual inventory method assuming 10 per cent depreciation rate. It includes the value of machinery, equipment, transportation equipment, buildings and structures in 1990 prices.[31]

Business Register on Plants (BRP) is another data source used in the present study. It has two main advantages over Industrial Statistics. Firstly, it includes also very small plants, as the cut-off limit is basically 0.6 persons. Secondly, the Business Register covers the whole business sector, which makes it possible to investigate the productivity evolution in service industries as well. On the other hand, the information content of the Business Register is rather limited; it includes sales and the number of persons, but not investments, for example. Therefore we can provide a proxy for labour productivity, while it is impossible to generate a more comprehensive indicator of performance.

The R&D survey is the third data source that is used in this study. This data is linked to LDPM data set by firm identification code in order to classify plants according to R&D intensity.

---

30 In fact this method is used to check the robustness of the results. Moreover, the measures of wage and productivity dispersion that are used in some parts of the analysis are constructed in this way.

31 Investment series, which are needed for the calculation of the capital stock, are converted into 1990 prices by using implicit price indexes obtained from National Accounts. The initial capital stock of those plants that were in operation pre-1975 is estimated from fire insurance value of the capital stock that is available from 1974 to 1985. More specifically, we have used an industry specific proportion (at the 2-digit industry level) of the fire insurance value of the capital stock in the plant. This whole exercise needs to done because of the different concepts behind our alternative measures of capital input. This proportion is determined so that the industry-level capital productivity series generated with, respectively, the PIM estimate and the fire insurance value share as similar a pattern as possible from 1975 to 1985. In fact, our plant level PIM estimates seem to yield quite similar series for capital productivity as those obtained from National Accounts. Maliranta (1997b) provides more details about the procedure of measuring plant level capital stocks.

5 Empirical analysis of productivity evolution

5.1 Components among continuing manufacturing plants

We have decomposed the annual rates of aggregate productivity growth in the manufacturing sector by using the various methods introduced above. Computations are made both for labour productivity and total factor productivity indicators and by using gross output as well as value added as the output measure.

Tables 5.1a and 5.1b summarise the results for manufacturing. It should be noted that since these decompositions are made at the total manufacturing level, the micro-structural components also include the effect arising from changes in industry structures. We have, however, performed similar exercises for 2- (or 3-digit) industries. These computations demonstrate that most of the productivity-enhancing reallocation takes place within industries and that changes in industry structures play only a minor role.[32]

Aggregate level productivity indicators suggest quite uniformly that there was an acceleration in productivity growth in the mid-1980s. This holds true especially for total factor productivity.[33] For the within effect the acceleration is not as pronounced. Taken together, the micro-structural factors have, in other words, played an increasing role in the aggregate productivity evolution.

On the other hand, we find that the method used may make a lot of difference. The deviations in the results come very much up to our expectations. When input weights are used, the within component is usually larger in the FHK- and MBBH-methods, which include the cross term, than in MBJ- and GR-methods, where the cross term is eliminated. The between component is also substantially larger in those methods that include the cross term.[34] However, when input shares are used, both types of methods seem to indicate that input reallocation has had a positive impact on aggregate productivity performance. As usual, the cross term is negative when input weights are used. When output weights are used instead of input weights, the signs of the between and cross terms are reversed. Furhermore, the within effect suggests very modest or even negative productivity growth within plants (see also Baily, Hulten, and Campbell, 1992). When this type of exercises with output weights is performed, the role of micro-structural factors becomes very strongly emphasised. However, this result should be interpreted with caution as it may reflect (natural) short-term fluctuation or classical measurement error in output measure. When the more robust GR-method is used with output weights, the estimates of total factor productivity growth within plants become more reasonable. When adopting the type of method that makes use of the average weight of the initial and the end year (e.g. the GR-method), it does not make much difference whether output or input is used as weights (see also Foster, Haltiwanger, and Krizan, 1998).

---

32 Bernard and Jones (1995) examine the effect of changing industry shares for the cross-country convergence to the United States in total factor productivity.

33 We have also performed some computations with a multi-factor-productivity (MFP) indicator that includes also material input. Generally the patterns of these series over time are quite similar to ones obtained with our total factor productivity (TFP) indicator that includes labour and capital. There are some doubts about the quality of our material input (we have used the price deflator of total manufacturing), which may be critical point as intermediate input has a large cost share. The absolute sizes of the values of the components obtained for MFP are much lower than in the case of our TFP indicator. This discrepancy may suggest that a different weighting method (Domar weights) might be more appropriate when aggregating plants to the industry and manufacturing level in the case of MFP.

34 Finding a positive between effect is consistent with the results in Maliranta (2000) that a high productivity level is associated with greater ensuing employment growth.

Table 5.1a Decomposition of productivity growth rates among incumbents, annual averages, %

Growth rate component	Gross output per hour					Gross output per input index, TFP				
	1976-80	1981-85	1986-90	1991-94	1995-98	1976-80	1981-85	1986-90	1991-94	1995-98
Aggregate										
$\Delta P / \overline{P}$,MBJ,MBBH	5.2	3.1	5.1	5.5	4.0	2.7	0.3	1.8	4.6	5.5
FHK, GR; input	4.4	3.3	5.3	4.4	4.2	2.8	0.5	2.4	4.3	5.7
FHK, GR; output	5.7	2.5	5.0	6.5	3.6	2.6	0.1	0.8	4.6	5.0
Within										
MBBH	4.4	3.3	5.2	3.5	4.9	2.4	0.5	1.9	2.9	5.3
FHK	4.5	3.3	5.3	3.6	5.0	2.4	0.4	2.0	2.9	5.3
FHK, output weight	2.3	1.5	3.1	2.2	2.2	-0.6	-1.9	-1.1	0.6	2.4
MBJ	4.1	2.9	4.6	3.1	4.2	1.6	-0.3	0.6	2.9	4.5
GR	4.1	2.9	4.7	3.1	4.3	2.0	0.0	1.4	2.8	5.0
GR, output weight						1.8	-0.2	0.7	2.9	4.6
Catching up										
MBBH	0.7	0.1	0.3	1.4	0.3	0.0	-0.1	-0.5	0.3	-0.2
MBJ	0.5	0.0	0.1	1.1	-0.1	-0.4	-0.4	-0.8	0.0	-0.5
Between										
MBBH (and BBH)	1.3	0.8	1.2	2.1	1.1	1.8	1.3	2.0	2.1	1.6
FHK	0.7	0.7	1.2	1.8	0.7	1.2	1.0	1.5	1.6	1.0
FHK, output weight	-1.0	-1.8	-1.2	0.4	-2.2	-1.6	-1.3	-1.6	-0.7	-1.8
MBJ (and BJ)	0.7	0.2	0.4	1.4	-0.1	1.1	0.7	1.2	1.8	1.0
GR	0.3	0.3	0.6	1.3	0.0	0.8	0.5	1.0	1.5	0.7
GR, output weight						0.8	0.3	0.2	1.6	0.4
Cross										
MBBH (and BBH)	-1.3	-1.1	-1.7	-1.5	-2.3	-1.5	-1.3	-1.6	-0.7	-1.3
FHK	-0.8	-0.8	-1.3	-1.0	-1.5	-0.8	-0.9	-1.0	-0.2	-0.6
FHK, output weight	4.4	2.8	3.1	4.0	3.7	4.9	3.3	3.5	4.7	4.4

Table 5.1b Decomposition of productivity growth rates among incumbents, annual averages, %

Growth rate component	Value added per hour					Value added per input index, TFP				
	1976-80	1981-85	1986-90	1991-94	1995-98	1976-80	1981-85	1986-90	1991-94	1995-98
Aggregate										
$\Delta P / \overline{P}$,MBJ, MBBH	3.5	4.0	6.0	4.2	0.1	1.0	1.1	2.8	3.4	1.4
FHK, GR; input	3.5	3.6	5.7	3.2	1.4	2.1	1.0	3.2	4.2	2.5
FHK, GR; output	3.0	4.1	6.4	4.8	-1.0	0.1	1.4	2.3	2.2	0.9
Within										
MBBH	3.6	3.2	5.0	1.8	1.3	1.7	0.5	2.3	2.4	1.6
FHK	3.8	3.5	5.3	1.8	1.4	1.8	0.7	2.4	2.5	1.6
FHK, output weight	-6.9	-4.2	-3.8	-5.6	-8.0	-10.3	-7.7	-7.7	-7.5	-8.2
MBJ	3.2	2.9	4.5	1.6	0.8	1.2	0.1	1.8	2.4	1.4
GR	3.4	3.1	4.8	1.7	0.8	1.4	0.2	1.9	2.6	1.3
GR, output weight						0.3	0.2	1.6	1.4	-0.1
Catching up										
MBBH	0.4	0.7	0.9	1.6	-0.7	-0.7	0.4	-0.2	-0.5	-0.9
MBJ	0.0	0.5	0.7	1.1	-1.3	-1.2	0.1	-0.5	-0.9	-1.3
Between										
MBBH (and BBH)	1.0	1.1	1.5	2.3	1.6	1.9	1.6	2.4	2.3	2.0
FHK	0.5	0.9	1.4	1.7	1.2	1.2	1.3	1.8	1.5	1.4
FHK, output weight	-10.5	-6.9	-8.2	-6.1	-7.7	-10.8	-6.7	-8.6	-8.3	-7.0
MBJ (and BJ)	0.2	0.5	0.8	1.5	0.6	1.0	0.9	1.5	1.9	1.4
GR	0.1	0.5	0.9	1.5	0.6	0.7	0.8	1.3	1.6	1.2
GR, output weight						-0.3	1.2	0.7	0.7	1.1
Cross										
MBBH (and BBH)	-1.5	-1.1	-1.4	-1.4	-2.1	-1.9	-1.4	-1.6	-0.7	-1.3
FHK	-0.8	-0.7	-1.1	-0.3	-1.1	-1.0	-1.0	-1.0	0.2	-0.5
FHK, output weight	20.3	15.2	18.3	16.6	14.8	21.1	15.9	18.7	18.0	16.1

The negative catching-up term, especially in the MBJ-method used for total factor productivity, suggests that plants with a low total factor productivity level are able to perform a high productivity growth rate. Thus we obtain some evidence on a convergence tendency among Finnish manufacturing plants.

It is worth bearing in mind, however, that the negative catching up term may also reflect that large plants have low relative productivity level (and positive productivity growth). This is likely to explain the finding that catching up term is usually negative for total factor productivity but typically positive for labour productivity. This is because large plants usually have high capital intensity and high labour productivity, but as it comes to total factor productivity the difference between large and small plants does not seem so marked (see Maliranta, 1997b). So the interpretation of the catching up term is not quite straightforward. However, the variation over time in this component may nonetheless reveal important changes in growth process. It may help us in explaining the changes in productivity dispersion, for example, as we will see in subsequent sections.

Finally, we observe that although the aggregate productivity growth rate series obtained with the FHK- or GR-method share by and large the same pattern with those calculated from sum-aggregates (e.g. MBJ-method), there are some notable differences as well. Visual inspection of graphical displays performed in the next sub-section proves to be particularly fruitful at this point. The cross terms in the MBBH- and FHK-method are practically always negative suggesting that those plants who decrease input usage more than average are able to achieve above-average productivity growth rates.

To get a better view on the trends and fluctuations in the productivity growth we have drawn pictures to depict the evolution of the different components in the period from 1976 to 1998. Output is measured with gross production and value added. Figure 5.1a shows the series of labour productivity growth components and Figure 5.1b those of total factor productivity.

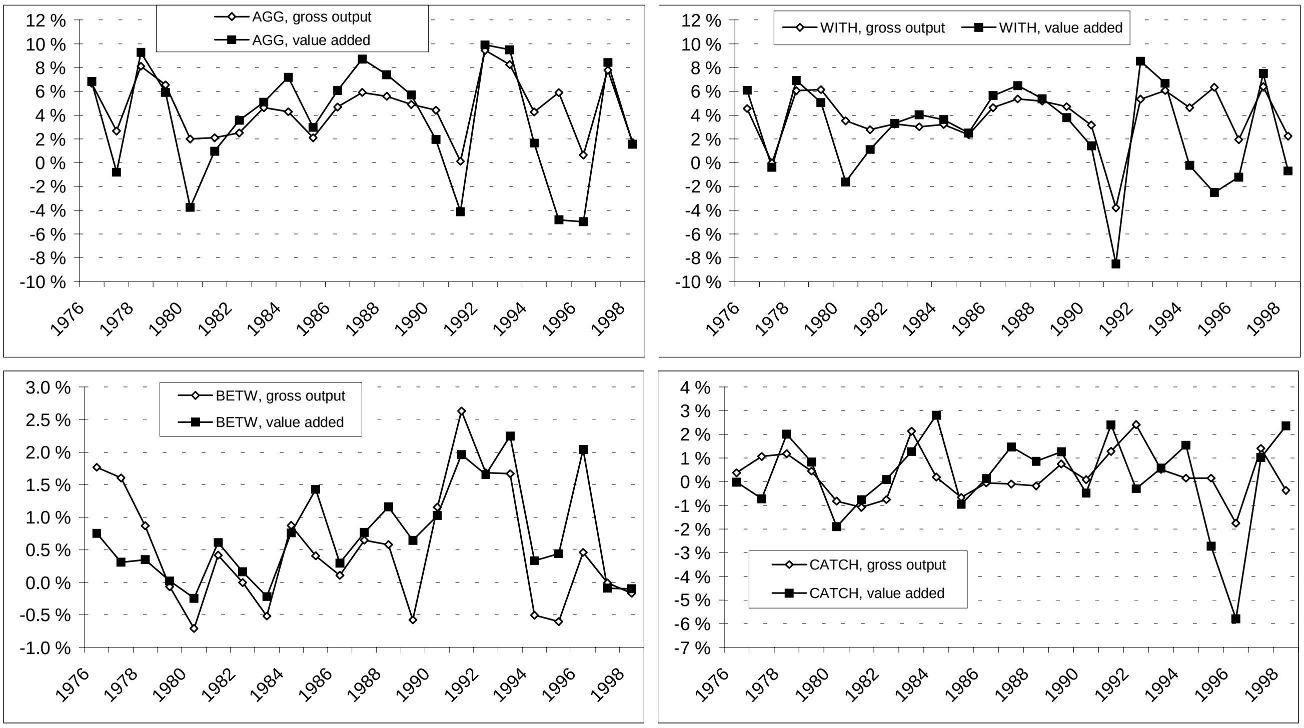
The aggregate productivity series (AGG) show the fluctuations in productivity growth rates over time. As might be expected, the fluctuations are stronger when using value added as the output measure. The difference between the gross production and the value added measure is strongest on the outset of the recovery period. The changes in relative prices of final products and intermediate inputs are likely to be apparent in the series. It can be argued that gross output per input measures changes in productivity within plants more reliably than value added per input.

The between component in Figures 5.1a and 5.1b shows perhaps more clearly and reliably with the value added measure than with the gross output measure, the tendencies in productivity-enhancing input reallocation. The between effect springs to action in the mid-1980s and gains more strength up to the mid-1990s. We also see signs of the 'chill' in the between effect since the mid-1990s.

The catching up term exhibits no trend, at least not up to the early 1990s. As already noted above, this term is generally negative for total factor productivity. We also gain some evidence that the catching up process was more effective than usual during the first years after the hit of the recession. The fact that the dispersion in productivity levels may change due to movements in the level of technical (in)efficiency is reflected in the difference between the aggregate growth rate values obtained by the different ways of aggregating plant level observations. This can be seen clearly in Figure 5.2. We have included two series in the figure. The first (the opposite number of deviation in the FHK- and GR-method) indicates the difference in the aggregate productivity growth rates obtained with the FHK- (or GR-) method and with traditional sum-aggregate indicators (or with the MBBH- and MBJ-method). The second is the catching up term obtained by the MBJ-method.

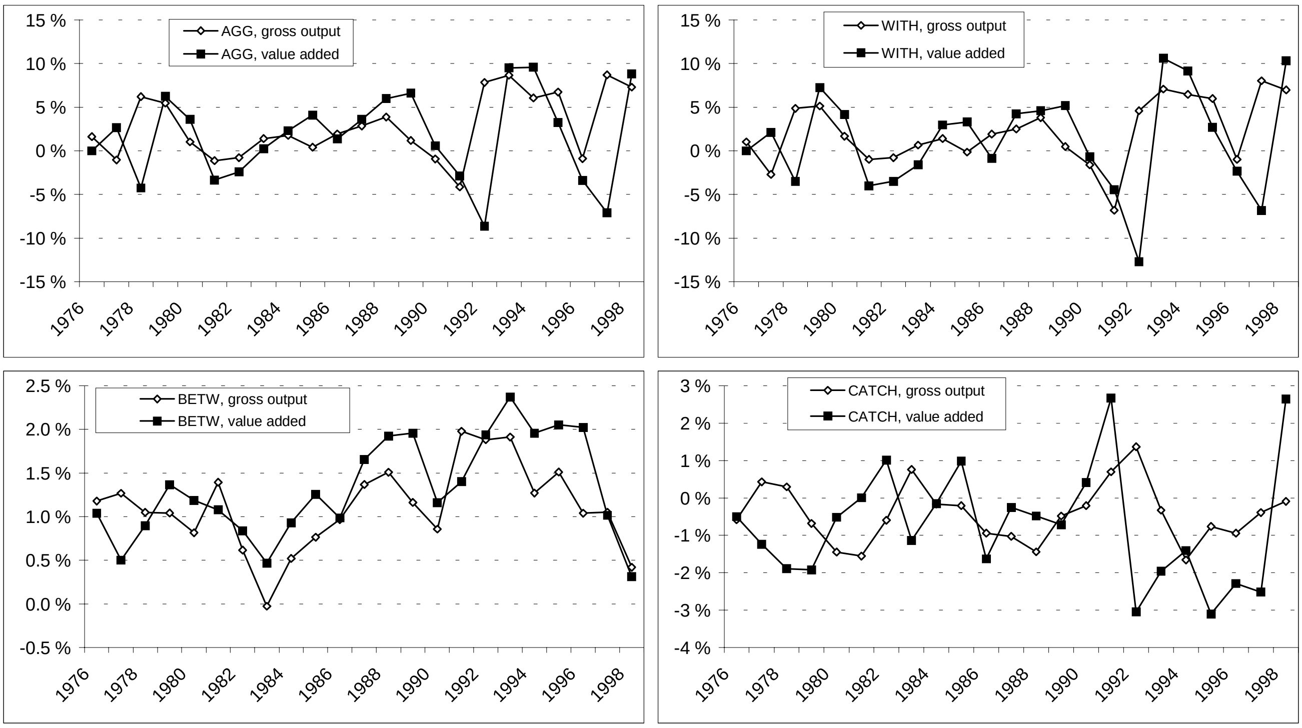
Figure 5.2 demonstrates that the aggregate productivity growth rate obtained with a method (FHK- and GR-method), where the plant's log productivity indicators are aggregated using plant weights, overrates the productivity growth obtained from sum-aggregates, when the catching up term is low. In fact, it can be seen that this ‘bias’ in the FHK- and GR-method can be predicted quite closely with our catching-up component, which can be calculated by MBJ- or MBBH-method.

Figure 5.1a Components (AGG, WITH, BETW and CATCH) of labour productivity growth rates, with gross output and value added measures, MBJ-method



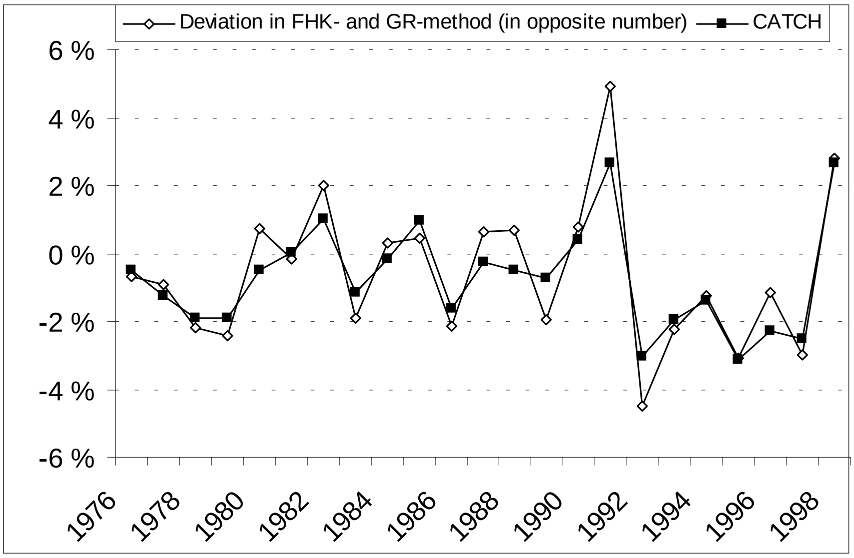
Notes: The components are calculated with a modified version of the formula used by Bernard and Jones (1996) (MBJ-method) with balanced panel data. AGG denotes aggregate growth, WITH the within component, BETW the between component and CATHC the catching up term. Value added and gross output are measured in end year prices by using industry specific producer's price index.

Figure 5.1b Components (AGG, WITH, BETW and CATCH) of total factor productivity growth rates, with gross output and value added measures, MBJ-method



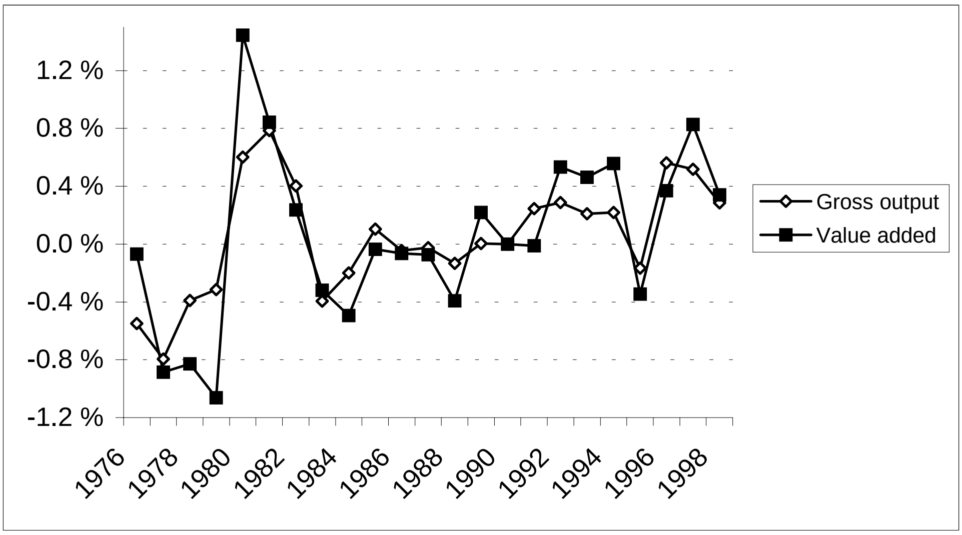
Note: see above.

Figure 5.2. The deviation in the aggregate total factor productivity growth rate obtained when using the FHK- or GR-method and the catching up component



Notes: Deviation is the difference in the total factor productivity growth rate obtained differencing log of aggregate productivity (MBBH- and MBJ-method) and differencing aggregated log-productivities (FHK- and GR-method). CATCH denotes the catching-up term of productivity growth obtained by the MBJ-method.

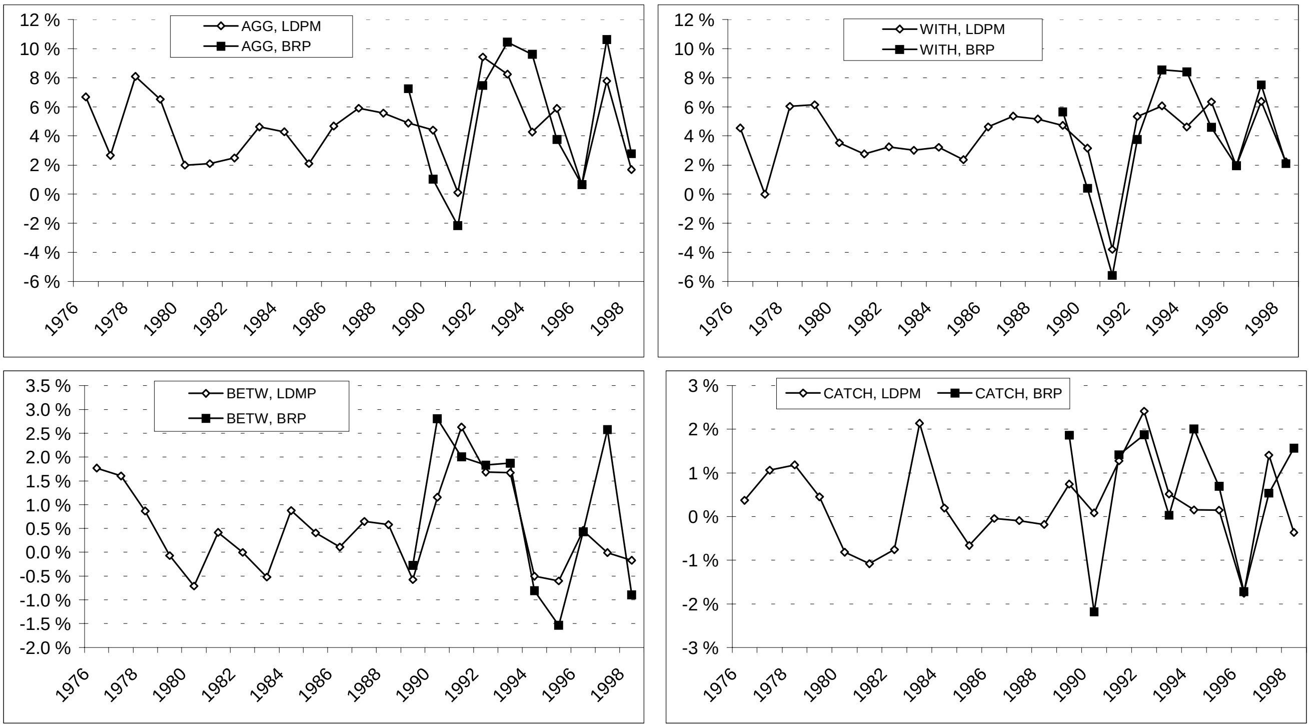
Figure 5.3. The bias in the labour productivity growth rate with fixed base year (year 1990) as contrasted to the rolling-base-year strategy



In the results presented above the output measures were expressed in end year prices, i.e. we used rolling base years. Quite often, however, this type of productivity analysis is carried out by using fixed base year prices instead. In order to inspect what sort of bias may be caused by using such a procedure in the analysis of aggregate productivity, we have in Figure 5.3 depicted the difference for aggregate labour productivity growth rate when calculated by fixed year prices versus rolling base year prices. The trend in the bias is very much in agreement with our expectations. The use of the fixed-base-year strategy yields negatively biased growth rates before the base year (in this case 1990) and positively biased rates henceforth. Thus, the use fixed-base-year strategy overstates the acceleration in productivity growth.[35] For the within component it does not make any difference which type of approach is employed.

In order to check the robustness of the results obtained by using Longitudinal Data on Plants in Manufacturing (LDPM) we have repeated the analysis for some parts by using Business Register on Plants (BRP) data. Some comparisons of results are shown in Figure 5.4. Although the output and input measures vary to some extent between the two data sets, the components seem to be mutually in agreement reasonably well. However, the within component stands out as more procyclical when calculated from the BRP data set. These series seem to confirm our view that there was productivity promoting reallocation at least in the period 1990-1993, but it was chilled after that. Finding qualitatively similar results by using BRP data sources is encouraging from the standpoint that we are going to use this alternative data set for examining productivity evolution in the service industries (see Section 5.7).

Figure 5.4. Components of labour productivity growth, LDPM and BRP data



Notes: In the LDPM data set output is measured with gross output and in the BRP data with sales. Decompositions have been made with the MBJ-method.

5.2 Net entry

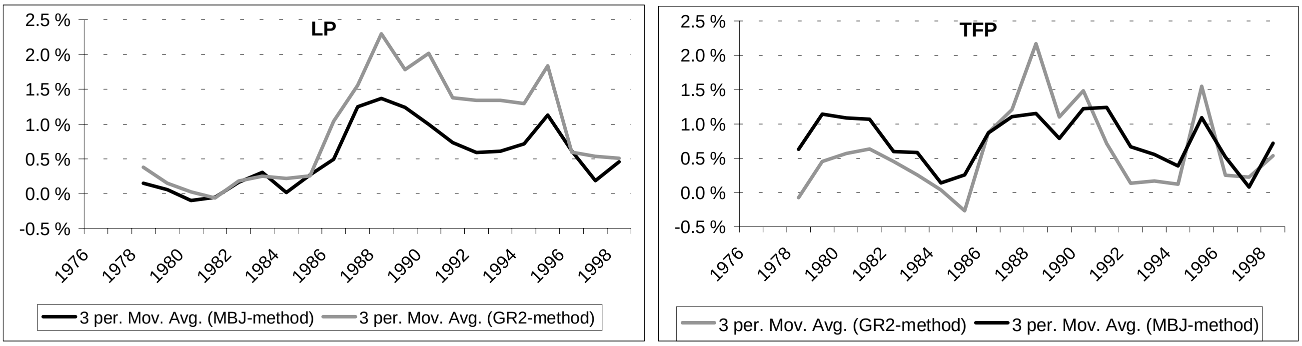
Above we were able to verify that the between effect has played a significant role in the aggregate productivity evolution of the Finnish manufacturing sector. Next we examine the extreme part of input reallocation that comes into being through the entry and exit of plants. In the MBBH- and MBJ-method the net entry component is defined as the difference of aggregate productivity growth among all plants and among continuing plants only. Alternatively, we use the methods introduced by Foster, Haltiwanger, and Krizan (1998) (FHK2 and GR2) that were presented in Section 3.2 (Equations (25) and (26)).

[35] See for example Corrado, Gilbert, and Raddoc (1997) and Varjonen (1994).

We have smoothed the series by using three-year moving averages (see Figure 5.5). This brings out the tendencies in the annual results more clearly. The net entry effect seems to be strongest at the onset of the recession (see also Maliranta, 1997c). We find that although the series for net entry obtained by MBJ- and GR2-method yield a rather similar pattern over time, some differences in the values for labour productivity can still be found.[36]

It should be noted that the break in the series between 1994 and 1995 might have some effect on the subsequent net entry figures, because some of the smaller plants are missing. We have, however, performed the same analysis with BRP data and these results (not reported here) suggest that the net entry effect has indeed been chilling, in a similar way as the between effect.

Figure 5.5 Net entry effect of labour and total factor productivity



Notes: Output is measured with value added. The results from year 1995 are removed because of the break in the series.

Entry as well as exit can be expected to be long term processes that involve a substantial amount of learning by doing and selection over time. Although new plants may appear to have not-so-superior productivity performance, at least some of them may have a potential. Jensen and McGuckin (1997) state that the surviving entrants grow very quickly and improve the productivity, reaching average levels in 5 to 10 years. Maliranta (1997b and 1998) investigates the development of productivity performance in new plants in Finnish manufacturing and comes to more or less similar conclusions. It is further shown that also the decaying process in terms of relative productivity[37] and input share is a long lasting process. Thus it can be argued that an analysis based on one-year periods fails to capture some essential features of the turnover of plants.

Due to these considerations, the contribution of entry and exit to aggregate TFP growth has been explored by using longer, 5-year ,periods. To circumvent the problem arising due to the change in the cut-off limit in 1995, we have included only those plants that employ at least 20 persons.[38] We see in Figure 5.6 that the entry, exit and between components have had important contribution and they seem to share quite a similar pattern during the period under consideration. This is in accordance with our intuitive idea that in essence the entry and exit of plants as well as the changing input shares among incumbents are all reflections of the same underlying renewal process. Figure 5.7 indicates that the net entry and between effects also share a similar type of short-run variation, at least up to the recession.

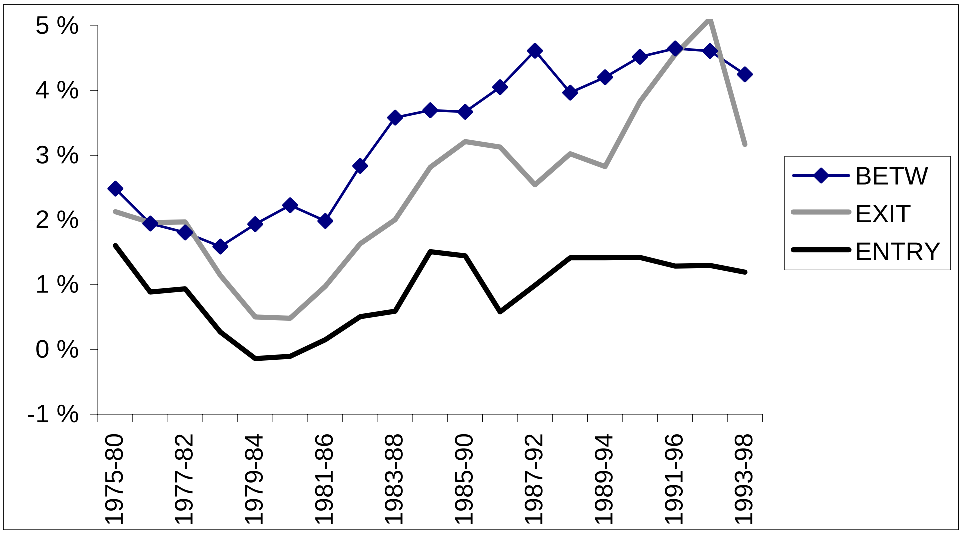
---

[36] The between and within components are, however, quite similar between the two types of methods for both labour and total factor productivity (not reported).

[37] Griliches and Regev (1995, 195) state in a study of firm productivity in Israeli industry that "the 'shadow of death' is reflected not only in levels but also in the growth rates of productivity".

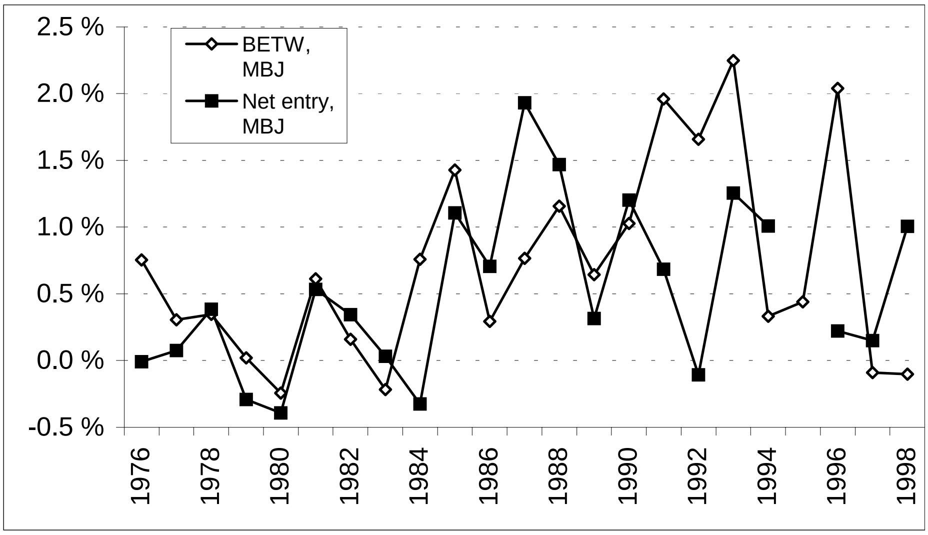
[38] As a robustness check we have performed similar computations for all plants employing at least 5 persons. We find that at least in the period up to the year 1994 the difference is hardly visible.

Figure 5.6. Entry, exit and between effects of total factor productivity, 5-year periods



Notes: Output is measured with value added. Decompositions are made with the GR2-method by including only those plants that employ at least 20 persons.

Figure 5.7. Between and net entry component of aggregate labour productivity growth



Notes: Output is measured with value added. Decomposition is made with the MBJ-method. The year 1995 is dropped because of a break in the data.

5.3 *Roles of plant characteristics in the restructuring process*

Heretofore we have found that the acceleration in aggregate productivity growth in the total manufacturing since the late-1980s can be attributed for the main part to the between and net entry components. Next we try to locate the source more closely. Attempts are made to seek out what kind of plants are behind this change of the evolution pattern. We explore the role of three attributes that can be expected to play a role in the micro-level restructuring process; 1) research and development investments made for creating new technologies, 2) the cohort of the plant and 3) exports. We classify plants into three groups, each of which covers one third of input usage. For example, the between components of each group add up to the total between component that we analysed above.

5.3.1 R&D intensity

We would expect that R&D efforts have an important role to play in the productivity promoting restructuring process. The amount of such activities is here measured with R&D intensity, which is the ratio of nominal R&D expenditures to nominal sales. The R&D intensity of a plant is defined here by firm-level data. In other words, we assume that each plant of a multi-unit firm has the same R&D intensity independent of, for example, its line of business.

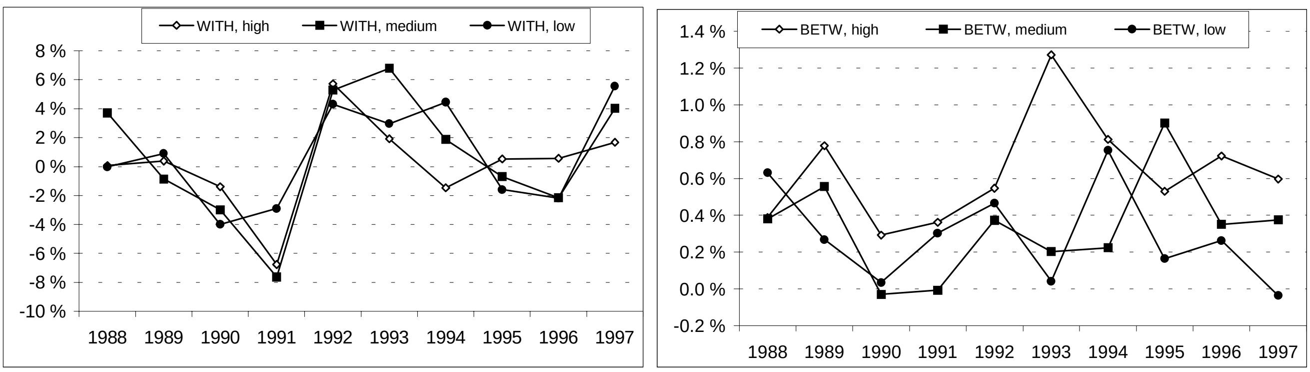
Perhaps somewhat surprisingly, the within component does not seem to vary systematically with R&D intensity. Maliranta (2000) obtains similar findings with a different approach and with partly different data sets. Thus it appears that the firms cannot generate extra productivity growth among their incumbent plants by investing to the creation of technological knowledge. We have also found that, on average, there is no significant difference in total factor productivity levels between low and high R&D intensity plants, either (results are not reported here).

However, we see that plants with high R&D intensity contribute to aggregate productivity significantly through the between component. Maliranta (2000) discovers that R&D intensity is an attribute that plays an important role in the process of reallocation of labour input. First, there appears to be a substantial amount of flows of labour between high and low R&D intensity plants to the direction of the former group. In addition, there is also restructuring among high R&D intensity plants.

These pieces of evidence suggest that high productivity plants owned by high R&D intensive firms increase their input usage shares at the expense of low productivity plants that may be owned by high as well as low R&D intensity firms. R&D activities generate variation in technologies that, in turn leads to experimentation and selection in the market environment. This process seems to be one of the driving forces of technological progress.

These observations are important from several perspectives. It seems that a substantial proportion of the fruits of R&D activities can be crept through restructuring. This being the case one would expect a considerable time lag before the increased innovation activity can be recognised in aggregate data. We come back to this issue in Section 5.5, where we look at time series evidence on the relationship between R&D and the between component in a simple econometric set-up.

Figure 5.8. Within and between components of TFP growth by R&D intensity



Note: GR2-method with value added used as the measure of output has been used.

Evidence obtained here seems to imply that a large proportion of the plants is incapable of boosting technological progress by means of new technological knowledge. It is possible that new technological knowledge must be embodied into tangible capital and transformed as human capital of the labour force to be effective. On the other hand, the internal restructuring could be time-consuming and this may explain our failure to identify the link between R&D intensity and productivity growth within plants. The implementation of new technological advances may require establishing new plants and hiring of new labour with modern skills. These considerations lead us to expect that new plants have an essential but slow stimulus in the process of aggregate productivity evolution.

5.3.2 Plant cohorts

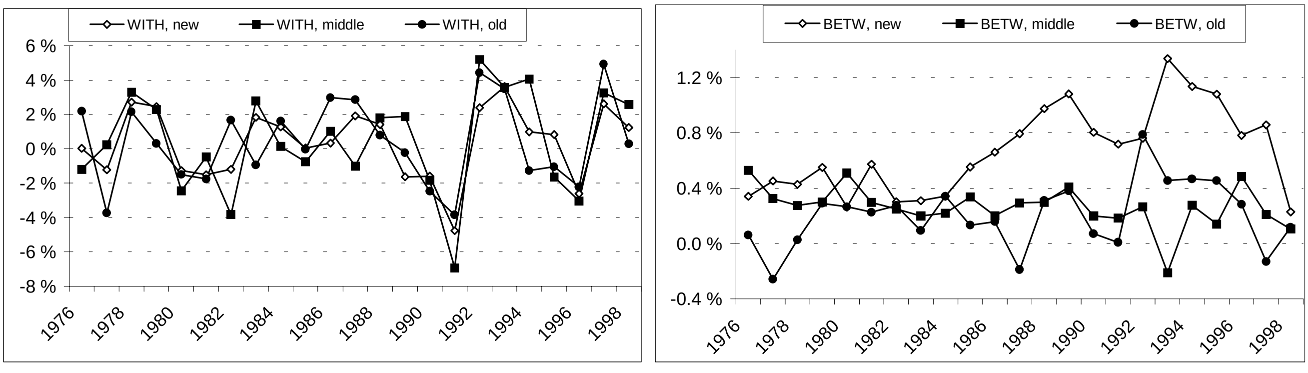
Information on the year of plants' birth is incomplete before year 1974. However, we can apply a strategy that, despite its obvious limitations, has proven useful in other contexts (see for example Maliranta, 1998, and Ilmakunnas, Maliranta and Vainiomäki, 1999; and Ilmakunnas and Maliranta, 2000b). The order of appearance of plants in the plant register system can be inferred from the identification numbers of plants with at least some accuracy. Making use of this property we have formed three broad cohorts, which each covers an equal share of input usage.

We would expect productivity growth within new plants to exceed that of older cohorts. There are at least two obvious reasons for this prediction. Firstly, new plants can be expected to have a greater learning potential. Secondly, new plants have usually more modern equipment. It may be easier to accommodate new technological knowledge, originating from research laboratories of the owner or some other firm, into more modern technology than into older ones.

However, we are unable to see any indication whatsoever of younger cohorts experiencing a higher rate of productivity growth. This seems to be in contrast with the results obtained by Maliranta (1998), who found relatively new plants to have above-average productivity growth rates, when a large number of control variables were included. However, here much broader categories are used and no control variables, which is likely to explain the difference in findings.

Our categories, however, are not too broad to capture one striking difference in the role of the reallocation effect between relatively new and old plants. One important conclusion that can be drawn from Figure 5.9 is that the appearance of an increasing between component in the mid-1980s can be attributed to new plants. Maliranta (1998) has studied the components separately for each cohort and found that since the mid-1980s also the restructuring *among* new plants has played an important role in the aggregate productivity growth of new plants. This suggests that there is a large-scale selection process in operation among the younger cohorts. Ilmakunnas and Maliranta (2000b,c and d) in turn found that younger plants increase their labour share at the expense of the older ones.

Figure 5.9. Within and between components of TFP growth by plant cohorts



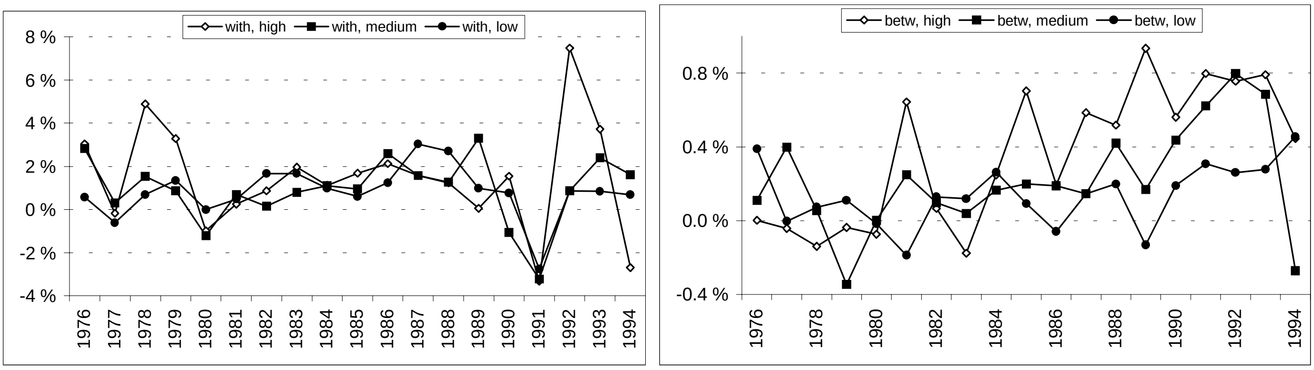
Note: GR2-method with value added used as the output measure.

All in all, it seems that the plants that have been successful in achieving high productivity level are those who create new jobs. As it seems that high R&D intensity firms are those who establish and expand plants, we are apt to believe that those new plants contributing positively to the between effect are typically owned by a firm with relatively high R&D intensity.

5.3.3 Exports

Finally we investigate to what extent export-orientated plants contribute to the between and within components of total factor productivity growth. Again we find hardly any differences in the within component between different groups of plants. However, we see in Figure 5.10 that export intensity (export per output) is positively linked with the size of the between component especially since the mid-1980s. This should be no surprise when recalling our theoretical considerations made in Section 2. Global markets give a lot of room for high productivity plants (and firms) to expand. It is likely that R&D (and possibly plant age) and export orientation are mutually inter-related.

Figure 5.10. Within and between components of TFP growth by plant's export intensity



Note: GR2-method with value added used as the output measure.

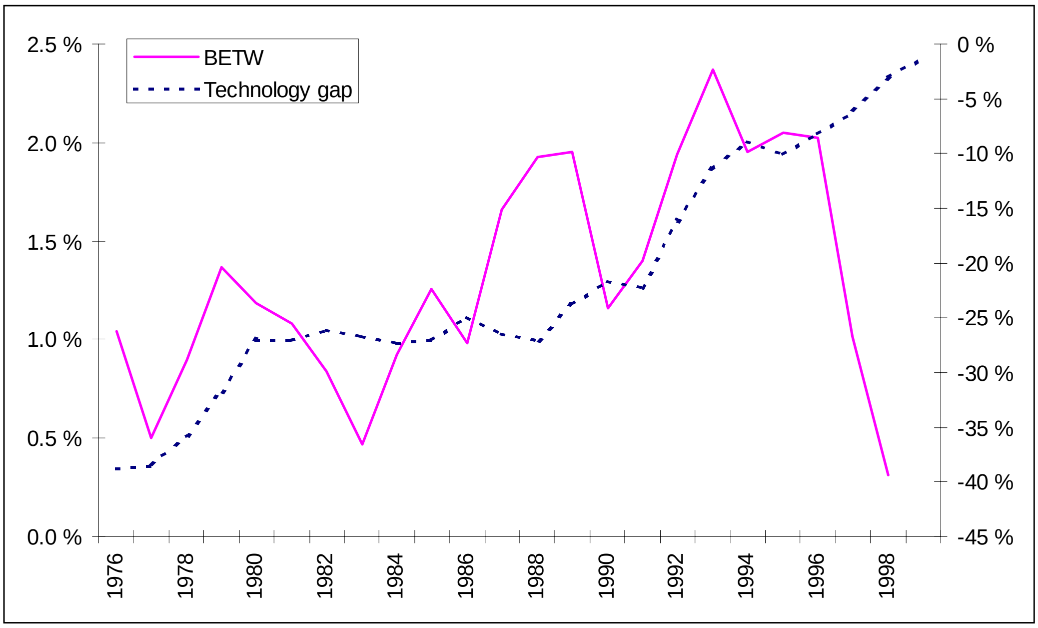
5.4 Consequences of micro-structural factors

Next we examine in what way the micro-structural components, and especially the between component, have been associated with catching up of the international technology frontier, on one hand, and with the evolution of productivity and wage dispersion, on the other.

5.4.1 Catching up of the international production frontier

Even bearing in mind the difficulties involved in international productivity comparisons, Figure 5.11 seems to provide further support to our conviction that the between component has played an essential role in productivity evolution in Finnish manufacturing. We note that the productivity performance level was quite low in the beginning of the 1980s and that the catching-up process was strikingly slow during the first part of the 1980s. Indeed, it seems that the Finnish manufacturing sector was inefficient and stagnant in terms of catching up until the mid-1980s. First signs of improvement in relative performance started to appear in the late 1980s and the progress accelerated substantially in the early 1990s, together with the rise of the between component of productivity growth. The rate of the catching up process moderated slightly in the mid-1990s and the between component has fallen down subsequently.

Figure 5.11. Between component (scale on the left) and technology gap (scale on the right) to the United States



Notes: BETW denotes the between effect component calculated with the MBJ-method using a value added measure of output. The technology gap series is based on updated results from Maliranta (1996), see notes of Figure 1.

5.4.2 Productivity dispersion

The components of the MBJ productivity decomposition method, introduced in the equation (16), are particularly useful when disentangling various sources of productivity dispersion. Narrowing *labour input weighted* labour productivity dispersion among plants (σ-convergence) can be a consequence of a negative correlation between initial productivity level and subsequent productivity growth (β-convergence) or, with given productivity levels, reallocation of labour input away from the plants of the lowest productivity. The former factor can be evaluated with our catching-up term and the latter with the between plants component. For example, tightening competitive pressure may suppress productivity dispersion by forcing low productivity plants to improve their conduct or by cleaning low productivity plants.

We evaluate this issue by performing simple regression analysis with manufacturing time-series data on productivity dispersion and micro-level components of productivity. We use the log of labour weighted coefficient of variation of labour productivity (cvlp) as the dependent variable. Explanatory variables include productivity components of the MBJ-method and their lagged value. Furthermore we incorporate a time trend in the model. The results, which are very much in accordance with our expectations, are shown in Table 5.2.

The restructuring of labour among plants, which is reflected in the between component of the aggregate labour productivity growth rate (BETWLP variable), tends to keep productivity dispersion low. Moreover, above-average productivity growth among the low productivity plants curbs the increase of labour productivity dispersion, which can be inferred from the positive coefficient of the catching-up variable (see model (1)). Also the between component of total factor productivity seems to predict labour productivity dispersion (see model (3)). We have estimated the models also in differenced form. The results validate our discovery that micro-structural component are important for the development of productivity dispersion (see models (2) and (4)).[39] Maliranta (1997b, pages 23-24) reports similar findings.

All in all, our simple model predicts quite well the variation in manufacturing productivity dispersion over time. It indicates that the downward tendency in productivity dispersion in Finnish manufacturing since the mid-1980s can be explained by the appearance of productivity-enhancing structural changes at the plant level.[40] This finding is striking for two related reasons. The tendency in Finnish productivity dispersion is in sharp contrast with that in the USA. Moreover, the results by Foster, Haltiwanger, and Krizan (1998) obtained with a method most comparable with MBJ (that is, the GR2-method) suggest that the between component has played hardly any role in the evolution of aggregate labour productivity growth in US manufacturing.

Table 5.2. Labour productivity dispersion

Dependent variable	(1) cvlp Coefficient	Std. Error	(2) d(cvlp) Coefficient	Std. Error	(3) cvlp Coefficient	Std. Error	(4) d(cvlp) Coefficient	Std. Error
Intercept	-0.199 (***)	0.030	0.002	0.013	-0.145 (***)	0.045	0.007	0.020
BETWLP	-1.958 (*)	1.109						
BETWLP(-1)	-5.535 (***)	1.435						
CATCHLP	0.775 (*)	0.397						
CATCHLP(-1)	2.245 (***)	0.466						
d(BETWLP)			-0.915	1.318				
d(BETWLP(-1))			-5.512 (***)	1.556				
d(CATCHLP)			1.506 (***)	0.514				
d(CATCHLP(-1))			2.032 (***)	0.459				
BETWTFP(-1)					-5.968 (*)	3.308		
CATCHTFP(-1)					-0.699	0.962		
d(BETWTFP(-1))							-11.21 (**)	4.819
d(CATCHTFP(-1))							-0.525	0.707
trend	0.000	0.002			-0.002	0.004		
N	22		21		22		21	
R-squared	0.769		0.724		0.259		0.267	
Adjusted R-squared	0.697		0.655		0.135		0.185	
S.E. of regression	0.044		0.059		0.074		0.091	
Sum squared resid	0.031		0.056		0.098		0.148	
Log likelihood	41.13		32.48		28.31		22.20	
Durbin-Watson	2.081		2.486		1.648		1.768	

Notes. Productivity components are obtained from MBJ decomposition. Productivity dispersion is calculated as the log of the labour input weighted coefficient of variation (cvlp) among plants employing at least 20 persons. White's corrections have been made for the standard error estimates.
(***) 1 % significance level
(**) 5 % significance level
(*) 10 % significance level

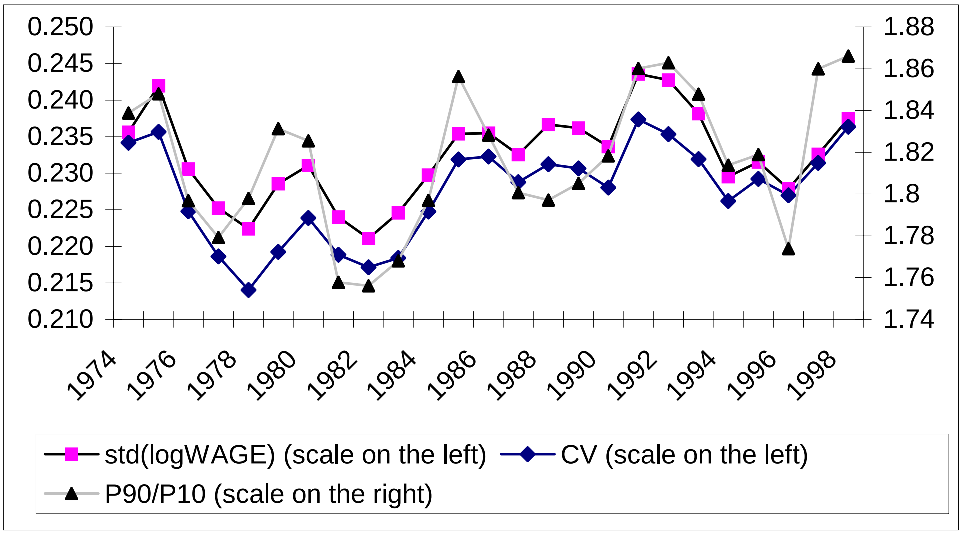
[39] Diagnostic tests indicate that the models in Table 5.2 are generally satisfactory (about tests performed, see below).

[40] We have performed the analysis also by measuring productivity dispersion with the standard deviation of log labour productivity and with the P90/P10 ratio (with labour input weights). It should be noted that there were some differences in the pattern of the series. In particular, these two alternative measures of productivity dispersion do not exhibit as clear a downward tendency in labour productivity dispersion. When the standard deviation of log labour productivity was used, we did not obtain as significant statistical relationships as in Table 5.2.

5.4.3 Wage dispersion between plants

Dunne, Foster, Haltiwanger, and Troske (1999) report a substantial increase in hourly wage dispersion between plants, when measured with the coefficient of variation among production workers and especially among non-production workers. A similar tendency can be found in Finnish manufacturing for non-production workers. The pattern of dispersion evolution among production workers seems to be different, however. There is variation in dispersion over time, but no clear upward tendency can be found after the late 1980s (see Figure 5.12)

Figure 5.12. Wage dispersion of production workers (hours weighted) in Finnish manufacturing



Notes. To render time-series as comparable over time as possible we have included only those plants employing at least 20 persons. The inclusion of plants employing less than 20 (but at least 5) persons do not change the picture materially.

The departure from the US experience invites us to seek for determinants of wage dispersion development in Finnish manufacturing. As noted above, the productivity components seem to have affected the development of labour productivity dispersion. As we have reason to believe that the evolution of wages and productivity are mutually linked according to the arguments emphasised by Dunne, Foster, Haltiwanger, and Troske (1999), we anticipate that the productivity components have some role to play in the determination of wage dispersion as well.

The dependent variable is the log of the coefficient variation for hours weighted wage dispersion among production workers. Findings from simple regression models suggest that the same factors that drive productivity dispersion push wage dispersion among production workers, but a perhaps slightly longer lag. Model (1) in Table 5.3 is estimated in level form. The positive between component of labour productivity points to narrowed wage dispersion through external restructuring. A weaker 'catching-up effect' seems to work in the same direction with a slightly shorter lag. These results gain some further confirmation when the model is estimated in differenced form. Perhaps somewhat surprisingly, the productivity components of total factor productivity have even more predictive power than the labour productivity components. Again a high between component, indicating external adjustment and a low catching-up term, denoting internal adjustment, appears to lead to lower wage dispersion among production workers in few years (Models (3) and (4)).

Table 5.3. Dispersion of hourly wages, production workers

	(1)		(2)		(3)		(4)	
Dependent variable	cvwpr		d(cvwpr)		cvwpr		d(cvwpr)	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Intercept	-1.539 (***)	0.009	0.006	0.004	-1.511 (***)	0.008	0.004	0.004
BETWLB(-3)	-1.659 (**)	0.613						
CATCHLB(-1)	0.470 (***)	0.126						
CATCHLB(-2)	0.436 (**)	0.155						
d(BETWLB(-2))			-1.006 (*)	0.490				
d(BETWLB(-3))			-1.089 (*)	0.575				
d(CATCHLB)			0.401 (*)	0.204				
d(CATCHLB(-1))			0.553 (***)	0.153				
d(CATCHLB(-2))			0.643 (**)	0.228				
BETWTFP(-2)					-2.237 (***)	0.733		
BETWTFP(-3)					-2.049 (**)	0.871		
CATCHTFP					0.469 (*)	0.224		
CATCHTFP(-1)					0.548 (**)	0.214		
d(BETWTFP(-3))							-2.039 (**)	0.707
d(CATCHTFP)							0.408 (**)	0.144
d(CATCHTFP(-1))							0.492 (**)	0.222
trend	0.005 (***)	0.001			0.007 (***)	0.001		
N	20		19		20		19	
R-squared	0.693		0.473		0.792		0.318	
Adjusted R-squared	0.611		0.271		0.717		0.182	
S.E. of regression	0.017		0.016		0.014		0.017	
Sum squared resid	0.004		0.003		0.003		0.005	
Log likelihood	56.44		54.77		60.33		52.32	
DW	1.428		1.656		1.387		2.000	

(***) 1 % significance level
(**) 5 % significance level
(*) 10 % significance level
Notes. Productivity components are obtained from MBJ decomposition. Wage dispersion is calculated among plants employing at least 20 persons.

Irrespective of whether wages are determined in centralised wage agreements or in competitive labour markets, firms and plants take wage levels as given. If the wages do not adjust at the plant level, internal adjustment of productivity performance within plants or external adjustment through restructuring is needed. Our results provide at least some suggestive evidence that this, in turn, is likely to lead to a narrowing in productivity dispersion.

Our results seem to suggest that external adjustment has been quite marked in Finnish manufacturing especially since the mid-1980s. Low productivity and low wage jobs have been cleaned in the course of plant level restructuring. This may provide at least a partial explanation for the finding by Suoniemi (2000) that despite dramatic restructuring of the Finnish economy in the 1990s no marked expansion in wage differentials can be found.[41] Of course, the argument can be reversed, too; perhaps depressing the expansion of wage differentials between plants has led to exceptionally strong reallocation of jobs with negative unemployment and positive aggregate productivity as main outcomes. The critical question is, of course, to what extent the jobs that were lost during the recession can be supplanted by high productivity and high wage jobs during the recovery period.

The above results solely concerned the wages of production workers in manufacturing. We have performed similar analysis also for non-production workers (and all workers).[42] For non-production workers we were, however, unable to find any statistical relationship between wage dispersion and micro-structural factors. Wage dispersion of non-production workers exhibits, in contrast to production

[41] Suoniemi finds that developments in capital income are the main source for the increase in relative income inequality.
[42] The analysis of all workers yielded similar results as for solely production workers (but somewhat poorer fit).

workers, an upward tendency for the whole period from 1975 to 1998. It seems tha for some reason, the appearance of significant micro-level productivity components especially since the mid-1980s, reverted the tendency of increasing wage dispersion for production workers but not for non-production workers.

One possible explanation for this may that the nation- and industry-level bargaining is more relevant from the standpoint of wage formation of production workers. It is possible that job mobility and matching are becoming more relevant in the determination of the wages (see Manning, 1998a and 1998b) of higher educated workers, while for the less educated general wage agreements still play quite a decisive role.[43] Plants that are unable or unwilling to pay high wages to non-production workers are piled up relatively immobile (or uninformed a la Acemoglu and Shimer, 2000, or loyal) non-production workers.[44] This tendency may also be a reflection of highly educated workers having become more able to appropriate the quasi-rents of plants and firms so that the 'ability to pay' argument plays a bigger role than before.

The illustrative analysis performed above was based on manufacturing time series. Therefore, the dispersion of productivity and wage levels includes dispersion within industries as well as between industries. Analogously our explanatory variables capture the contribution of changes in industry structures as well as changes in plant structures within industries. However, the dispersion between 2-digit industries accounts for an almost negligible proportion of the wage dispersion for non-production workers and a minor share of the wage dispersion of production workers. We have also found that a lion share of the productivity-enhancing structural change takes place within industries. All told, a more comprehensive analysis on the role of productivity-enhancing micro-structural change for productivity and wage dispersion should rest on industry-level observations and will be carried out in a separate study.

5.5 Determinants of the between component

The appearance of the between effect has been forceful in the above analyses and it seems to have had various important implications. Therefore it is of great interest to learn about its determinants. We focus on three factors.

1) The competitive pressure that firms face in the domestic markets can be expected to play a role in the productivity evolution. But it can also be argued that exposure to global competition is especially important for a small open economy like Finland. The relatively extensive trade with the former Soviet Union is one of the distinctive features of the Finnish economy in the post-war period up to the mid-1980s. At its height in the early 1980s, the export to the Soviet Union accounted for some one fifth of total export and some 7 per cent of GDP. Given the considerable difference in the competitive pressure in the bilateral trade negotiations with the Soviet Union as contrasted to that in the Western markets, it seems important to make a clear distinction between these two markets. The collapse of the bilateral trade with the former Soviet Union due to the decline in oil prices in the mid-1980s compelled Finnish manufacturing firms to seek for markets elsewhere (e.g. Western markets). Another shock coming from the former Soviet market was experienced in the early 1990s when the Soviet Union broke down. We use exports to Western markets[45] per value added as an indicator of the competitive pressure aris-

---

[43] Piekkola and Böckerman (1999) provide evidence that the highly educated have been more mobile than the less educated.

[44] These arguments appear to suggest that the wage ratio between non-production and production workers is relatively low among plants with low ability to pay. For example, non-production workers seem to have relatively low wages in the public sector nowadays in Finland (see Korkeamäki, 2000).

[45] This group includes the following countries: the United States, Japan, Canada, Sweden, Norway, Denmark, Germany, France, Austria, Belgium, the United Kingdom, Italy and the Netherlands.

ing from highly competitive markets. It should then be noted that the collapse of exports to the Soviet Union in the mid-1980s was only one of the episodes of a broader process that integrated Finland more closely with Western Europe. Moreover, even in the early 1980s, the dominant proportion of export shipments went to Western markets. It seems obvious, however, that the Finnish manufacturing sector witnessed important and profound changes in its economic environment.

2) As discussed in Chapter 2, innovation activities can be expected to be another source of restructuring. The intensity of innovation activity is measured here in a quite traditional way, i.e. as R&D expenditure per value added (*RDINT*).

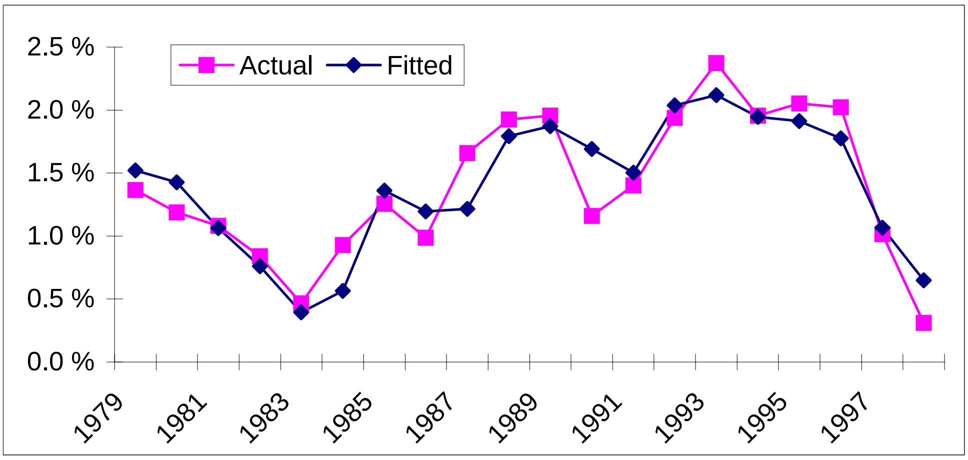
3) It is possible that the catching-up of the international technology frontier goes partly through a 'creative destruction' process. Therefore we have also included a variable indicating the difference between the Finnish and US total factor productivity level.

In order to avoid a 'spurious' relationship, which may arise because of trends in our series, we have included also a TREND variable in the model. We have obtained the following model[46]:

BETW =	0.226 +	0.040*ln(EXPWEST(-1)) +	0.033*ln(RDINT(-4)) +	0.016*ln(TFPGAP(-1)) -	0.002*TREND
	(0.044)	(0.010)	(0.011)	(0.004)	(0.001)
	(***)	(***)	(***)	(***)	(**)

N = 20, R^2 = 0.828, adj. R^2 = 0.782. (***) denotes 1 % and (**) 5 % significance level.

Figure 5.13 Explaining between component of TFP growth in Finnish manufacturing



Note: See text and model above.

The model yields quite a good fit (see Figure 5.13). It provides explanations for a couple of turns in the between component in Finnish manufacturing from the late 1970s to the late 1990s. It appears that the increase in R&D intensity in the early 1980s as well as the increased exports to Western markets in the 1980s have resulted in accelerated total factor productivity growth via the increased between component. According to the model the 'chill' in the between component toward the end of the 1990s can be attributed to the narrowing gap to the technology frontier in the mid-1990s. There was less micro-structural inefficiency to be 'cleaned' through restructuring in the latter part of the period under consideration, which may have brought about a chill in the ongoing re-structuring process.

---

46 White's corrections are performed for the standard error estimates. See also notes about the data in Table 5.4.

In addition to the fact that our simple model seems to have quite a bit of explanatory power reflected in reasonably high R^2 statistics, it also has other reasonably good statistical properties. The Breusch-Godfrey LM test suggests that our model is not plagued by a serial correlation problem. The ARCH test tells that autoregressive conditional heteroscedasticity is no problem, either. The Ramsey RESET test does not give any indication whatsoever of potential specification errors. Our model passes stability tests with recursive residuals. The coefficients seem to be reasonably stable over time as well. We do not find any evidence on non-normality, either.

We have assumed that our variables are stationary (with allowance for deterministic trends). This assumption can be argued to be questionable. Although tests of stationarity with this small a sample should be interpreted cautiously they suggest, if anything, that our variables are rather I(1) than I(0) processes.[47] Therefore a more careful investigation may be needed. Table 5.4 reports the results obtained with differenced variables.

Models (1) - (4) in Table 5.4 estimated in differenced form confirm our findings from our previous regression model. They show that R&D intensity affects total factor productivity through the between growth component with a lag of some three to five years. In other words, it seems that to reap all fruits of R&D efforts at the aggregate level some time is needed for productivity increase through restructuring at the micro-level. Rouvinen (1999) has studied the effect of R&D on TFP from an unbalanced panel of 14 industries in 12 OECD countries from 1973 to 1997. He also observes that R&D affects TFP with a considerable lag. In most cases the fourth lag is the highest, which accords in an interesting way with our finding. Current R&D has typically a statistically significant negative coefficient estimate in Rouvinen's study.

Table 5.4. Determinants of between component in Finnish manufacturing

Dependent variable	(1) d(BETW) Coefficient	Std. Error	(2) d(BETW) Coefficient	Std. Error	(3) d(BETW) Coefficient	Std. Error	(4) d(BETW) Coefficient	Std. Error
Intercept	-0.001	0.001	-0.006	0.004	-0.008 (**)	0.003	-0.002 (***)	0.001
d(BETW(-1))			-0.182	0.342				
d(BETW(-2))			-0.665 (**)	0.255				
d(*expwest*)					0.036 (***)	0.009	0.024 (***)	0.007
d(*expwest*(-1))	0.027 (***)	0.008			0.018	0.011	0.027 (**)	0.009
d(*rdint*(-1))			-0.004	0.020	0.018 (*)	0.009		
d(*rdint*(-2))			-0.002	0.018	-0.001	0.009		
d(*rdint*(-3))			0.031	0.022	0.008	0.018		
d(*rdint*(-4))			0.038 (**)	0.013	0.043 (***)	0.012	0.036 (***)	0.011
d(*rdint*(-5))			0.036	0.021	0.035 (**)	0.012		
d(tfpgap(-1)							0.015 (***)	0.004
N	22		18		18		19	
R-squared	0.164		0.509		0.653		0.634	
Adjusted R-squared	0.122		0.165		0.411		0.530	
S.E. of regression	0.004		0.004		0.004		0.003	
Sum squared resid	0.000		0.000		0.000		0.000	
Log likelihood	89.14		77.41		80.54		84.99	
Durbin-Watson	1.712		2.349		2.021		2.413	

(***) 1 % significance level
(**) 5 % significance level
(*) 10 % significance level

Notes: *BETW* is the between component of *TFP* growth computed by MBJ method. White (1980) corrections are made for standard error estimates. R&D expenditures per value added (*RDINT*) is calculated from STAN and ANBERD databases (OECD). Information for calculating exports to Western markets per value added is obtained from ETLA's economic database. Small letters indicate that the variable is in the log-form.

[47] In view of the nature of the between component we might expect the BETW variable to be stationary. However, tests performed for the period from 1976 to 1998 suggest that it may rather be non-stationary.

As one might expect, orientation to the more demanding Western markets has more immediate consequences. Our third finding is that the magnitude of the restructuring component is associated with backwardness in productivity performance. The greater the gap to the frontier, the more easily a high between component can arise.

Also for these models a large set of diagnostic tests were made (Breusch-Godfrey LM test for serial correlation, and Ramsey RESET test and recursive residuals for miss-specification). They do not indicate noteworthy problems in the functional form or the error term (autocorrelation, heteroscedasticity or non-normality). There seems to be two somewhat exceptional observations, though, 1987 and 1990. When they are controlled for the other coefficient estimates in Model (4) remain basically the same, but the adjusted R^2 increases to 0.78 (results not reported here).

We have sought for the proper variable composition by estimating a large number of models by adding and dropping variables step by step. For instance, lag structures are identified by first estimating a large model allowing long lags (six years or so). Then we have dropped variable, one at a time, on the basis of t-values. We have also carried out this procedure the other way around, i.e. by first using such lagged variables that have the highest t-values and then including more variables. Different model selection approaches resulted in more or less similar outcomes. Those reported here are typically those having a relatively high adjusted R^2 (and other good statistical properties).

There is some anecdotal evidence that the quality of products and processes among plants that were orientated towards Soviet markets did not correspond to the standards of Western markets. The results presented above seem to suggest that the external adjustment (i.e. through restructuring at the plant level) has, indeed, played an important role. Increased international openness may be beneficial for the country because this expands the market for successful units, those being the most able to compete with foreign rivals. They may invest in capital and create new jobs and by this means increase their production to foreign markets.

The shift towards more competitive and more demanding Western markets may also be expected to yield accelerated productivity growth within plants. For example, a harder competition leads to the need of eliminating X-inefficiencies that might have arisen in the softer economic environment. To evaluate this, we have examined the effect of exports, R&D intensity and total factor productivity gap on the catching up term. We obtained the following result[48]:

$$\begin{array}{llll} \text{CATCH} = & -0.106 & -\ 0.064 \cdot \ln(\text{EXPWEST}(-1)) & +\ 0.002 \cdot \text{TREND} \\ & (0.046) & (0.029) & (0.001) \\ & (**) & (**) & \end{array}$$

$N = 23$, $R^2 = 0.158$, adj. $R^2 = 0.074$.

We have estimated models in differenced form as well (results not reported). The coefficient estimates of the export variable had generally the same sign as above, but with low statistical significance. Although we have obtained some scant evidence that greater exposure to Western markets has reduced inefficiency among plants through increased β-convergence, this finding seems somewhat uncertain and fragile.

48 R&D variable was not statistically significant.

5.6 Structural factors in manufacturing industries

So far we have considered structural change within the manufacturing sector as a whole. Some proportion of plant level structural change takes the form of changes in industry structures. In this section we look at the components of aggregate productivity by industries. To provide more robust results we have calculated trimmed averages of the annual components over the period by deleting minimum and maximum values. Computations are made for labour productivity and total factor productivity.

Looking at the contribution of the between component of labour productivity growth reveals some interesting differences between industries (Table 5.5). In the early periods the effect seems to be modest or even negative in food products, wearing apparel as well as in footwear and leather products. Also in the manufacture of stone, clay and glass products the between effect has been insignificant until the recession. A considerable increase in the contribution of the between component can be observed at the advent and during the recession in those and also some other industries. The increase in the effect is especially pronounced in electric engineering. In paper industry instead the between effect has been important for long.

The catching-up component varies between industries and periods quite considerably but the lower values in the last period suggest that β-convergence in productivity levels has been important especially in the period from 1995 to 1998. The net entry effect has values from quite a wide range and should be interpreted cautiously. However, in many industries the effect seems to have been quite positive in the period from 1991 to 1994 and especially from 1995 to 1998.

The corresponding results for the total factor productivity indicator are reported in Table 5.6. As a whole, the between effect appears to be more positive and the catching up term more negative when the use of capital is taken into account. Again we discover that the between component has been relatively small in manufacture of food products and wearing apparels, but has ameliorated remarkable in the 1990s. Quite a huge improvement can also be seen in manufacture of stone, class etc. Since the mid-1980s the between effect has been at a high level in the metal industries. As we saw earlier, the catching-up term is more commonly negative for total factor productivity than for labour productivity. Not surprisingly, the same seems to be true at the industry level as well.

It is interesting to note that the change in the role of the micro-structural factors has been so substantial especially in the food industry and in non-metallic minerals. Traditionally domestic markets have been the main field of the struggle among firms and plants in these industries. However, the upsurge in the export as well as in the import share has been substantial during the 1990s (see Figure 5.13). Consequently the change in the economic environment has been particularly important in these industries. This is in accordance with our hypothesis that increased competition entails structural change at the plant level.

Table 5.5. Micro-structural factors of aggregate labour productivity growth, %, trimmed annual averages.

	Between component, %					Catching-up component, %					Net entry component, %				
ISIC Rev 1	**76-80**	**81-85**	**86-90**	**91-94**	**95-98**	**76-80**	**81-85**	**86-90**	**91-94**	**95-98**	**76-80**	**81-85**	**86-90**	**91-94**	**95-98**
Food, beverages and tobacco	0.1	-0.5	-0.4	0.8	-0.9	-1.6	0.0	2.3	0.8	-2.7	5.8	-2.1	-3.5	1.0	4.4
Textiles	0.4	0.7	0.9	0.6	1.0	1.2	-1.3	-0.6	0.1	0.8	2.4	-0.5	2.3	0.8	0.1
Wearing apparel	-0.2	-0.1	0.0	0.9	0.3	0.2	0.0	1.6	0.4	-0.7	-0.4	-0.1	0.8	1.3	8.1
Footwear and leather prod.	-0.2	0.1	1.1	1.3	0.6	-0.1	0.0	2.3	-1.1	-0.1	1.5	1.8	0.8	1.7	2.5
Wood prod. and furniture	0.9	0.1	0.6	0.8	-0.1	-0.9	0.5	0.2	2.1	-0.2	-2.3	4.7	-1.4	-1.5	12.8
Paper and pulp	1.8	0.6	1.1	1.4	1.3	1.3	0.1	1.3	1.0	2.1	-2.2	-1.6	0.5	-3.6	0.4
Printing and publishing	0.3	0.7	0.7	0.8	0.6	1.0	-0.1	-1.0	-0.6	-0.2	2.4	-0.7	1.2	1.9	0.7
Chemicals	0.3	0.2	0.6	1.0	0.3	-1.1	1.7	0.0	0.3	1.0	0.6	-0.7	-1.7	3.3	-0.3
Petroleum refining	1.1	-0.5	-0.4	0.4	1.3	3.1	1.6	5.0	-1.3	-1.1	-11.1	-1.3	-5.4	-2.0	5.8
Rubber and plastic	0.9	0.6	0.4	0.7	0.4	-0.3	-1.2	0.3	0.2	-0.9	1.6	0.0	-0.6	1.0	0.7
Non-metallic minerals	0.6	-0.1	0.2	1.2	0.3	0.0	0.2	0.4	0.7	-0.9	1.1	-0.3	-1.6	1.0	1.8
Basic metals	-0.1	0.5	2.9	0.6	1.1	1.7	0.2	-1.1	8.1	-4.2	2.5	0.2	-3.4	-4.2	2.8
Metal products	0.3	0.4	0.8	0.5	-0.1	-0.6	1.4	0.5	0.3	0.2	3.4	-0.2	1.7	3.1	0.4
Machinery	-1.2	0.9	1.5	1.6	0.5	1.5	1.8	-1.5	0.2	0.0	1.6	0.9	-0.2	4.5	1.9
Electrical machinery	-0.1	0.2	1.0	2.6	0.8	2.1	0.0	0.7	0.4	0.4	0.3	-0.8	0.4	4.0	4.7
Transport equipment	0.0	0.5	0.6	0.5	0.7	0.0	2.9	-1.5	1.5	-1.4	0.4	-1.4	-1.5	0.2	4.8
Other	0.1	0.4	1.7	2.0	0.8	-0.3	0.0	2.1	-1.3	-1.1	0.4	0.0	3.1	1.0	5.1

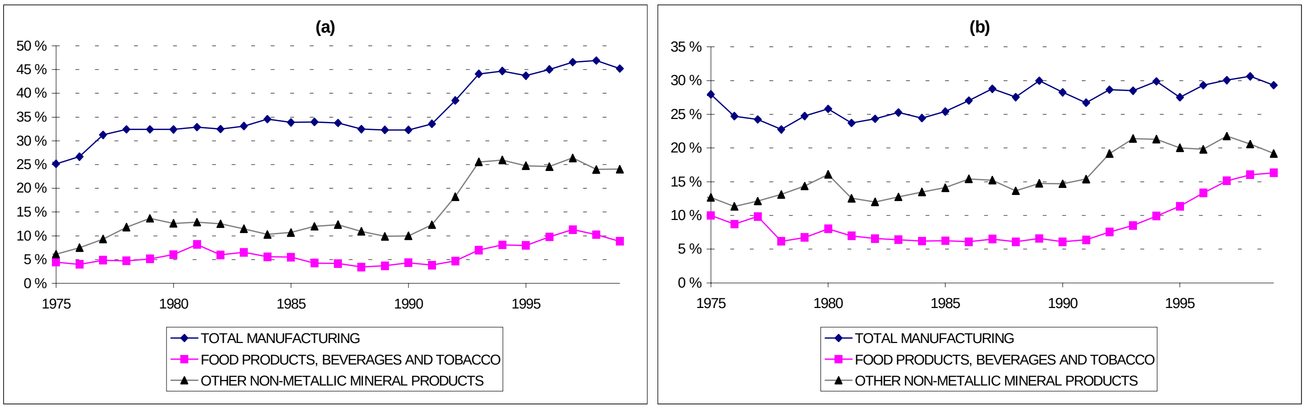
Note: Decompositions are made with the MBJ-method by using value added output.

Table 5.6. Micro-structural factors of aggregate TFP growth, %, trimmed annual averages

ISIC Rev 1	Between component, %					Catching-up component, %					Net entry component, %				
	76-80	81-85	86-90	91-94	95-98	76-80	81-85	86-90	91-94	95-98	76-80	81-85	86-90	91-94	95-98
Food, beverages and tobacco	0.7	0.4	0.3	1.6	0.8	-1.8	-0.2	0.7	-0.4	-3.2	6.7	-1.8	-2.8	1.0	5.8
Textiles	1.7	0.4	1.5	0.7	1.5	0.7	-1.4	-1.2	-0.5	0.1	2.4	-0.5	2.6	-0.4	1.7
Wearing apparel	0.5	0.1	0.4	1.4	0.4	-0.7	-0.1	1.1	0.4	-0.4	0.8	0.2	1.5	0.1	8.9
Footwear and leather prod.	0.4	0.3	1.8	1.7	1.1	0.6	-0.4	2.4	-3.1	-0.2	1.8	2.3	1.4	1.3	3.4
Wood prod. and furniture	0.9	0.7	1.3	0.9	0.5	-2.4	1.2	-0.2	-0.3	0.7	-1.8	4.9	-1.1	-1.7	14.2
Paper and pulp	2.5	0.6	0.3	0.3	0.8	0.8	-0.9	-1.7	-3.4	0.2	-1.2	-1.7	0.5	-4.8	3.2
Printing and publishing	1.3	1.1	2.5	1.2	2.0	0.1	0.2	-2.0	-0.6	-0.2	4.1	0.6	1.7	3.2	2.2
Chemicals	1.8	1.2	1.7	4.2	0.3	-3.7	1.7	-1.1	-5.4	0.3	0.8	-2.1	-3.3	2.5	1.6
Petroleum refining	0.2	0.7	0.3	0.0	0.7	-4.5	0.0	3.3	-5.6	4.0	-3.6	-12.0	-1.4	5.3	-10.9
Rubber and plastic	0.6	0.9	0.9	1.1	1.1	-0.2	-0.2	-1.5	-0.4	-0.8	3.9	-0.1	1.7	2.9	0.7
Non-metallic minerals	0.8	1.2	0.8	2.8	1.3	-0.2	-1.2	0.4	0.2	-0.8	1.7	-0.5	-1.8	1.7	1.4
Basic metals	0.0	-0.3	1.8	0.9	0.8	0.8	0.7	-0.5	6.6	-3.2	1.0	0.3	-2.8	-4.2	3.9
Metal products	0.6	1.0	1.5	1.4	0.2	-1.5	0.7	-0.2	-0.2	-0.8	5.0	0.6	2.0	3.5	1.7
Machinery	0.0	1.4	2.6	2.5	1.4	0.0	1.8	-3.1	0.1	0.0	2.2	1.2	-0.1	5.1	3.8
Electrical machinery	-0.2	1.3	2.3	3.5	2.3	1.5	-0.5	-0.7	-0.4	0.3	0.8	-0.1	2.0	7.0	6.7
Transport equipment	0.5	0.4	0.8	0.7	0.4	-1.3	2.5	-1.0	1.0	-0.2	0.8	-1.6	-1.3	-0.1	3.8
Other	0.1	1.0	2.1	1.9	0.8	-0.4	0.5	1.3	-1.7	-1.6	0.5	-0.1	2.7	-0.1	6.8

Note: Decompositions are made with MBJ method by using value added output.

Figure 5.13. Exposure to global competition, exports per production (a) and import per production (b)



5.7 Productivity components in non-manufacturing sectors

Studies on the role of micro-level dynamics for aggregate productivity growth in the service sector are scarce.[49] Obtaining appropriate deflators is a generic obstacle for having reasonable productivity growth estimates. If we are unable to split the change in nominal output between a change in volume and a change in price, we cannot, of course, measure the rate of technological progress within plants either. However, it should be noted that this type of measurement problem does not plague the results for the between component; especially while we are using rolling-base-year strategy. What we need to assume is that the plants share the same prices. If there are differences in unit prices, they should reflect differences in quality.

We use the Business Register on Plants as the source of information. It includes sales and number of persons, which are needed to generate a measure of labour productivity. Deflators for the service sectors we constructed by calculating sector specific implicit price indexes from OECD's STAN database.[50]

We find that the results for manufacturing are very closely in line with those obtained by using the Industrial Statistics data source. This, of course, increases our confidence in the results that are generated for service industries.

Three general conclusions can be drawn from Table 5.7. First, the between component is usually much weaker in non-manufacturing industries. Second, there is a clear tendency towards lower contribution in the between component, when business conditions improved after the recession period. Third, entry as well as exit effects seem to have a significant effect on aggregate productivity in a number of service industries. For instance, in the period from 1988 to 1993 entry and exit contributed to productivity a lot in trade as well as in hotels and restaurants although the between effect was negative or negligible there. Similar results are obtained also for mining and electricity.

---

[49] An analysis of the productivity components in US automotive repair shops by Foster, Haltiwanger and Krizan (1998) is the one of few we are aware of.

[50] For manufacturing industries we use producer price indexes.

Contrasted to manufacturing, productivity-enhancing structural change seems to consist of more lumpy events in those industries. Once a firm has established a production unit by constructing or renting a building, it may be difficult to expand its operations without losses in terms of productivity and/or profitability. It is also possible that local markets, especially typical of the trade and hotel sectors determine the optimal scale of operations more tightly than in manufacturing.

Table 5.7. Components of aggregate labour productivity growth by sectors

INDUSTRY	Period	AGG	WITH	BETW	NET ENTRY	ENTRY	EXIT	NOBS	AVEMP
Mining and quarrying	88-93	61.9	46.8	-5.1	20.1	3.1	17.0	1 067	4 434
	93-98	18.2	25.4	-6.9	-0.3	-0.1	-0.2	1 311	3 939
Manufacturing	88-93	23.8	12.5	6.0	5.3	-1.5	6.8	31 467	393 876
	93-98	26.0	23.9	0.1	2.1	-1.8	3.9	31 815	357 614
Electricity, gas and water supply	88-93	18.9	13.1	0.4	5.4	3.7	1.7	742	10 933
	93-98	-3.8	7.3	-10.0	-1.1	3.2	-4.3	845	11 371
Wholesale and retail trade; repairs	88-93	10.5	1.4	1.7	7.3	0.3	7.0	74 062	230 720
	93-98	9.5	11.3	-0.2	-1.6	-3.0	1.3	69 060	201 409
Hotels and restaurants	88-93	32.8	24.5	-0.4	8.8	4.8	4.0	13 660	50 531
	93-98	2.2	5.4	-1.1	-2.1	-2.6	0.5	16 150	45 137
Transport and storage	88-93	17.2	7.3	2.1	7.9	3.3	4.6	9 155	61 447
	93-98	13.6	18.0	-2.6	-1.8	-4.5	2.7	24 500	74 235
Post and telecommunications	88-93	37.9	38.4	-3.9	3.5	1.4	2.1	315	9 636
	93-98	67.7	37.0	4.3	26.4	10.2	16.2	671	12 754
Renting of machinery and equipment	88-93	9.7	-4.7	9.2	5.1	-3.3	8.4	2 095	3 446
	93-98	14.4	10.6	-7.1	11.0	6.6	4.3	1 390	2 254
Computer and related activities	88-93	-0.2	-7.5	1.1	6.2	2.3	3.9	2 442	13 154
	93-98	-3.1	2.8	-2.1	-3.8	-4.8	1.0	4 053	17 987
Research and development	88-93	-11.3	-4.9	0.7	-7.0	-6.3	-0.8	71	477
	93-98	-7.4	5.7	-4.7	-8.5	-10.2	1.6	230	1 549
Other business activities	88-93	0.6	-4.0	2.8	1.9	3.3	-1.5	14 647	63 136
	93-98	-4.8	1.0	-5.0	-0.8	-0.9	0.1	28 901	76 742

Notes. Decompositions are made with the GR2-method. AGG represents aggregate productivity growth, WITH the within component, BETW the between component. Data source of computations is Business Register on Plants. Producer price index is used as a deflator for industries in mining, quarrying, manufacturing, electricity, gas and water supply. Implicit price index obtained from STAN database by OECD is used for other sectors. NOBS denotes number of plants appearing in initial or end year and AVEMP is the average employment in these two points of time.

6 Summary and concluding remarks

In the latter part of the 1980s the Finnish manufacturing sector experienced the start-up of a rigorous adjustment process that was aggravated by an exceptionally severe recession in the early 1990s. This adjustment process entailed substantial catching-up of the international technology frontier in manufacturing.

Our empirical evidence for manufacturing suggests that the transition was to a great extent based on plant level restructuring. We have found that the productivity-enhancing restructuring process at the plant level, as measured with the so-called between component of the productivity decomposition, begun to speed up aggregate labour and total factor productivity growth since the latter part of the 1980s. The contribution of the between component was at its peak during the recession. In the course of the recovery period the productivity promoting re-structuring process chilled down. Turnover of plants through entry and exit, which are the extreme manifestations of restructuring, has also contributed to the rapidly improved productivity performance, in sync with the between component. The increase in the between effect is found to have emerged from relatively new, R&D intensive and export-orientated plants. This is to say, for example, that part of the acceleration in total factor productivity growth can be attributed to increasing input (labour and capital) usage share of the plants that have both a high productivity level and R&D intensity. On the other hand, no marked differences can be found in the plants' productivity growth rates between different R&D intensity groups. This observation was captured with the so-called within plants component of aggregate productivity change.

Regression analysis with time-series data on Finnish manufacturing provided evidence that the rise in the between effect was fuelled by the increased export orientation to Western markets and by the increased R&D intensity in the past. In particular, our analysis suggests that R&D efforts contribute to total factor productivity through plant level restructuring with a lag of some 3 to 5 years. Chilling in the between component in the mid-1990s can be explained by the fact that while the technology gap to the international frontier was narrowing there was less and less need and opportunity for restructuring

There are some interesting differences in the magnitude of the between component not only between different periods but between different industries as well. The between component of aggregate productivity growth was relatively small in industries such as food, wearing apparel and non-metallic minerals up to the late 1980s. Moreover, the increase in the contribution of the between component was particularly marked in these industries during the recession. The between component has been important also in machinery and electrical machinery as well as in manufacture of metal products. These industry-level observations further suggest that the competitive environment that units are facing is essential for creative restructuring (external adjustment). Industry-level observations invite us to examine the relationship between re-structuring, export orientation and R&D more closely in the future by using also cross-industry variation in the estimation.

We have also investigated whether changes in the business environment have led to convergence in productivity levels among plants through rapid productivity growth of low productivity plants (internal adjustment). This feature of micro-level productivity evolution is tackled by modifying the productivity decomposition formula so that it includes a so-called catching-up term in addition to the other components presented in the literature. The results for the catching-up term seem to indicate that convergence in the plants' productivity levels through high productivity growth of low productivity plants has been in operation especially in the 1990s.

Regression analysis with manufacturing time series provides evidence that both external adjustment (the between component) and internal adjustment (catching-up component) reduce the dispersion in labour productivity levels among plants. Thus these processes can be argued to be important for the elimination of inefficiency in the economy. Furthermore, these factors seem to obstruct the increase of wage dispersion among production workers.

We have examined the role of micro-level components of aggregate productivity growth also in some service industries. It turned out that external adjustment has played a role in some service industries especially through entry and exit (net entry component) but also, to a lesser extent, through restructuring amongst incumbents (the between component) in the period 1988-93. Considerable amount of chilling can be found in the period 1993-98 also in non-manufacturing industries.

In this study we have found a bigger role for the restructuring process in the aggregate productivity evolution than in most other studies in this literature (see relevant references in Foster, Haltiwanger, and Krizan, 1998). Direct comparison between studies is, however, difficult to make, because productivity indicators, the length of the period under investigation, methods and data properties vary considerably. We have demonstrated that those methods using weights obtained from the initial year are apt to indicate a bigger role for restructuring than those using the average of initial and end year weights. For example, Foster, Haltiwanger, and Krizan (1998) find a relatively small role for the between component in aggregate labour productivity growth in US manufacturing based on the latter type of method. As it comes to data we have evaluated the sensitivity of these results by using two separate data source. They yielded quite a coherent view on the development of labour productivity.

One possible explanation for the discrepancy in results between countries may be that thoroughgoing restructuring is not very common. In the Finnish case the profound change in the business environment of manufacturing since the latter part of the 1980s was followed by an abrupt decline in demand in the early 1990s. Secondly, it is important to note that institutions differ substantially between countries. Collective bargaining may also have fuelled productivity-enhancing restructuring as wage agreements can make it difficult for low productivity plants and firms to compensate their lack of competitiveness with downward adjustments in wage expenses. At the same time, employment potentials embodied in high productivity plants and firms are not appropriated away in the form of higher wages. In this process bad jobs in low productivity plants are replaced by better jobs in high productivity plants.

References

Acemoglu, D., and Shimer, R. (2000), *'Wage and Technology Dispersion'*, Review of Economic Studies (2000) 67, 585-607.

Aghion, P., Caroli, E., and Garcia-Penalosa, C. (1999), *'Inequality and Economic Growth: The Perspective of the New Growth Theories*', Journal of Economic Literature, 37, 1615-1660.

Aghion, P., and Howitt, P. (1992), *'A Model of Growth Trough Creative Destruction'*, Econometrica, Vol. 60, No. 2 (March, 1992), 323-351.

Aghion, P., and Howitt, P. (1994), *'Growth and Unemployment'*, Review of Economic Studies, 61, 477-494.

Aghion, P., and S.-P., G. (1998), *'On the Virtue of Bad Times: an Analysis of the Interaction between Economic Fluctuations and Productivity Growth'*, Macroeconomic Dynamics, 2, 322-44.

Andersson, F. (1999), *'Job Flows in Swedish Manufacturing 1972-1996'*, IFAU, Office of Labour Market Policy Evaluation, Working Paper 1999:4.

Aw, B. Y., Chen, X., and Roberts, M. J. (1997), '*Firm-Level Evidence on Productivity Differentials, Turnovers, and Exports in Taiwanese Manufacturing*', NBER Working Paper No. 6235.

Baily, M, N., Hulten, C, and Campbell, D. (1992), '*Productivity Dynamics in Manufacturing Plants*', Brookings Papers on Economic Activity, Microeconomics 1992, 187-267.

Baily, M. N., Bartelsman, E. J., and Haltiwanger, J. (1997), '*Labour Productivity: Structural Change and Cyclical Dynamics',* NBER Working Paper No. 5503, revised 1997.

Baily, M.N., and Zitzewitz, E. (1998), *'Extending the East Asian Miracle: Microeconomic Evidence from Korea'*, Brookings Papers on Economic Activity, Microeconomics 1998, 249-308.

Baldwin, J. R. (1993), *'The Dynamics of Industrial Competition. A North American Perspective'*, Cambridge University Press.

Barro, R.J., and Sala-i-Martin, X. (1995), *'Economic Growth'*, McGraw Hill, New York.

Bassanini, A., Scarpetta, S., and Visco, I. (2000), *'Knowledge, Technology and Economic Growth: Recent Evidence from OECD Countries*', OECD Economics Department Working Papers No. 248, Paris.

Baumol., W. J., Blackman, S.A. B., and Wolff, E. N. (1989), *'Productivity and American Leadership. The Long view'*, Cambridge, MITT Press.

Bentolila, S., and Bertola, G. (1990),*'Firing Costs and Labour Demand: How Bad is Eurosclerosis?*', Review of Economic Studies (1990) 57, 381-402.

Bernard, A. B., Eaton, J., Jensen, J. B., and Kortum, S. (2000), *'Plants and Productivity in International Trade'*, NBER Working Paper 7688.

Bernard, A. B., and Jones, C. I. (1996), *'Productivity across Industries and Countries: Time Series Theory and Evidence'*, The Review of Economics and Statistics, Vol. LXXVII, Number 1, 135-145.

Bertin, A. L., Bresnahan, T. F., and Raff, D. M. G. (1996), *'Localized Competition and the Aggregation of Plant level Increasing Returns: Blast Furnaces, 1929-1935'*, Journal of Political Economy, 1996, vol. 104, No 2, 241-266.

Bertola, G., and Rogerson, R. (1997), *'Institutions and labour reallocation'*, European Economic Review 41, 1997, 1147-1171.

Borenstein, S., and Farrell, J. (1999), *'Do Investors Forecast Fat Firms? Evidence from the Gold Mining Industry*', National Bureau of Economic Research, Working Paper 7075.

Borenstein, S, and Farrell, J. (2000), *'Is Cost Cutting Evidence of X-inefficiency?*' NBER/Sloan Project Report, Industrial Technology and Productivity: Incorporating Learning from Plant Visits and Interviews into Economic Research, Papers presented at the Annual Meetings of the American Economic Association, January 2000, 15-20.

Burgess, S, Lane, J., and Stevens, D. (2000), *'Job Flows, Worker Flows and Churning'*, Journal of Labor Economics, 18, 473-502.

Böckerman, P. (2000), *Schumpeter ja 'luova* tuho' (Schumpeter And' Creative Destruction (in Finnish)), Labour Institute for Economic Research, Working Papers 167.

Börsch-Supan, Axel (1998), *'Capital's Contribution to Productivity and the Nature of Competition*', Brookings Papers: Microeconomics 1998, 205-248.

Caballero, R. J. (1998), '*Discussion*', in J.C. Fuhrer, and S. Schuh (eds.), *'Beyond Shock: What Causes Business Cycles?*' Conference Series No. 42, Federal Reserve Bank of Boston, 338-348.

Caballero, R. J., and Hammour, M. L. (1994), *'The Cleansing Effect of Recessions'*, American Economic Review 84 (5), 1350-1368.

Caballero, R. J., and Hammour, M. L. (1998), *'Jobless Growth: appropriability, factor substitution, and unemployment'*, Carnegie-Rochester Conference Series on Public Policy, 48, June 1998, 51-94.

Caballero, R. J., and Hammour, M. L. (1999), *'The Cost of Recessions Revisited: A Reverse-Liquidationist view'*, National Bureau of Economic Research, Working Paper No. 7355.

Caballero, R. J., and Hammour, M. L. (2000), *'Creative Destruction and Development Institutions, Crises, and Restructuring'*, paper prepared for the Annual World Bank Conference on Development Economics, Washington, D.C., April 18-20, 2000.

Campbell, J. R., and Fisher, J. D. M. (1998), *'Organisational Flexibility and Employment Dynamics at Young and Old Plants'*, NBER Working Paper 6809.

Cannon, E. S., and Duck, N. W. (2000), *'Galton's Fallacy and Economic Convergence'*, Oxford Economic Papers, 52, 415-419.

Cappelli, P. (2000), *'Examining the Incidence of Downsizing and Its Effect on Establishment Performance'*, National Bureau of Economic Research, Working Paper No. 7742.

Caselli, F. (1999), *'Technological Revolutions'*, American Economic Review 89, 78-102.

Caves, R.E. (1974), *'Multinational Firms, Competition, and Productivity in Host-Country Markets*', Economica 41 (162), 176-196.

Clerides, S., Lach, S., and Tybout (1996), *'Is 'Learning-by-Exporting' Important? Micro-Dynamic Evidence from Columbia, Mexico and Marocco'*, Federal Reserve Board, Finance and Economics Discussion Series 96-30.

Cooper, R. W., and Haltiwanger, J. C. (1993), *'The Aggregate Implications of Machine Replacement: Theory and Evidence'*, The American Economic Review, 83(3), 360-382.

Cooper, R. W., Haltiwanger, J., and Power, L. (1997), *'Machine Replacement and the Business Cycle: Lumps and Bumps*', NBER Working Paper No. 5260, revised 1997.

Corrado, C, Gilbert, C, and Raddock, R. (1997), *'Industrial Production and Capacity Utilization: Historical Revision and Recent Developments'*, Federal Reserve Bulletin, February 1997, 67-92.

Davis, S.J., Haltiwanger, J.C., and Schuh, S. (1996), '*Job Creation And Destruction',* MIT Press.

Davis, S.J., and Haltiwanger, J. (1999), '*Gross Job Flows'*, in Ashenfelter, O. C., and Card, D. (eds.), *'Handbook of Labor Economics*', Volume 3B, 2711-2805, North-Holland.

Disney, R., Haskel. J., and Heden, Y. (2000), *'Restructuring and Productivity Growth in UK Manufacturing*', Centre for Economic Policy Research, Discussion Paper No. 2463, May 2000.

Dunne, T., Foster, L., Haltiwanger, J., and Troske, K. (1999), *'Wage and Productivity Dispersion in U.S. Manufacturing: The Role of Computer Investment*', manuscript, July 1999.

Ewijk, C. (1997), *'Entry and Exit, Cycles, and Productivity Growth'*, Oxford Economic Papers 49 (1997), 167-187.

Flanagan, R. J. (1999), *'Macroeconomic Performance and Collective Bargaining: An International Perspective'*, Journal of Economic Literature, 38, 1150-1175.

Friedman, M. (1992), *'Do Old Fallacies Ever Die?*' Journal of Economic Literature 30 (1992), 2129-2132.

Foster, L., Haltiwanger, J., and C. J. Krizan (1998), '*Aggregate Productivity Growth: Lessons from Microeconomic Evidence',* Working Papers No. 6803, National Bureau of Economic Research.

Färe, R., Grosskopf, S., Norris, M. and Zhang, Z. (1994), *'Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries'*, American Economic Review, 1, 84 (1994), 66-83.

Gourinchas, P.-O. (1999), *'Exchange Rates Do Matter: French Job Reallocation and Exchange Rate Turbulence, 1984-1992'*, European Economic Review 43, 1279-1316.

Griliches, Z., and Regev, H. (1995), *'Productivity and Firm Turnover in Israeli Industry: 1979-1988'*, Journal of Econometrics, 65, 175-203,

Gunnarsson, G., and Mellander, E. (1999), *'Input Aggregation Matters a Lot in Productivity Measurement, Even in the Short Run; Evidence from the Swedish Manufacturing Sector 1985-1995'*, Paper presented at the 14th Annual Congress of the European Economic Association, September 2-4, 1999.

Hall, R. E. (1991), *'Labor Demand, Labor Supply, and Employment Volatility'*, NBER Macroeconomics Annual 6, 17-46.

Haskel, J., and Sanchis, A. (20000), *'A Bargaining Model of Farrell Inefficiency'*, International Journal of Industrial Organisation, 18, 539-556.

Hassink, W.H.J., *'Job destruction through quits or layoffs?'*, Applied Economics Letters 7, 2000, 45-47.

Hibbs, Jr. D. A., and Locking, H. (2000), *'Wage Dispersion and Productive Efficiency: Evidence for Sweden'*, Journal of Labor Economics, Volume 18, Number 4, 755-782.

Hjalmarsson, L. (1973), *'Optimal Structural Change and Related Concepts'*, Swedish Journal of Economics, 75 (2), 176-192.

Hobijn, B., and Jovanovic, B. (2000), *'The Information Technology Revolution and the Stock Market: Evidence'*, National Bureau of Economic Research, Working Paper No. 7684.

Honkapohja, S. and Koskela, E. (1999), *'The Economic Crisis of the 1990s in Finland'*, Economic Policy, No. 29, 399-424.

Hopenhayn, H., and Rogerson, R. (1993), *'Job Turnover and Policy Evaluation: A General Equilibrium Analysis'*, Journal of Political Economy, 1993, vol. 101, no. 5, 915-938.

Hulten, C. R. (1992), *'Growth Accounting When Technical Change is Embodied in Capital'*, American Economic Review, 82 (4), 964-980.

Ilmakunnas, P., and Maliranta, M. (2000a), *' The Turnover of Jobs and Workers in a deep recession: Evidence from the Finnish business sector'*, manuscript November 27, 2000.

Ilmakunnas, P., and Maliranta, M. (2000b), *'Turnover of Jobs and Workers in Finland'*, manuscript October 6, 2000.

Ilmakunnas, P., and Maliranta, M. (2000c), *'Turnover of Jobs and Workers in Recession and Recovery: The Finnish Experience'*, paper prepared for the Applied Econometrics Association conference "Econometrics and Human Resource Management", Helsinki, September 22-23, 2000.

Ilmakunnas, P., and Maliranta, M. (2000d), *'Työpaikkojen syntyminen ja häviäminen ja työvoiman vaihtuvuus* (*Job Creation and Destruction and Worker Turnover*)', Ministry of Labour, Studies in Labour Policy, No. 209.

Ilmakunnas, P., Maliranta, M., and Vainiomäki, J. (1999), '*The Roles of Employer and Employee Characteristics for Plant Productivity',* Helsinki School of Economics and Business Administration, Working Papers, W-223.

Jensen, M. C, (1986), *'Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers'*, American Economic Review Papers and Proceedings, 76(May), 323-329.

Jensen, J. B., and McGuckin, R. H. (1997), *'Firm Performance and Evolution: Empirical Regularities in the U.S. Microdata'*, in Laaksonen, S. (eds), *'The Evolution of Firms and Industries'*, Research Reports 223, 24-49, Statistics Finland

Jorgenson, D. W. (1990), *'Productivity and Economic Growth'*, in Berndt, E. R. and Triplett, J. E. (eds.), *'Fifty Years of Economic Measurement'*, The University of Chicago Press.

Jorgenson, D. W., Gollop, F. M., and Fraumeni, B. M. (1987), *'Productivity and U.S. Economic Growth'*, Cambridge, Mass, Harward University Press.

Jovanovic, B., and Stolyarov, D. (2000), *'Optimal Adoption of Complementary Technologies*', The American Economic Review, 90, 15-29.

Klette, T. J., and Førre S. E. (1998), '*Innovation And Job Creation in a Small Open Economy — Evidence from Norwegian Manufacturing Plants'*, Economics of Innovation and New Technology, 5(1998), 247-272.

Klette, T. J., and Griliches, Z. (2000), *'Empirical Patterns of Firm Growth and R&D Investment: A Quality Ladder Model Interpretation'*, The Economic Journal, 110 (April), 363-387.

Kremer, M. (1993), *'The O-Ring Theory of Economic Development'*, Quarterly Journal of Economics, 108, 551-575.

Koop, G., Osiewalski, J. and M. F. J. Steel (1999), *'The components of output growth: A stochastic frontier analysis*', Oxford Bulletin of Economics and Statistics, 61, 4(1999), 455-487.

Korkeamäki, O. (2000), *'Valtion palkat yleisiin työmarkkinoihin verrattuna: vuodet 1989-1997' (Wages in public sector relative to general labour market levels: years 1989-1997,* abstract in English), Government Institute for Economic Research, Research Reports 61.

Lambson, V., (1991), *'Industry Evolution with Sunk Costs and Uncertain Market Conditions'*, International Journal Industrial Organisation', 9:2, 171-196.

Leibenstein, H. (1966), *'Allocative Efficiency versus X-efficiency'*, American Economic Review, 56(June).

Levinsohn, J. (1999), *'Employment Response to International Liberalization in Chile'*, Journal of International Economics 47, 321-344.

Levinsohn, J., and Petrin, A. (1999), *'When Industries Become More Productive, Do Firms?'*, NBER Working Paper Series 6893.

Liu, L., and Tybout, J. R. (1996), *'Productivity Growth in Chile and Columbia: The Role of Entry, Exit and Learning'*, in Roberts and Tybout (eds.), *'Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity and Market Structure*, New York: Oxford University Press for the World Bank, 1996, 73-103.

Maliranta, M. (1995), *'Elintason ja tuottavuustason kansainvälinen vertailu. Menetelmät, aineistot ja tulokset' (International Comparison of Living Standards and Productivity. Methods, Data and Results),* Statistics Finland.

Maliranta, M. (1996), *'Suomen tehdasteollisuuden tuottavuus'* (*Productivity in Finnish manufacturing*, with English abstract), Statistics Finland, Research Reports 215.

Maliranta, M. (1997a), *'Plant Level Explanations for the Catch Up Process in Finnish Manufacturing; A Decomposition of Aggregate Labour Productivity Grow*th', in Laaksonen (eds.), 'The Evolution of Firms and Industries, International Perspectives', Statistics Finland, Research Reports 223.

Maliranta, M. (1997b), *'Plant productivity in Finnish Manufacturing. Characteristics of High Productivity Plants'*, ETLA Discussion Papers, No. 612, Helsinki.

Maliranta, M. (1997c)), *'The determinants of aggregate productivity: The evolution of micro-structures and productivity within plants in Finnish manufacturing from 1975 to 1994',* Etla, Discussion Papers No. 603.

Maliranta, M. (1998), *'Factors of Performance by Plant Generation. Some Findings from Finland'*, in Biffignandi, S. (Ed.), *'Micro- and Macrodata of Firms. Statistical Analysis and International Comparisons'*, 391-424, Physiga-Verlag.

Maliranta, M. (2000), *'Job Creation by supporting technology advances? Evidence from Finnish plants*', in Asplund, R. (eds.), *'Public R&D Funding, Technological Competitiveness, Productivity, and Job Creation*', The Research Institute of the Finnish Economy ETLA, Series B 168, 89-128.

Manning, A. (1998a), *'Mighty Good Thing: The Returns to Tenure'*, Centre for Economic Performance, Discussion Paper No. 383.

Manning, A. (1998b), *'Movin' on up: Interpreting Earning-Experience Profile'*, Centre for Economic Performance, Discussion Paper No. 380.

Martin, P., and Rogers, C. A. (1997), *'Stabilization Policy, Learning-by-doing, and Economic Growth'*, Oxford Economic Papers, 49 (1997), 152-166.

McKinsey Global Institute (1993), *'Manufacturing Productivity'*, Washington D.C.

McKinsey Global Institute (1995), *'Sweden's Economic Performance'*, Washington D.C.

McKinsey Global Institute (1996), *'Capital Productivity'*, Washington D.C.

Nasbeth, L., and Ray, G. (1974) (eds.), *'The Diffusion of New Industrial Processes: An International Study*', Cambridge: Cambridge University Press.

Nickell, Stephen, J. (1996), *'Competition and Corporate Performance'*, Journal of Political Economy, 104 (4), 724-746.

Okamato, Y. (1999), *'Multinationals, Productivity Efficiency, and Spillover Effects: The Case of the U.S. Auto Parts Industry'*, Weltwirtschaftliches Archiv 1999, Vol. 135 (2), 241-260.

Olley, G. S., and Pakes, A. (1996), *'The Dynamics of Productivity in the Telecommunications Equipment Industry'*, Econometrica, 64(6), November, 1263-1297.

Olson, M. (1982), *'The Rise and Decline of Nations, New Heaven'*, Yale University Press.

Piekkola, H, and Böckerman, P. (1999), *'On Whom Falls the Burden of Restructuring? Evidence from Finland'*, The Research Institute of Finnish Economy, Discussion Papers No. 714.

Pohjola, M. (1996), *'Tehoton pääoma. Uusi näkökulma taloutemme ongelmiin' (Inefficient Capital. A New Perspective on Our Economic Problems*), WSOY, Porvoo.

Pohjola, M. (1998a), *'Suomalaisten työmarkkinoiden toimivuus' (Functioning of Finnish Labour Markets)*, in Pohjola, M. (eds), *'Suomalainen työttömyys*' (Finnish unemployment), 23-49, Taloustieto Oy 1998.

Pohjola, M. (1998b), *'Investoinnit, talouden kasvu, ja työttömyys' (Investments, economic growth and unemployment*), in Pohjola, M. (eds), *'Suomalainen työttömyys'* (*Finnish unemployment*), 289-315, Taloustieto Oy 1998.

Ramey, V. A., and Shapiro, M. D. (1998), *'Capital Churning'*, mimeo.

Richards, Alan (1998), *'Connecting Performance and Competitiveness with Finance: A Study of the Chemical Industry*', in Arora, A., Landau, R., and Rosenberg, N. (eds.) *'Chemicals and Long-Term Economic Growth: Insights from the Chemical Industry'*, 461-511, New York: Wiley Interscience.

Rogers, E. M. (1983), *'Diffusion of Innovations*' (3rd ed.), New York: Free Press.

Rouvinen, P. (1999), *'Issues in R&D-Productivity Dynamics: Causality, Lags, and Dry Holes'*, ETLA Discussion Papers No 694, The Research Institute of Finnish Economy.

Salvanes, K. G., and Førre, S. V. (1999), *'Job Destruction, Heterogeneous Workers, Trade, And Technical Change: Matched worker/plant data evidence from Norway*', Norvegian School of Economics and Business Administration, Discussion Paper 15/99.

Schuh, S, and Triest, R.K. (1998), *'Job Reallocation and the Business Cycle: New Facts for an Old Debate'*, in J.C. Fuhrer, and S. Schuh (eds.), *'Beyond Shock: What Causes Business Cycles?*' Conference Series No. 42, Federal Reserve Bank of Boston, 271-337.

Schumpeter, J. A. (1942), *'Capitalism, Socialism, and Democracy'*, New York: Harper and Brothers.

Stennek, Johan (2000), *'Competition increases x-efficiency: A limited liability mechanism'*, European Economic Review 44 (2000), 1727-1744.

Suoniemi, I. (2000), *'Decomposing the Gini and the Variation Coefficients by Income Sources and Income Recipients'*, Labour Institute for Economic Research, Working Papers 169.

Torii, A. (1992), '*Technical Efficiency in Japanese Industries'*, in Caves, R. E. (eds.), *'Industrial Efficiency in Six Nations'*, 1992 Massachusetts Institute of Technology.

Tybout, J. R. (1996), *'Heterogeneity and Productivity Growth: Assessing the Evidence'* in Roberts and Tybout (eds.), *'Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity and Market Structure'*, New York: Oxford University Press for the World Bank, 1996, 43-72.

Tybout, J. R., and Westbrook, M. D. (1995), *'Trade Liberalization and the Dimensions of Efficiency Change in Mexican Manufacturing Industries'*, Journal of International Economics 39(1995), 53-78.

Vainiomäki, J., and Laaksonen, S. (1997), '*The Effects of Technology on Job Creation and Destruction in Finnish Manufacturing, 1986-93'*, in Laaksonen, S. (ed.) '*The Evolution of Firms and Industries: International Perspectives',* Statistics Finland, Research Reports 223, 234-251.

Vainiomäki, J., and Laaksonen, S. (1999), '*Technology, job creation and job destruction in Finnish manufacturing',* Applied Economic Letters, 6(1999), 81-88.

Varjonen, S. (1994), *'Kiinteähintaisen bruttokansantuotteen laskentavaihtoehdot' (Alternative for Measuring Gross Domestic Product in Fixed Prices* (in Finnish)), in Pahkinen, E., and Ritola, V. (Eds.), *'Suhdannekäänne ja taloudelliset aikasarjat' (The Turn in the Business Conditions and the Economic Time-Series),* Statistics Finland, Research Reports 210.

Walton, R. (2000), *'International Comparisons of Profitability'*, forthcoming.

Wihlborg, C. (1998), *'Economic Efficiency with Enabling and Mandatory Law'*, in Eliasson, G., and Green, C. (eds.), *'Microfoundations of Economic Growth. A Schumpeterian Perspective'*, 109-116, The University of Michigan Press.

APPENDIX 1. Three illustrative examples

We construct three examples, which aims to illustrate how different decomposition methods work in different kind situations. To keep things simple, we have only two plants and 5 years (and thus 4 periods over which the productivity changes are calculated). In all three examples we assume that the number of workers is fixed at 20 person. Of course, technology and labour input determine output. We consider here only methods based on labour input weights.

1. Errors in labour input values

In the first example we have data, which contains errors in the labour input (or fleeting level input that is unsustainable for the plant in question) in even years (see Table 1.a).

Table 1.a. Errors in labour input data

	Year 1		Year 2		Year 3		Year 4		Year 5	
Firm	Y	L	Y	L	Y	L	Y	L	Y	L
A	100	10	100	11	100	10	100	15	100	10
B	100	10	100	9	100	10	100	5	100	10
Aggregate	200	20	200	20	200	20	200	20	200	20

In reality plants are similar in respect of size and productivity level, but because of errors in labour input values (or deviation from sustainable steady state) in even years there appear to be occasional differences in productivity level and size. Furthermore, we assume that technological change within plants does not actually exist although occasional non-zero productivity change rates may appear. In year 2 there is a small and in year 4 a large error in distributing total labour input value among plants.[51]

Table 1.b shows the decomposition of aggregate productivity changes with different methods. Several observations can be made from the table. First, we find that aggregated log-differences are not equal to aggregate growth rates, which is here zero for each year by construction. However, all aggregate indicators are unbiased in a sense that average rates for the whole period are correctly zeros. Methods MBBH and FHK both seem to indicate a positive within component, which is a misleading result from the perspective that over a longer period there has not been any sustainable plant level productivity progress. The within component according to method GR, has some variation from year to year, but the average over the whole period gives an undistorted result. Method MBJ, in turn, indicates no within plant growth.

The average of the catching-up term over the whole period is zero according to formula MBJ, as we might wish, as there is no longer term catching up term in operation in our example. Method MBBH in turn seems to suggest a positive catching up term that can be argued to be a misleading result.

As expected, the between component is positively and cross term negatively distorted in the results obtained with formulations MBBH and FHK. In contrast, methods MBJ and GR suggest no between effect (and no within effect) in a longer term.

---

[51] It should be noted that there are a lot of unreal simultaneous annual job creation and destruction in the previous example Empirical research on this field suggests that measurement error problem is not that bad. For example, according to Ilmakunnas and Maliranta (2000) the gross job reallocation, i.e. the sum of job creation and destruction rates, is about 15 per cent in Finnish manufacturing. In the first example, gross job reallocation is 10 percent in year 2 and 3, and 50 per cent in the year 4 and 5. Thus our example dramatises the point quite a bit.

Table 1.b. Decomposing errors-in-variable data

Growth rate component	Growth rate				
	Year 2	Year 3	Year 4	Year 5	Average
Aggregate					
$\Delta P / \overline{P}$	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
$\Delta \ln(\sum Y / \sum X)$	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
FHK and GR	-0.5 %	0.5 %	-13.1 %	13.1 %	0.0 %
Within					
MBBH	0.5 %	0.5 %	13.3 %	13.3 %	6.9 %
FHK	0.5 %	0.5 %	14.4 %	13.1 %	7.1 %
MBJ	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
GR	0.0 %	0.0 %	0.7 %	-0.7 %	0.0 %
Catching up					
MBBH	0.5 %	-0.5 %	20.0 %	-13.3 %	1.7 %
MBJ	0.5 %	-0.5 %	16.7 %	-16.7 %	0.0 %
Between					
BBH (and MBBH)	0.0 %	1.0 %	0.0 %	33.3 %	8.6 %
FHK	0.0 %	1.0 %	0.0 %	27.5 %	7.1 %
BJ (and MBJ)	-0.5 %	0.5 %	-16.7 %	16.7 %	0.0 %
GR	-0.5 %	0.5 %	-13.7 %	13.7 %	0.0 %
Cross					
BBH (and MBBH)	-1.0 %	-1.0 %	-33.3 %	-33.3 %	-17.2 %
FHK	-1.0 %	-1.0 %	-27.5 %	-27.5 %	-14.2 %

2. Structural change at the plant level

Our second example has more economic content. There are no errors in data. Like in the previous example, there is no productivity change whatsoever within plants either. However, there is positive aggregate productivity growth because of a systematic labour input re-allocation toward the high productivity plant.

Table 2.a. Structural change data

	Year 1		Year 2		Year 3		Year 4		Year 5	
	Y	L	Y	L	Y	L	Y	L	Y	L
Plant A	125	10	137.5	11	150	12	162.5	13	175	14
Plant B	75	10	67.5	9	60	8	52.5	7	45	6
Aggregate	200	20	205	20	210	20	215	20	220	20

As there are no random errors-in-variables, all methods yield the correct result that there is no productivity growth within plants and, consequently the within component as well as cross term correctly have zero values. All in all, all methods seem to work equally well in this kind of situation.

Table 2.b. Decomposing productivity change in structural change data

Growth rate component	Year 2	Year 3	Year 4	Year 5	Average
Aggregate					
$\Delta P / \overline{P}$	2.5 %	2.4 %	2.4 %	2.3 %	2.4 %
$\Delta \ln(\sum Y / \sum X)$	2.5 %	2.4 %	2.4 %	2.3 %	2.4 %
FHK and GR	2.6 %	2.6 %	2.6 %	2.6 %	2.6 %
Within					
MBBH	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
FHK	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
MBJ	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
GR	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
Catching up					
MBBH	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
MBJ	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
Between					
BBH (and MBBH)	2.5 %	2.4 %	2.4 %	2.3 %	2.4 %
FHK	2.6 %	2.6 %	2.6 %	2.6 %	2.6 %
BJ (and MBJ)	2.5 %	2.4 %	2.4 %	2.3 %	2.4 %
GR	2.6 %	2.6 %	2.6 %	2.6 %	2.6 %
Cross					
BBH (and MBBH)	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %
FHK	0.0 %	0.0 %	0.0 %	0.0 %	0.0 %

Note: "Growth rate" spans Year 2 – Average.

3. Catching-up process at the plant level

In the last example there are long lasting differences in productivity growth rates that can be attributed to differences in productivity levels. As in our earlier examples, there is no technological progress within plants. More precisely, there is no productivity growth at the plant A, which is on the technological frontier. Plant B instead is able to achieve continuous positive productivity growth as it manages to catch-up gradually the frontier technology level. As can be calculated from Table 3.a., plant B achieves benchmark level in the final year 5. As long as plant A is ahead of B in the productivity level, it is also able to capture labour input share. In other words, there is also structural change in operation.

3.a. Catching-up process data

	Year 1		Year 2		Year 3		Year 4		Year 5	
	Y	L	Y	L	Y	L	Y	L	Y	L
Plant A	120.0	10.0	132.0	11.0	144.0	12.0	156.0	13.0	168.0	14.0
Plant B	80.0	10.0	79.7	9.0	78.4	8.0	75.9	7.0	72.0	6.0
Aggregate	200.0	20.0	211.7	20.0	222.4	20.0	231.9	20.0	240.0	20.0

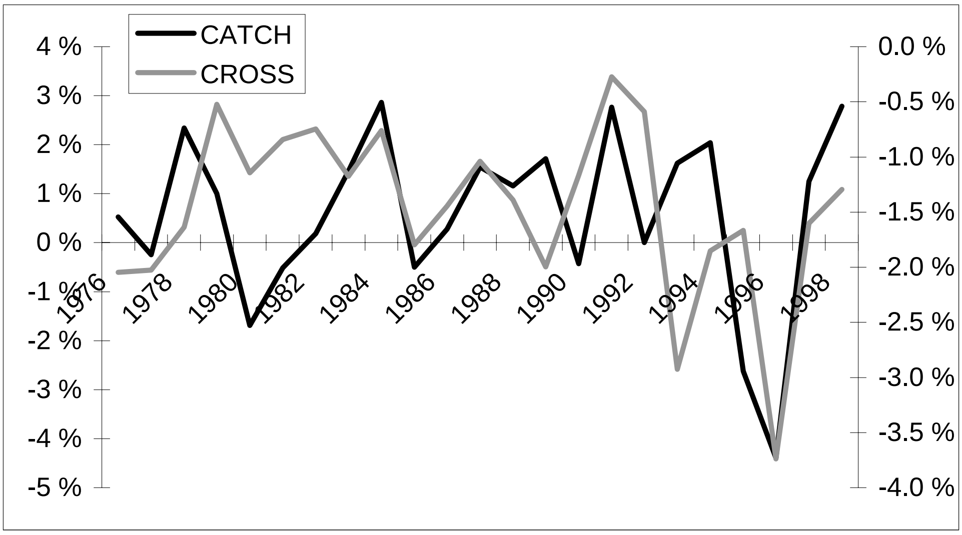
The within component is qualitatively the same in all methods considered here. The same holds true for the between plant effect. Cross term has negative values in methods MBBH and FHK. Concluding that negative cross term comes into being from the fact that extra rapid productivity growth rate can be achieved by downsizing would be a mistake at this point. In this case the persistently low productivity level entails two simultaneous developments, which both can be understood by economic theory. The low productivity plant is not able to sustain all of its jobs in contrast to the benchmark plant A, which has greater labour demand. This is reflected in the positive values of the between plant component. On the other hand, plant B experiences extraordinary high productivity growth rates (around 10 per cent) because it is reaping the catching-up potential. This can be concluded from the negative catching-up term. As there is less and less divergence in productivity levels, the absolute value of catching-up term diminishes over time. We observe that the within component declines as well. However, at the plant level there is no decline in the productivity growth — growth rate of plant A is zero and ten per cent for plant B. The reason for the falling within component is that labour input share of the fast-growing plant B is declining in our example.

3.b. Decomposing productivity growth in catching-up data

Growth rate component	Growth rate				
	Year 2	Year 3	Year 4	Year 5	Average
Aggregate					
$\Delta P / \overline{P}$	5.7 %	4.9 %	4.2 %	3.4 %	4.6 %
$\Delta \ln(\sum Y / \sum X)$	5.7 %	4.9 %	4.2 %	3.4 %	4.6 %
FHK and GR	6.6 %	5.6 %	4.6 %	3.5 %	5.1 %
Within					
MBBH	5.1 %	4.6 %	4.1 %	3.5 %	4.3 %
FHK	5.1 %	4.6 %	4.1 %	3.5 %	4.3 %
MBJ	4.8 %	4.3 %	3.8 %	3.3 %	4.1 %
GR	4.8 %	4.3 %	3.8 %	3.3 %	4.1 %
Catching up					
MBBH	-0.9 %	-0.6 %	-0.4 %	-0.1 %	-0.5 %
MBJ	-0.9 %	-0.6 %	-0.3 %	-0.1 %	-0.5 %
Between					
BBH (and MBBH)	1.9 %	1.4 %	1.0 %	0.5 %	1.2 %
FHK	2.0 %	1.5 %	1.0 %	0.5 %	1.3 %
BJ (and MBJ)	1.7 %	1.2 %	0.7 %	0.2 %	1.0 %
GR	1.8 %	1.3 %	0.8 %	0.3 %	1.0 %
Cross					
BBH (and MBBH)	-0.4 %	-0.4 %	-0.5 %	-0.5 %	-0.5 %
FHK	-0.5 %	-0.5 %	-0.5 %	-0.5 %	-0.5 %

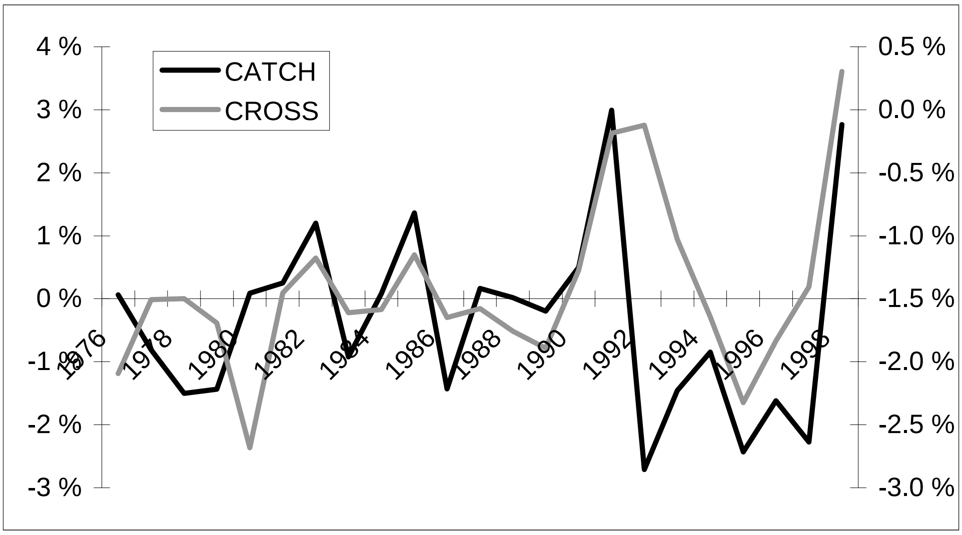
APPENDIX 2. Comparisons of components between different methods.

Figure A2.1. Catching-up term (scale on left) and cross term (scale on right) of MBBH-method, labour productivity



Notes: Output is measured with value added.

Figure A2.2. Catching-up term (scale on left) and cross term (scale on right) of MBBH-method, total factor productivity



Notes: Output is measured with value added.

E L I N K E I N O E L Ä M Ä N   T U T K I M U S L A I T O S   (ETLA)
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
LÖNNROTINKATU 4 B, FIN-00120 HELSINKI

Puh./Tel. (09) 609 900 Telefax (09) 601753
Int. 358-9-609 900 Int. 358-9-601 753
http://www.etla.fi

KESKUSTELUAIHEITA - DISCUSSION PAPERS ISSN 0781-6847

No 725 HELI KOSKI, Feedback Mechanisms in the Evolution of Networks: The Installed User Base and Innovation in the Communications Sector. 03.08.2000. 16 p.

No 726 KARI E.O. ALHO, Implications of EMU on Industrial Relations – The Country Report on Finland. 17.08.2000. 83 p.

No 727 ESA VIITAMO, Metsäklusterin palvelut – kilpailukykyanalyysi. 21.08.2000. 70 s.

No 728 ERKKI KOSKELA – MARKKU OLLIKAINEN, Optimal Forest Conservation: Competitiveness versus Green Image Effects. 31.08.2000. 22 p.

No 729 SINIMAARIA RANKI, Does the Euro Exchange Rate Matter? 01.09.2000. 24 p.

No 730 TOPI MIETTINEN, Poikkeavatko valtionyhtiöt yksityisistä? – Valtionyhtiöiden tavoitteiden kehitys ja vertailu yksityisomistettuihin yrityksiin. 05.09.2000. 41 s.

No 731 ERKKI KOSKELA – RONNIE SCHÖB – HANS-WERNER SINN, Green Tax Reform and Competitiveness. 06.09.2000. 15 p.

No 732 MATTI VIRÉN, Financing the Welfare State in the Global Economy. 06.09.2000. 16 p.

No 733 LAURA PAIJA, ICT Cluster – The Engine of Knowledge-driven Growth in Finland. 07.09.2000. 29 p.

No 734 STEFAN NAPEL – MIKA WIDGRÉN, Inferior Players in Simple Games. 14.09.2000. 35 p.

No 735 KARI E.O. ALHO, Optimal Fiscal and Monetary Policies in a Recession: Is There a Way Out of the Trap in an Open Economy? 26.09.2000. 34 p.

No 736 ERIK PLUG – WIM VIJVERBERG, Schooling, Family Background, and Adoption: Is it Nature or is it Nurture? 27.09.2000. 22 p.

No 737 ERKKI KOSKELA – MATTI VIRÉN, Is There a Laffer Curve between Aggregate Output and Public Sector Employment? 10.10.2000. 19 p.

No 738 PASI HUOVINEN, Työhön ja vapaa-aikaan liittyvä matkailu Helsinkiin. Analyysi majoitustilastosta. 24.10.2000. 21 s.

No 739 HANNU PIEKKOLA, Unobserved Human Capital and Firm-Size Premium. 08.11.2000. 33 p.

No 740 JOHANNA ALATALO – JUHA HONKATUKIA – PETRI KERO, Energiaturpeen käytön taloudellinen merkitys Suomessa. 08.11.2000. 51 s.

Elinkeinoelämän Tutkimuslaitoksen julkaisemat "Keskusteluaiheet" ovat raportteja alustavista tutkimustuloksista ja väliraportteja tekeillä olevista tutkimuksista. Tässä sarjassa julkaistuja monisteita on mahdollista ostaa Taloustieto Oy:stä kopiointi- ja toimituskuluja vastaavaan hintaan.

Papers in this series are reports on preliminary research results and on studies in progress. They are sold by Taloustieto Oy for a nominal fee covering copying and postage costs.