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FROM R&D TO PRODUCTIVITY THROUGH MICRO LEVEL RESTRUCTURING**

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ABSTRACT: This paper investigates the determinants of the between component of aggregate productivity growth, which gauges the productivity-enhancing part of plant-level restructuring. Results obtained from a panel of twelve Finnish manufacturing industries in the period from the mid-70s to the late 90s suggest that R&D contributes to aggregate productivity growth through plant-level restructuring with a lag of some 3 to 5 years. More generally, our empirical evidence is in keeping with the conjecture that the technology advances made in the industries, generated or captured by R&D efforts, initially tend to widen productivity dispersion between plants, but the plant-level restructuring needed to fully reap the fruits of technology improvements at the industry level simultaneously compresses the heterogeneity. We observe that international trade, and imports in particular, is positively related to the between component. This finding can be interpreted so that the competitive pressure being one important element of the creative destruction process. Finally, we do not find evidence that wage dispersion between plants stimulates labour reallocation in a productivity-enhancing way.

Keywords: productivity, total factor productivity, plant level restructuring, R&D, international trade, competition

JEL-Code: O12, O14, O19, O31, O47

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TIIVISTELMÄ: Tutkimuksessa selvitetään, mitkä tekijät selittävät aggregaattituottavuuden kasvun osuussiirtymäkomponenttia, joka mittaa tuottavuutta vahvistavan osan toimipaikkatason rakennemuutoksesta. Kaksitoista toimialaa 1970-luvun puolivälistä 1990-luvun loppuun käsittävästä paneeliaineistosta saadut tulokset viittaavat siihen, että T&K vaikuttaa aggregaattitason tuottavuuteen toimipaikkatason rakennemuutoksen kautta noin 3-5 vuoden viiveellä. Yleisesti ottaen empiirinen evidenssi on sopusoinnussa sen otaksuman kanssa, että toimipaikkatason rakennemuutosta tarvitaan teknologisten parannusten täysimääräiseen hyödyntämiseen ja että tämä prosessi samaan aikaan tiivistää heterogeenisuutta. Havaitaan, että kansainvälinen kauppa ja tuonti eritoten ovat positiivisessa yhteydessä osuussiirtymäkomponentin kanssa. Tämä havainto on tulkittavissa niin, että kilpailun luoma paine on yksi merkittävä luovan tuhon prosessin elementti. Lopuksi, empiirinen näyttö ei viittaa siihen, että toimipaikkojen väliset palkkaerot vilkastuttaisivat työvoiman uudelleenkohdentumista tuottavuutta vahvistavalla tavalla.

Yhteenveto

Tutkimuksessa tarkastellaan tuottavuuskasvun niin sanotun osuussiirtymäkomponentin selitystekijöitä. Osuussiirtymäkomponentti on yksi tärkeä aggregaattitason tuottavuuskasvun mikrotason tekijöistä. Se osoittaa, missä määrin mikrotason rakennemuutos vahvistaa toimiala- tai sektoritason tuottavuutta ja kilpailukykyä. Positiivinen osuussiirtymäkomponentti kertoo siitä, että tuotannontekijät siirtyvät heikon tuottavuuden toimipaikoista korkean tuottavuuden toimipaikkoihin. Tässä tutkimuksessa käytetään työn tuottavuuden lisäksi myös kokonaistuottavuusindikaattoria, jossa tuotannontekijöinä otetaan huomioon työn lisäksi myös kiinteä pääoma.

Tutkimuksen lähtöaineistona on Suomen teollisuustilaston toimipaikkakyselyn tiedot vuodesta 1975 lähtien, joista on laskettu tuottavuuskasvun mikrorakennekomponentit 12 teollisuusalalle. Näin saatua toimialapaneelia on käytetty osuussiirtymäkomponentin tutkimiseen. Tutkimuksessa on käytetty lisäksi tutkimus- ja kehittämistoimintaa (tästä lähtien T&K) sekä kansainvälistä kauppaa koskevia toimialatietoja, jotka on saatu OECD:n aineistolähteistä (ANBERD ja STAN).

Tulokset osoittavat, että T&K vahvistaa aggregaattitason tuottavuutta osin mikrorakennemuutoksen kautta niin, että tämä vaikutus tulee esiin 3-5 vuoden viiveellä. Sama tulema saadaan riippumatta siitä, millä tavalla muita asiaan vaikuttavia tekijöitä on kontrolloitu erilaisia tilastollisia menetelmiä käyttäen. Tulokset ovat ennakko-odotuksien mukaiset. T&K luo uusia teknologioita, jotka kuitenkin otetaan käyttöön onnistuneesti vain osassa tuotantoyksiköistä. Tästä syystä T&K:n lisääntymisen välitön, mutta väliaikainen seuraus on toimipaikkojen välisen tuottavuushajonnan lisääntyminen, mikä myös tulee ilmi tämän tutkimuksen tuloksissa. T&K:n myönteiset vaikutukset tulevat esiin täysimääräisesti vasta sen jälkeen, kun mikrotason rakenteet ovat sopeutuneet. Tämä tapahtuu työpaikkojen tuhon ja uusien työpaikkojen luonnin kautta. Kiinteät investoinnit suuntautuvat korkean tuottavuuden tuotantoyksiköihin, joten myös pääoman uudelleen kohdentuminen on osa tuottavuuskasvun kokokuvaa. Mikrorakennesopeutus pienentää ja poistaa alhaisen tuottavuuden toimipaikkoja, joten tuottavuushajonta supistuu sopeutuksen aikana.

Tulokset kertovat, että kansainvälinen kauppa, ja tuonti eritoten, ovat positiivisessa yhteydessä toimialan osuussiirtymäkomponentin kanssa. Havainto tukee käsitystä, jonka mukaan kilpailun luoma paine on yksi keskeinen niin sanotun luovan tuhon prosessin elementti.

Tutkimuksessa tarkastellaan myös toimipaikkojen välisen palkkahajonnan merkitystä tuottavuuskasvun mikrotason dynamiikan kannalta. Tässä saadut tulokset eivät tue sitä käsitystä, että toimipaikkojen väliset palkkaerot kiihdyttävät toimipaikkojen välistä rakennemuutosta toimialan tuottavuutta vahvistavalla tavalla.

Contents

1 INTRODUCTION

R&D efforts have often been seen as a major tool for the improving productivity of a country. Productivity is an important determinant of the profitability of businesses. Moreover, the sustained evolution of aggregate productivity is also the ultimate source of the growth of nation's living standards. No surprise then that policy makers aiming at increasing the prosperity of the nation would like to know which factors promote and which hamper R&D efforts.

Channels through which R&D turns into higher productivity may not be direct or immediate, however. There may be blockages in the channels which may obstruct the efficient transformation of R&D input into improved aggregate productivity performance. For example, well-functioning institutions may be needed to avoid sclerosis in the economy.

It seems natural to expect that the direct productivity effect of R&D at the firm level is time-consuming. It takes time to generate new technological knowledge. Implementation that takes place at plants may also be a lengthy process as time is needed to build new machines and constructions or an organisation with a suitable mix of skills. Sometimes even establishing brand new plants is required. The value of the new knowledge is typically uncertain and therefore the development may entail lots of experimentation and selection. The units proven successful in the market test are likely to expand and those being uncompetitive shrink and vanish (Jovanovic 1982 and Ericson and Pakes 1995). Productivity development can be expected to involve continuous time-consuming structural change at the plant-level. This being the case, a considerable lag before advances in technology are observed in the aggregate productivity measures can be expected (see Rouvinen 1999). It is argued that there may even be a temporary slowdown in productivity growth immediately after a technology shock (David 1990 and Greenwood and Jovanovic 2000).

The role of micro-structural change for development is interesting not only because it predicts a possibly substantial lag between seed and harvest at the aggregate level but also because this element of development is likely to be painful and costly as well (see Stigler 1947). This is because micro-structural change requires job creation in some plants and job destruction is some others. Firms make investments into some plants whereas in other plants tangible capital is scrapped or shifted to the expanding ones.

Exposure to global competition may also have various consequences for economic development. It may fuel technology transfer from abroad, which boosts productivity, and like R&D, possibly with some lag and turbulence. In addition, international trade may increase competition, which may be important for hampering inefficient usage of resources (the so-called X-inefficiency) and thus may directly compress productivity dispersion between plants.[1] Hard competition is also likely to bring about mobility of resources between plants, i.e. micro level restructuring.

The role of productivity-enhancing restructuring at the micro level may be particularly important for low technology and low productivity nations that are catching up the international technology frontier (Caballero and Hammour 2000). The Finnish manufacturing sector in the pre-recession period, that is up to the late 1980s, is one such exam-

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1 Hicks (1935) has stated that "The best of all monopoly profits is a quiet life".

ple. Its total factor productivity level was about two thirds of the level in the United States as late as the mid-1980, before the steady and strong catching up process started. Due to an exceptional productivity progress the Finnish manufacturing sector had succeeded in moving onto the international frontier in total factor productivity by the end of the 1990s (Maliranta 2001b).

The main purpose of this study is to examine to what extent the R&D input improves aggregate productivity through micro level restructuring. To this end we distinguish the restructuring element of aggregate productivity change (the between component), which is the main dependent variable in our analysis. The identification of this source of growth is made by means of decomposition methods. We construct a panel of 12 manufacturing industries covering the period from the mid-1970s to the latter part of the 1990s. Other explanatory factors include international trade (exports and imports) and the gap to the international technology frontier (TFP relative to the United States).

In order to have a wider view on the productivity evolution we also study the relationships between restructuring, R&D, international trade and the dispersion of productivity and wages.

The rest of the paper is organised as follows. Section 2 provides the theoretical background for our research problem. In Section 3 we briefly introduce a productivity decomposition method that identifies the restructuring components of the aggregate productivity growth rate. The data sets and variables are described in Section 4. Section 5 provides a description of the characteristics of the development in the Finnish manufacturing industries. An econometric analysis of the determinants of the restructuring component is performed in Section 6. This section also includes an exploration of the relationships between R&D, productivity dispersion, exposure to global competition and wage dispersion. Section 7 concludes the paper.

2 R&D AND RESTRUCTURING

An essential point of the creative destruction argument is that differences in technology (and productivity) levels are systematically associated with the subsequent reallocation of resources, which is the outcome of dispersed input growth rates among plants. The magnitude of the productivity-enhancing restructuring component of economic growth is dependent on two main factors; (1) the greater the dispersion of technologies and (2) the tighter the relationship between performance level and ensuing growth at the micro level. In the following sub-sections we discuss various aspects related to those two main factors behind the creative destruction process.

2.1 Restructuring

Decisions regarding technology, employment and investments made by firms for their plants are the main engines of the aggregate productivity growth process.[2] Firms are maximising present value of future cash flows. Managers need to form expectations for the distant future when making technology choices. The forward-looking nature of technology decisions is often due to irreversibilities that are involved. Once a decision has been implemented by investing, hiring employees or setting up an organisation, it is costly to take back because of sunk costs involved (see, for example, Bertola and Caballero 1994 and Thesmar and Thoenig 2000).

Creative destruction models of economic growth point out that the process of adopting new products and new methods requires the destruction of old ones; the idea that was emphasised by Joseph Schumpeter (1942) a long ago. To take an example, a process innovation may require constructing a brand new machine (or new plant), because the old one cannot be retooled. Before long the operations with old vintages become unprofitable, and those factors of production embodied with old technology must be scrapped (i.e. destructed). The challenge of the restructuring process is to reallocate factors used with less-productive inputs (e.g. in the low productivity plants) to places where they can be combined successfully with more-productive inputs (e.g. in which new technology is embodied).

Various types of life cycle models of firms invite attention to the role of experimentation, selection and learning in the restructuring process. In the passive learning model by Jovanovic (1982) a firm makes an entry in order to see, whether it has qualifications for profitable activities. On the basis of the information it has gained from markets, it decides to expand, contract, or exit. One important implication of this model is that there is a lot of productivity enhancing-restructuring especially among younger firms. Indeed this seems to be the case also for Finland according to results obtained by Maliranta (2001b, 38-39).

In the active learning model by Ericson and Pakes (1995) a firm makes investments to improve productivity and profitability. Competition continuously discriminates

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2 Of course, in reality decision-making is performed at different levels of enterprises. While plants possess a lot of relevant information, they may have a great deal of autonomy in respect to the headquarter. Furthermore, the properties of plants (productivity in particular) are considered when decisions are made in the headquarters. There may be a lot of restructuring not only within sectors or industries but also within multi-unit firms.

between winners and losers; the former gain and the latter lose market shares. According to this model, firms endeavour to develop the performance level of their plants all through the life-cycle. This may be done by R&D investments, for example. Due to the inherent uncertainty that is typical of productivity improving activities, there will be a lot of restructuring between successful and unsuccessful firms.[3]

According to a model of endogeneous growth developed by Aghion and Howitt (1992) the total amount of innovation may increase the dispersion of firm growth rates, that is to say firm-level restructuring.[4] This is, for example, one of the implications of the model by Klette and Griliches (2000) drawing on the quality ladder models in the macro growth literature. As a typical of quality ladder models, they assume that market shares are determined by performance (product quality). Greater innovation activity leads to more frequent strides that will boost reshuffling of market shares. Seeing from the aggregate level, all fruits of an innovation are not reaped before the restructuring is completed.[5]

Baldwin (1993) stresses the differences between two conceptual approaches to the notion of competition. The more traditional and widely adopted one is to see competition as a state of affairs. An alternative and complementary view, that follows the trails marked by Schumpeter, Hayek and the Austrian school, sees the competition as a dynamic process. Various types of mobility measures provide us with a useful tool to assess the intensity of competition. Simultaneous occurrences of declines and rises within an industry tell that there may be a competitive struggle taking place (see Baldwin, 1993, 4).

Plant-level restructuring may take place even when the market shares of the firms are relatively stable, when firms are trying to make best use of their resources.[6] On the other hand, even large shifts in the markets shares between firms do not necessarily imply that there is productivity-enhancing restructuring at the level where the production operation takes place. This is because firm-level restructuring may reflect changes in market shares due to ownership changes.

There are several factors that can be expected to affect the intensity of competition from the view point of restructuring among incumbents as well as through entry and exit. Firms may have monopoly power that insulates their fate from their productivity performance to some extent. This may be the case, if an industry can be characterised by natural monopolies or local competition. For example, Bertin, Bresnahan and Raff (1996) point out that blast furnaces have been more or less wrapped in cotton wool because of poor short-run substitutability of one plant's output for another's. They argue

3 Maliranta (2001, 37-38) provides empirical evidence that a disproportionately large proportion of productivity-enhancing restructuring can be attributed to the plants owned by high R&D intensity firms.

4 According to results by Maliranta (2001b) the dispersion of labour growth between plants has shown an upward trend since the mid-80s. Some signs of chill in the restructuring can be seen in the latter part of the 90s.

5 Thesmar and Thoenig (2000) consider how the higher innovation rate, stimulated for example by an increasing supply of skills or globalisation, leads to increased product market instability. This means that the projects' life expectancies become shorter. They argue that this has implications for organisational choices, demand of skills and wage dispersion. Sener (2001) considers the role of the creative destruction mechanism in the reallocation of resources in the global economy. It is argued that a global reduction in tariffs does not only stimulate innovation and growth but generates also Schumpeterian unemployment due to time-consuming job-matching processes.

6 About empirical evidence, see Disney, Haskel, and Heden (2000, 16)

that this helps us understand why the recession did not have a cleansing effect through restructuring at the blast furnace level in the United States in the 1930s.[7] So there may be persistent differences in the intensity of the restructuring process across industries due to the nature of technology or markets. This needs to take into account in the analysis.

Public subsidies may damage the connection between productivity performance and subsequent growth (and survivor probability) which is one of the two main elements behind the restructuring process. On the other hand, the business environment may be rendered more apt to productivity-enhancing reallocation by exposing domestic producers to global competition.

2.2 Heterogeneity in technology

There are several reasons why firms and plants even within a specific industry may use different technologies. Owner firms that are initially heterogeneous in their market positions or in their innovation and adoption abilities may end up to different strategic behaviour as regards R&D efforts, for example, when maximising the present value of future profits.[8]

It is also possible that the level of aggregate R&D intensity is positively associated with the R&D intensity dispersion at the firm level. This may be due to the fact that the same factors may lie behind the total amount of innovations and the dispersion of innovations.

The models by Pakes and Schankerman (1984) and Klette and Griliches (2000), for example, predict that increased innovative opportunities lead to a higher aggregate R&D intensity. Globalisation and increased scientific knowledge, for example, may open new opportunities to increase industrial knowledge technology through own R&D efforts, and may thus induce firms' R&D effort. Guellec and van Pottelsberghe (2001) provide evidence that foreign R&D is important for domestic productivity growth (with two years lag). That study and the one by Griffith, Redding, and van Reenen (2000) show that investing in R&D (and human capital) helps the country to catch up the international technology frontier that is, of course, determined by foreign R&D made in the past.

If we assume that all firms are motivated by potential profits but they are different in terms of expected private returns to research, then an increase in technological opportunities can be expected to lead to greater dispersion in R&D efforts among firms. To the extent that the productivity in R&D efforts varies between firms within an industry, new waves in innovation opportunities are likely to lead initially to greater dispersion in technological efforts and technological levels between firms within the industry. Trade-related international R&D spillovers may lead to technological steps among those plants with the capability to adopt and implement new technological opportunities.

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7 Retail trade is another obvious example. The situation may also change over time due to deregulation or technological change. For example, the economic environment of the telephone companies has changed in Finland quite markedly since the late 1980's. In the banking sector competition has also increased a lot, resulting in huge restructuring and substantial gains in efficiency.

8 See Pakes and Schankerman (1984), Cohen (1995), Lerner (1997) and Klette and Johansen (1998) for discussion and further references to other relevant literature concerning heterogeneity in innovation activity.

In the competitive environment low technology and low productivity plants owned by a profit-maximising firm have their raison d'être as long as they have positive quasi-rents (see Hjalmarsson 1973). So the existence of sunk costs implies that high technology and low technology plants may operate side by side, resulting in productivity dispersion between plants.

In order to achieve high productivity and profitability firms successful in their R&D inputs have to implement their innovations in a technically efficient and commercially profitable way in their production plants. It is possible, however, that not all plants of the same firm in the very same industry use the same technology. In some plants the implementation of new technology may have higher returns than in others. As the technological evolution is usually a cumulative process, it is possible, for example, that incremental new innovations can be effectively incorporated into pre-existing embodied technology of the relatively new plants. Stein (1997) states that established firms may manage to stay "on the cutting edge" of new technology, since they pioneer the majority of improvements. As incumbent plants have valuable practical knowledge about technology for example due to learning-by-doing, at least some of them may have a special role in the process of generating and implementing incremental innovations in the firm.

In the case of radical innovations, pre-existing technology and the capital into which it is embodied, becomes obsolete. Then new technology may be better to put into use in a brand new plant.[9] A class of models including Caballero and Hammour (1994) and Campbell (1997) is based on this idea, emphasising the potential role of entry and exit. Some other models (Cooper, Haltiwanger and Power 1999, for example) state that the new technology is usually embodied in new capital that can be put in use in the old plants through a retooling process.

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 one would nevertheless expect modern technology to be more easily integrated with relatively new technology vintage and equipment capital than with ancient ones.[10]

All in all, these considerations as well as those by Jovanovic (1982) suggest that plant vintage plays an important role in the creative destruction process. Brand new and relatively new plants are those in which radical and incremental innovations are implemented, while outdated technologies are buried along with the disappearing old plants.

Since technology is a non-rival good, and at least to some extent excludable, a firm is usually unable to reap all fruits of its R&D efforts. Seeing from the other side, instead of creating technology for itself by itself, a firm or a single plant may also absorb technological knowledge that is spread from other innovative firms.

Knowledge spillovers among firms and plants, from best practise ones to low productivity ones, in itself might bring about convergence[11] in technology levels (internal adjustment) and by this means mitigate the need for structural change among firms (exter-

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9 In the Finnish Industrial Statistics Survey a brand new plant code is given in such cases where there has been a thorough-going change in the way the production is performed. This is the case for example, when a substantial proportion of tangible assets is replaced. This treatment of plants' deaths and births accords roughly with the one we would need when using this data source for analysing the life cycles of plants from the standpoint of technology adaptation.

10 This is consistent with the argument by Campbell and Fisher (1998) that young plants have greater organisational flexibility that can be expected to pave the way to the adaptation of new technologies.

11 And reduce incentives for innovations (see, for example, Stein, 1997).

nal adjustment) (see Bala and Goyal 1998). However, since the opportunities and the abilities to adopt new technological knowledge may vary between firms (see Leiponen 2000), the technology spillovers across borders, for example, may be a source of dispersion among domestic firms as well.

2.3 Heterogeneity in plants' productivity levels

In practise, we do not usually observe the technological level of a firm or plant directly, but we may compute indicators of the productivity level that are wavering indirect reflections of the technological level. Inaccuracy in this sense arises because some firms or plants may fail to use their technology and factors of production in an efficient manner. So, productivity dispersion may gauge both technology heterogeneity and technical inefficiency. In practise, a sharp distinction may be difficult to draw between these two aspects of productivity performance, but it is worth bearing in mind.

From the standpoint of aggregate productivity, the part of the inadequate productivity that can be attributed to X-inefficiency (see Leibenstein 1966) or "remediable defect" (see Torii 1992) or "fat" (see Borenstein and Farrell 1999) deserves special notice. Productivity improvements through 'internal adjustments' among low productivity plants may be less painful and gains are more immediate than in the case of 'external adjustment', i.e. through destruction and creation of jobs in plants during the transition period.

When dispersion in the embodied technology is the source of productivity dispersion, plant-level restructuring is needed. In this case, adjustment involve immediate losses in jobs as well as in output, and when the transition is successful, gains may appear later in the form of growth of employment and disproportionate voluminous increase in output (see Greenwood and Jovanovic 2000).

Of course, internal adjustment that is needed to clean inefficiency within low productivity plants may not be painless either. Although, by definition, it is possible to improve efficiency by increasing output with a given amount of input, it seems that in practise quite frequently adjustments are carried out by downsizing. Foster, Haltiwanger, and Krizan (2000) argue that some technological improvements lead to substantial downsizing by plants that adopt the new technology. An internal adjustment among low productivity plants entails incremental productivity growth within the efficiency-improving plants, whereas this is not the case when the plants having low productivity due to low embodied technology are cleaned through external adjustment.

2.4 Co-movement of productivity and wage dispersion

In the competitive labour markets identical workers (with identical working conditions) share the same wage levels. 'Equal pay for equal work' is also one of the goals expressed by major trade unions attending collective bargaining for instance in the Nordic countries (see, for example, Hibbs and Locking 2000). In both models of wage determination a firm's or plant's profitability or ability to pay has no role to play. Consequently the dispersion of average hourly wages between plants should reflect differences in the skill composition across plants. Differences in skill levels across plants in turn should be reflected in productivity dispersion, when the quality of labour input is not controlled for in the productivity indicator as is the case when labour input is measured by hours worked.

If wages are determined in competitive labour markets (or collective bargaining that is strictly guided by the principle of 'equal pay for equal work') then co-movement of productivity (with labour quality uncontrolled) dispersion and wage dispersion can be expected to entail similar variations in skill dispersion, that is changes in segregation of labour across plants by skills.[12]

The waves in skill-biased technological revolutions is one candidate as an explanation for joint movement of productivity, wage and skill dispersion across plants over time, given by a model of Casselli (1999). In this model technological progress entails the adaptation of a new type of machines at plants. A major point of the model is that when a skill-biased technological revolution occurs, high-skilled workers will be the first to use the new machines since it is less costly for them to learn to use new machines. This model predicts segregation of labour after an occurrence of a great technological advancement. At one extreme of the distribution there are low-wage and low-productivity plants with less skilled workers and old machines. At the another extreme of the distribution there are high-productivity plants with high-wage and high-skilled workers.

Haltiwanger, Lane, and Spletzer (1999) and Ilmakunnas, Maliranta, and Vainiomäki (1999), for example, provide empirical evidence that differences in productivity levels across plants are systematically related to differences in workforce composition. These two studies as well as Maliranta (2000), however, fail to find an unambiguous positive relationship between *changes* in productivity and *changes* in workforce characteristics. Thus there is not much empirical support to the view that improvements in productivity, due to adaptation of a new type of machine for example, are positively correlated with an increase of skill level at the plant-level. The failure to find a positive correlation at this point may be due to measurement errors that are likely to be particularly severe in the case of measuring changes, or due to problems in timing. An alternative explanation is that firms and their workforce have locked in different modes of production. This is an important point for the analysis undertaken in the present study as it suggests that plant-level restructuring is important for the efficient utilisation of upgraded skills in the economy.[13]

In Casselli's (1999) model an increase in inequality is an immediate consequence of technological revolution. He points out that it is possible that in the long run this process will lead to widespread adoption of leading-edge technology and declining inequality. The economy also achieves high aggregate productivity performance. However, it is also possible that an economy gets stuck to a steady state in which not all skills are upgraded. There is little productivity-enhancing restructuring. Labour markets remain segmented

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[12] Of course, changes in returns to skills will also show up as changes in wage dispersion between plants having varying skill levels.

[13] Leiponen (1995) and Ilmakunnas, Maliranta, and Vainiomäki (1999) find that high total factor productivity *growth* is positively associated with the *level* of education. This is consistent with the conjecture that education has an important role to play in increasing the steady-state productivity growth rate by enabling the workforce to create, adopt and implement continuously new technologies (see Benhabib and Spiegel 1994). Results by Maliranta (2000) seem to suggest, quite intuitively, that it is the skills in the field of natural sciences and engineering that are essential from this perspective. In that analysis, by the way, the *change* of 'non-technical' skills appears to be positively correlated with productivity *growth*, which supports the view that at least certain types of skills can be considered as distinct inputs in the production function. Lloyd-Ellis (1999, 67) considers the importance that institutions support adequate acquisition of technical skills.

and inequality stays. In this case an economy has permanently a long and thick tail on the left-hand side of the productivity distribution.

Another strand of reasoning is based on the idea that dynamic wage premiums might be needed to guarantee optimal reallocation of labour across sectors. Recently Acemoglu and Shimer (2000) adopted an approach with some similar features, when providing a framework for analysing the co-determination of wages and technology at the micro level. In their model, wage dispersion is needed because workers must gather information about heterogeneous jobs and this search involves costs. Firms in turn end up with different choices in technology and irreversible investments, even though they had initially identical opportunities. In equilibrium, there is segregation of labour by the amount of information they have. Informed, high wage individuals work in the firms that have high productivity technology, which is built with high fixed costs. Uninformed low wage workers are mostly hired by firms that have low productivity technology. There is a wage premium between identical workers hired by different firms, which makes workers indifferent about whether to gather information with costly efforts. Search induced by wage dispersion may be important both from external adjustment and internal adjustment. Regarding external adjustment, wage dispersion may fuel labour reallocation that is important especially for high R&D intensity firms so that expensive vacancies created by costly irreversible investments do not remain unfilled. On the other hand, search activities reduce firms' monopsony power and drive wages up. Harder competitive pressure is likely to impede X-inefficiency through internal adjustment.[14]

Acemoglu and Shimer (2000) emphasise that although workers are able to appropriate rents generated by fixed costs, the outcome may nevertheless be optimal in the above framework. The view outlined above seems to be in sharp contrast with those considerations where intra-firm bargaining over wages or rent sharing leads to distorted investments (see, for example, Acemoglu 1996). The crucial point here is whether wages are set before or after the match, as pointed out by Acemoglu and Shimer (2000). Caballero and Hammour (1996) emphasise the difficulties in writing and enforcing complete long-term contracts that might be needed in the presence of appropriable specific quasi rents that arise when establishing new jobs equipped with the best techniques available. The creative destruction process is affected by the magnitude of contracting problems which are in turn dependent on legislation and institutions, for example.

Referring to the three broad categories of considerations presented above, the analysis of variation of productivity and wage dispersion may provide us with useful information about the process of technological development.

If changes in productivity dispersion precede changes in wage dispersion, this may be a sign of ex post bargaining and adjustment in the appropriation of rents at the plant-level, as predicted in the model by Acemoglu (1996). Then changes in plants' relative productivity correlate with changes in plants' relative wages, possibly with some lag that is needed for that employees to observe changes in surplus subject to bargaining.

The lack of the correlation between wages and productivity at the plant-level may fuel aggregate productivity growth by accelerating job destruction in relatively in-efficient plants and job creation in new, more efficient plants. This is an essential element of the Rehn-Meidner model that includes solidarity wage policy. This model can be used for

[14] About the intensity of competition and bargaining the amount of inefficiency, see Haskel and Sanchis (2000)

characterising the development process in Sweden and other Scandinavian countries (see Erixon 2000).[15]

When the main driving force of wage and productivity dispersion is the skill-biased technological strides (Casselli 1999) or the need to encourage reallocation between plants (Acemoglu and Shimer 2000), we would not expect changes in wage dispersion to follow the turns of productivity dispersion with some lag.

If the technology steps are characterised by the adoption of new types of machines that are immediately more productive when run by skilled high-wage workers, as suggested by the model of Casselli (1999), we would expect wage and productivity dispersion to vary hand-in-hand. However, as it may require some time to learn by doing with a new type of machines before all potentials embodied in the machines are discovered, we might expect some delay in the change in productivity dispersion.

In the framework of Acemoglu and Shimer (2000) firms making irreversible R&D investments are concerned of whether the vacancies created by large fixed costs will be filled quickly enough. Firms that have invested in high technology set high wage levels. Especially, as it is likely to take some time to build the process and as lots of productivity potentials are materialised with a delay, we would, again, expect changes in wage dispersion to precede rather than follow changes in productivity dispersion arising from widened production possibilities created by innovation efforts.

Looking from the policy point of view, if the considerations arising from the model by Acemoglu and Shimer (2000) are relevant, increases in wage dispersion may contribute to restructuring positively. However, to the extent that the upsurge in wage inequality is due to bargaining after the match of workers and firms (or plants), it may be harmful for productivity-enhancing reallocation, as higher wages of high productivity firms/plants reduce their subsequent job creation. If the increase in wage dispersion is a consequence of skill biased technological advancements, the general skill level of the labour force may be an obstacle to productivity-enhancing restructuring.

In this section we have introduced some theoretical underpinnings that are relevant from the standpoint of restructuring that may have stimulated by innovation efforts or changes in the economic environment. Next we introduce an analytical tool by which we can quantify the component of aggregate productivity development that can be attributed to the creative destruction process.

[15] This point is also mentioned for example by Flanagan (1999).

3 PRODUCTIVITY DECOMPOSITION

The aggregate productivity level *P* in year *t* is defined as follows:

$$P_t = \frac{Y_t}{X_t} = \frac{\sum_i Y_{it}}{\sum_i X_{it}}, \tag{1}$$

where *Y* is output, *X* is input and *i* denotes the plant. In order to measure labour productivity, input *X* is measured here by hours worked and *Y* is value added. In the case of total factor productivity (*TFP*) or multi-factor productivity (*MFP*), input *X* is an index of various types of inputs. We use a simple Cobb-Douglas formula:

$$X = \prod_j X_j^{\alpha_j} , \tag{2}$$

where *j* denotes input type and α is a parameter. We require that $\sum_j \alpha_j = 1$. We call the productivity measure as *TFP*, when the input index includes labour (*L*) and capital (*K*). We have also computed a type of productivity indicator that includes material input (*M*) in addition to labour and capital. For clarity we call this indicator as *MFP*. In this case output *Y* is measured by gross output.

In the case of *TFP*, the output elasticity of labour (i.e. α_L) is defined as the proportion of labour compensation (wages plus supplements) to value added. The output elasticity of capital α_K is then one minus α_L. When material input *M* is included for computing *MFP* the weight of labour α_L is the proportion of labour compensation (wages plus supplements) to nominal gross output and the weight of material α_M is the nominal costs of intermediate inputs per nominal gross output. Now α_K = 1- α_L - α_K.[16]

In this study we examine the sources of productivity growth. We calculate the annual aggregate productivity growth rate[17] in year *t* by using the following formula:

$$\frac{\Delta P_t}{\overline{P}_t} = \frac{P_t - P_{t-1}}{(P_t + P_{t-1})/2} . \tag{3}$$

This provides a very close approximation to the log-difference of aggregate productivity, which is commonly used in analyses of aggregate productivity growth. We consider here the micro level components of productivity growth among continuing plants (i.e. we use balanced panels).[18] Then our measure of aggregate productivity change can be broken down into several additive components in the following way:

16 The weights of different input types are defined at the industry level. To obtain more robust estimates, we use the arithmetic averages of year *t* and *t*-1.

17 Nominal output figures are converted into end year (*t*) prices by using the producer's price index at 2- or 3-digit industry level when computing productivity changes between pairs of successive years. In this way we avoid fixed base year bias that will arise if a certain fixed base year is used and different price indexes are used for plants in different industries (see Maliranta, 2001b).

18 The effect arising from entrants and exitors (net entry) can be measured by subtracting the aggregate productivity growth rate among incumbents from the total aggregate productivity growth rate (this is aggregate productivity growth rate among all plants). Thus the total aggregate productivity growth rate is net entry plus productivity growth components among incumbents (see Maliranta 1997 and 2001b).

$$\frac{\Delta P_t^C}{\overline{P_t^C}} = \sum\nolimits_{i \in C} \overline{w}_{it} \frac{\Delta P_{it}}{\overline{P}_{it}} + \sum\nolimits_{i \in C} \Delta w_{it} \frac{\overline{P}_{it}}{\overline{P}_t^C} + \sum\nolimits_{i \in C} \overline{w}_{it} \left(\frac{\overline{P}_{it}}{\overline{P}_t^C} - 1 \right) \frac{\Delta P_{it}}{\overline{P}_{it}} \qquad (4)$$

where C (continuing plants) denotes that only those plants are included in the calculations that are observed both in year t and t-1. The weight of plant i (w_{it}) is the plant's input share, i.e. $w_{it} = X_{it}/\Sigma X_{it}$. In this decomposition formula the average share in the initial and end year is used (indicated by $\overline{w}_{it}$).

The first term in the right-side of the equation indicates the productivity growth rate within plants. The second term, the between component (*bwbj*[19]), is the main focus of this study. It specifies how much plant-level restructuring contributes to aggregate productivity growth. It is positive when relatively high-productivity plants expand their share of input usage.[20] The last component could be called the catching up (*chbj*[21]) term. Supposing that size and productivity level are mutually uncorrelated, a negative value suggests that plants having a relatively low productivity level are able to catch up thanks to an above-average productivity growth rate. Therefore it can be used as an indicator of productivity converge.[22] Negative values should predict narrowing productivity dispersion.

It is worth noting that the between component may be also linked to the changes in productivity dispersion when the dispersion is measured with input weights. If there is a lot of jobs in inefficient low productivity plants then labour input weighted productivity dispersion is skewed to the left and input weighted productivity dispersion is high. Input weighted productivity dispersion declines, if there is a cleansing effect in operation at the left-hand tail of the productivity dispersion. This is the case, when the resource shares move from the low productivity units to average and high productivity units. Then productivity dispersion narrows and straightens. As this type of reallocation of the resource shares is reflected as a positive between effect, we might expect a negative correlation between the change in productivity dispersion and the between component.[23]

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19 The name of this variable is due to the fact that it is the Between component obtained by a modified version of the formula presented by Bernard and Jones (1996)

20 Maliranta (2001b) shows that the between component generally varies in quite a similar way as the entry and exit components of productivity growth. Between component appears to be a suitable indicator of the process of creative destruction, especially when remembering the inaccuracies we are bound to have in identifying entries and exits. Entries and exits observed in data include true as well as some artificial births and deaths possibly in somewhat varying proportions. Therefore the series of entry and exit components can be argued to be subject to less reliability.

21 The catching up component is a term that is obtained by reformulating the decomposition formula presented by Bernard and Jones (1996).

22 If the relative productivity levels across size groups are reasonably stable over time, short-term variation in this component may reveal something interesting about the changes in the economic environment. This term can be expected to be low when productivity improving adjustment among low productivity plants is common.

23 About empirical evidence, see Maliranta (2001b).

4 DATA

Measures for productivity growth rates and micro-structural components of aggregate productivity growth are calculated by using a plant-level panel data set constructed especially for research purposes. It is based on the annual Industrial Statistics surveys that cover basically all Finnish manufacturing plants employing at least 5 persons up to the year 1994. Since 1995 it includes basically all plants owned by firms that employ no less than 20 persons. The same data source is used in the computations of productivity and wage dispersions. In order to ensure comparability over the whole period up to the year 1998, we have dropped plants with less than 20 persons when generating the dispersion series.[24]

In the labour and total factor productivity indicators output is measured by value added. In the case of multi-factor productivity we use a gross production measure instead. Nominal output measures are converted into end year prices by means of industry-specific producer price indexes (see footnote 17). Labour input is measured by total hours worked. Capital stock, which is used as a measure of capital input, is estimated by using the perpetual inventory method and assuming 10 percent annual depreciation (see more details from Maliranta 2001b).

Following the way applied by Mairesse and Kremp (1993) we have dropped those plants, whose log productivity differs more than 4.4 standard deviations from the input weighted industry-average in the year in question.[25]

Industry-level information on R&D expenditures that is used for computing the R&D intensity variable is obtained from OECD's ANBERD databases. Information on the industry's exports and imports of products of the industry as well as value added, that is needed to render variables into intensity form, are obtained from STAN databases by the OECD.

[24] We have examined how sensitive the patterns of the dispersion series over time are to changes in the cut-off limit from 5 to 20 in the period 1975-94. It turns out that patterns are quite similar.

[25] In addition to this we have dropped 6 influential observations from those about 10 000 plants that appear at least once in the period from 1975 to 1998 when calculating total factor productivity components (6 in labour and 10 in multi-factor productivity computations). They have clearly erroneous information that is reflected for example so that the absolute values of the between and catching up terms of equation (4) are quite large and have opposite signs.

5 CHARACTERISTICS OF THE DEVELOPMENT IN INDUSTRIES

In this section we look at some tendencies in the growth processes in the Finnish manufacturing industries. Besides this, we introduce the main variables that will be used in the more detailed econometric analysis performed in Section 6.

5.1 Aggregate productivity performance relative to the United States

We examine the development of productivity and other factors in twelve industries that are introduced in Table 5.1. The classification is based on ISIC Revision 2 scheme. For these industries we have estimates of the productivity level relative to the United States. They are obtained by updating the results in Maliranta (1996 and 1997).

The productivity comparisons for the base year, that is 1992 for metal industries and 1987 for the others, have been made by using the same approach as in the ICOP (International Comparisons of Output and Productivity) project at the Groningen University (see for example van Ark and Pilat 1993).

In this so-called industry-of-origin approach the 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.

Relative total factor productivity is measured here traditionally as a weighted geometric average of the relative labour and capital productivities. The weights are calculated by taking arithmetic averages of the income shares in the two countries. 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 each country.[26] Finnish investments have been converted into dollar terms by using the purchasing power parities of investment goods. This information has been obtained from the International Sectoral Database (ISDB) by the OECD. Extrapolation of the series and the measurement of capital stock estimates are based on information obtained from the STAN Industrial Database by the OECD, DSTI.[27]

Table 5.1 indicates that the Finnish manufacturing industries were quite heterogeneous in terms of relative productivity performance. The aggregate productivity level is high in basic metal industries, paper and paper products and non-electrical machinery. The backwardness appears to be worst in food industry, transport equipment and textiles etc.

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[26] Typically somewhat less than 10 percent depending on the industry. We have determined the depreciation rate so that our series generated from investment series by the PIM-method for the United States have as similar pattern over time as possible with official capital stock series.

[27] Printing & Publishing is dropped from our analysis. There are two main reasons for this. Firstly, for that industry it was not possible to compute an industry specific unit value ratio that is used in converting outputs into comparable units in the Finland/US productivity comparison. Secondly, R&D intensity, which is one of the main variables in our analysis, is obtained from OECD's ANBERD database. This source has, however, R&D expenditures for the combined Paper, Products & Printing industry only. As the paper industry covers about 80 per cent of the value added and some 90 percent of the R&D expenditures in the 90s, these figures indicate reasonably well the development of the R&D intensity (R&D expenditure per value added) in Paper & Products, but not necessarily in Printing & Publishing.

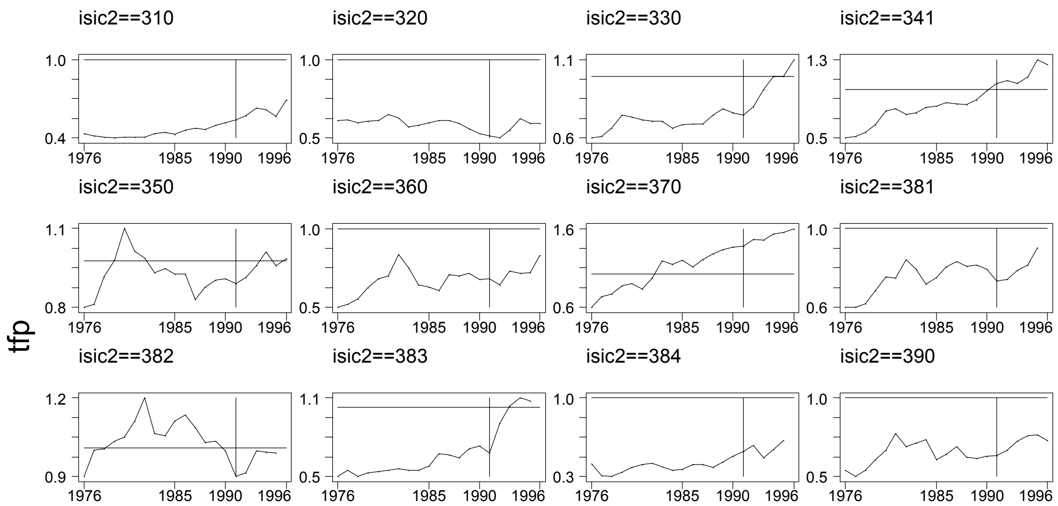
There seems to be a considerable amount of divergence in the developments over time across industries as well (see Graph 5.1). Electrical machinery is from the one extreme — the performance level has climbed from 70 per cent slightly over the US level in a few years' time. Food and wood industries used to be at the other extreme. Despite the very low productivity level they managed to catch up with the US level quite slowly. On the other hand, marked acceleration in catching up can, however, be found in the post-recession period (i.e. since the early 1990s). Productivity performance has traditionally been quite poor also in non-metallic minerals and in textile industry.

Table 5.1. Relative productivity performance in Finnish manufacturing industries in 1990 (USA=100)

Industry	*isic2*	*lp*	*tfp*
Food, Beverages & Tobacco	**310**	50	48
Textiles, Apparel & Leather	**320**	60	56
Wood Products & Furniture	**330**	90	75
Paper & Products	**341**	127	98
Chemical Products	**350**	89	92
Non-Metallic Mineral Products	**360**	72	71
Basic Metal Industries	**370**	117	135
Metal Products	**381**	81	78
Non-Electrical Machinery *	**382**	91	99
Electrical Machinery **	**383**	67	72
Transport Equipment	**384**	47	50
Other Manufacturing	**390**	67	62

* excludes computers, ** includes computers, instruments and other professional goods. *lp* denotes labour productivity and *tfp* total factor productivity.

Graph 5.1. TFP levels in the Finnish manufacturing industries relative to the United States (USA=1)



5.2 Productivity dispersion

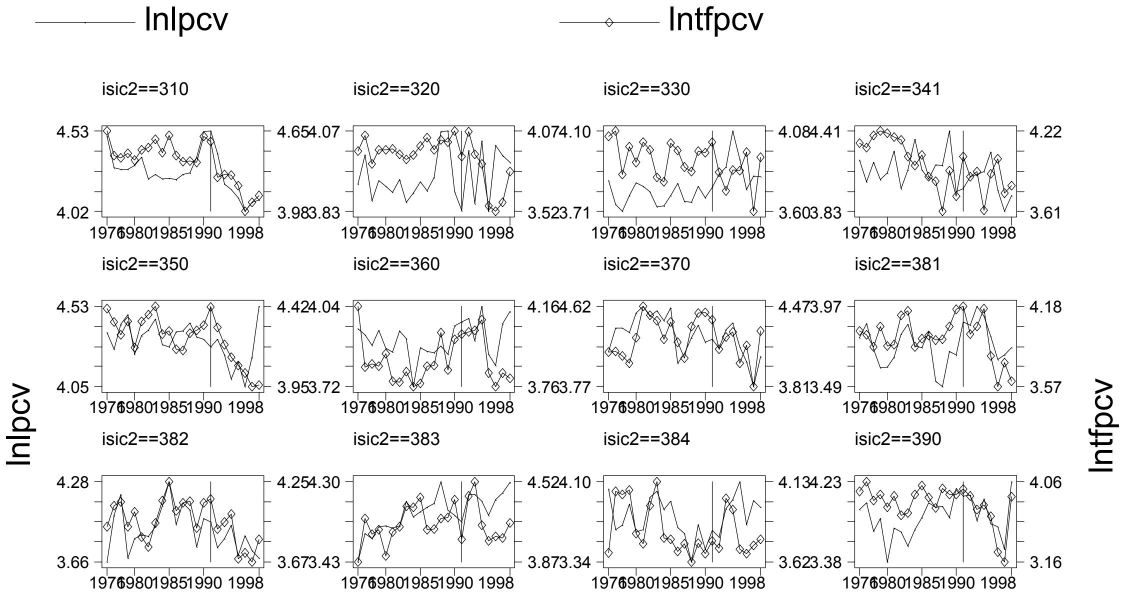
The aggregate productivity level as well as the aggregate productivity growth rate measures mask a substantial amount of dispersion in the productivity levels and divergence in the developments at the plant-level.

Graph 5.2 shows that there is indeed a considerable amount of variation in labour and total factor productivity levels between plants within manufacturing industries, measured by the log of the input weighted coefficient of variation of labour productivity (*lnlpcv*) and total factor productivity (*lntfpcv*).[28] Of course, this variation is likely to reflect not only true differences between plants in technology and in the ability or incentives to use technology efficiently between plants, but also a great deal of other noise like measurement errors or temporary differences in capacity utilisation etc.

The fact that the amount of dispersion varies between industries may be a reflection of inherent differences in the characteristics of technology and the economic environment.

However, it is interesting to see that there have been a great deal of changes in the amount of dispersion over time that may indicate changes in the economic environment, for example. Moreover, the patterns over time vary across industries. It is important to know what factors drive these developments. This is not only because large productivity dispersions may be a symptom of wasteful usage of resources in industries but also because the same factors may affect both productivity and wage dispersions, as were discussed in Section 4.

Graph 5.2. Labour (*lnlpcv*) and total factor productivity dispersion (*lntfpcv*) in manufacturing industries



Notes: Plants employing less than 20 persons have been excluded from these calculations. Indicators are input weighted. See text.

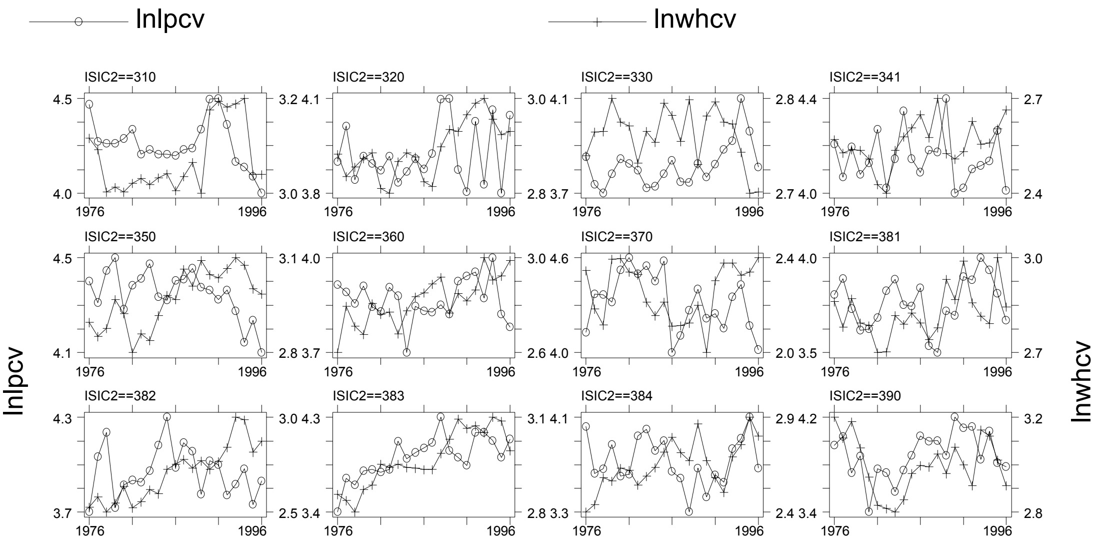
28 In the case of *TFP* the measure of dispersion is calculated by the Cobb-Douglas input index weights that in turn are calculated by making use of the average industry-specific income shares the in initial and the end year.

We notice, among other things, that the dispersion of *TFP* has been relatively high (right-hand scale) in some industries (in food industry, for example). Secondly, a sharp decline in dispersion can be found in many industries during the 1990's. On the other hand, periods of long-lasting increases in the productivity dispersion characterise the development in some industries (e.g. electrical machinery and non-metallic minerals). Finally, we observe that the labour and total factor productivity dispersions usually share reasonably similar patterns over time.

5.3 Wage dispersion

Graph 5.3 shows the development in the plant-level wage dispersion within industries, again measured by the log of the labour input weighted coefficient of variation of hourly wages (*lnwhcv*). In order to inspect the co-movements of wage and productivity dispersion, that is predicted by various theoretical considerations, we have also reproduced our measure of labour productivity dispersion shown in Graph 5.2. We see that the series usually share similar patterns over time, even though they do not appear to be exactly synchronised in all cases.

Graph 5.3. Labour productivity dispersion (*lnlpcv*) and wage dispersion (*lnwhstd*) in manufacturing industries



Notes: Plants employing less than 20 persons have been excluded from these calculations. Indicators are input weighted. See text.

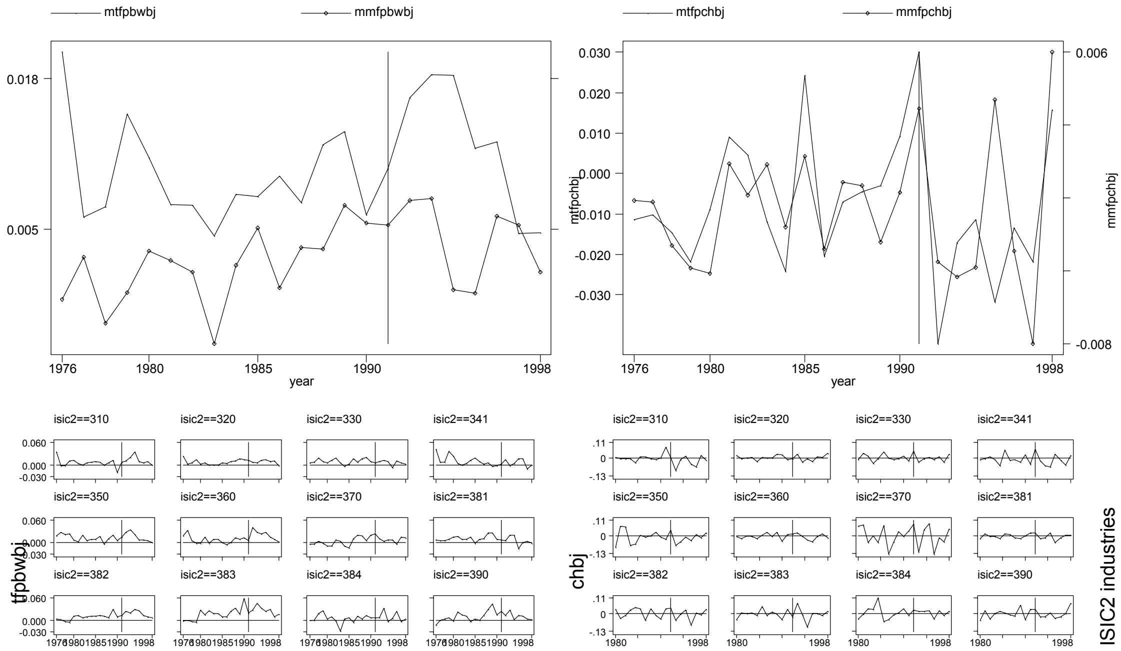
5.4 Micro structural component of aggregate productivity change

Results from productivity decompositions made for 12 industries are depicted in Graph 5.4. Variables *mtfpbwbj* and *mmfpbwbj* aim to summarise the development of the between component of total factor productivity and multi-factor-productivity, respectively, in the

12 industries.[29] Quite consistently with findings made by Maliranta (2001b), we observe that the restructuring component of aggregate productivity begun to become increasingly important in the manufacturing industries since the mid-1980's, and some signs of chilling can be found in the very recent years.

Variables *mtfpchbj* and *mmfpchbj* in turn show the general tendencies of the catching up term, identified by equation (4).[30] We obtain evidence on a striking change in the evolution process after the hit of the recession in the early 1990's. The catching up term comes clearly down suggesting that it has become more common that a below-average productivity plant catches up with the average productivity level thanks to an above-average productivity growth rate.

Graph 5.4. Micro-structural components of TFP and MFP



Notes: See text.

Diagrams at the bottom of Graph 5.4 show that there is, however, a substantial amount of variation in the levels of the restructuring components as well as in their patterns over time across industries. There are some industries, like food industry, textile and wearing apparel industry and manufacture of non-metallic minerals, where the between component was quite insignificant during the first part of the period under consideration. In some industries a notable increase in the restructuring component can be found in the late 1980's or in the early 1990's. This is the case especially in food industry, chemical industry, manufacture of non-metallic minerals, non-electrical machinery industry and, particularly, in electrical machinery industry. Quite commonly, the catching up term became clearly negative in these industries in the 1990's. To sum up these

29 These components have been computed by using a modified version of the method presented by Bernard and Jones (1996) that was introduced in Section 3. Industry-level results are aggregated by using industries' nominal value added shares as weights.

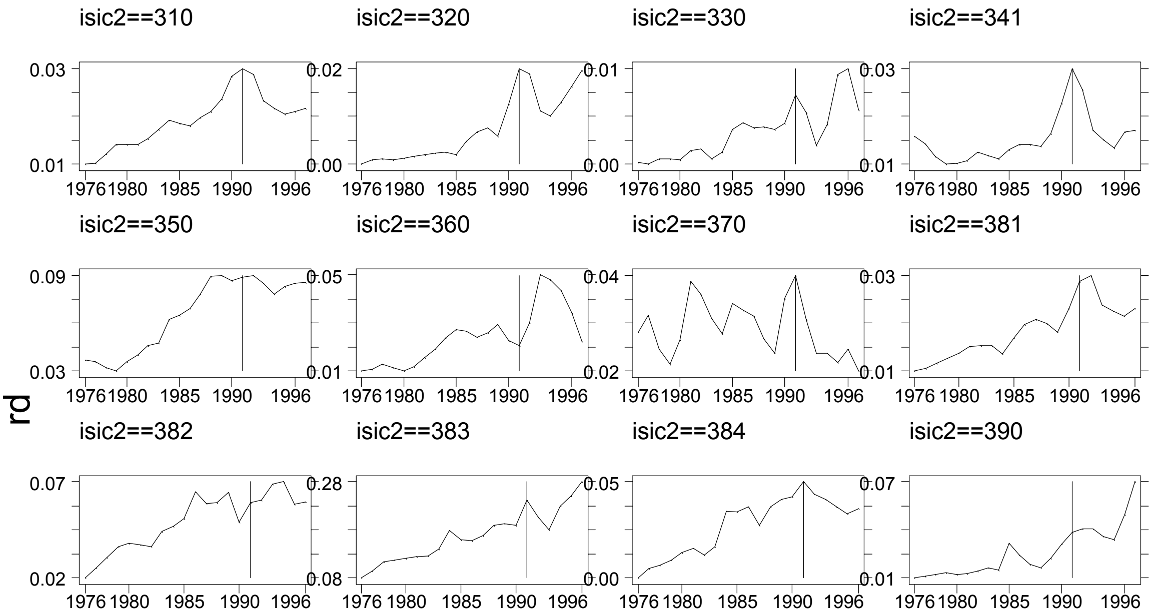
30 Analogously, these are nominal value added weighted averages of the catching up components in the 12 industries.

findings, we have obtained evidence that industry-specific technology shocks and other industry-specific factors may have had important roles to play in the development process during the recent decades.

5.5 R&D efforts

As was argued in Section 2, R&D can be expected to increase aggregate productivity partly through the restructuring process and also to generate turbulence. Graph 5.5 indicates that R&D intensity (nominal R&D expenditures per value added) has increased markedly in most industries. R&D efforts are long-term activities and thus the abrupt drop in value added, the denominator, in 1991 shows up as a peak in R&D intensity. However, overlooking the short term fluctuations reveals important tendencies in the innovation activity.

Graph 5.5. R&D intensity (rd)



Notes: R&D intensity (rd) is nominal R&D expenditures per nominal value added. Data sources are ANBERD and STAN databases by OECD.

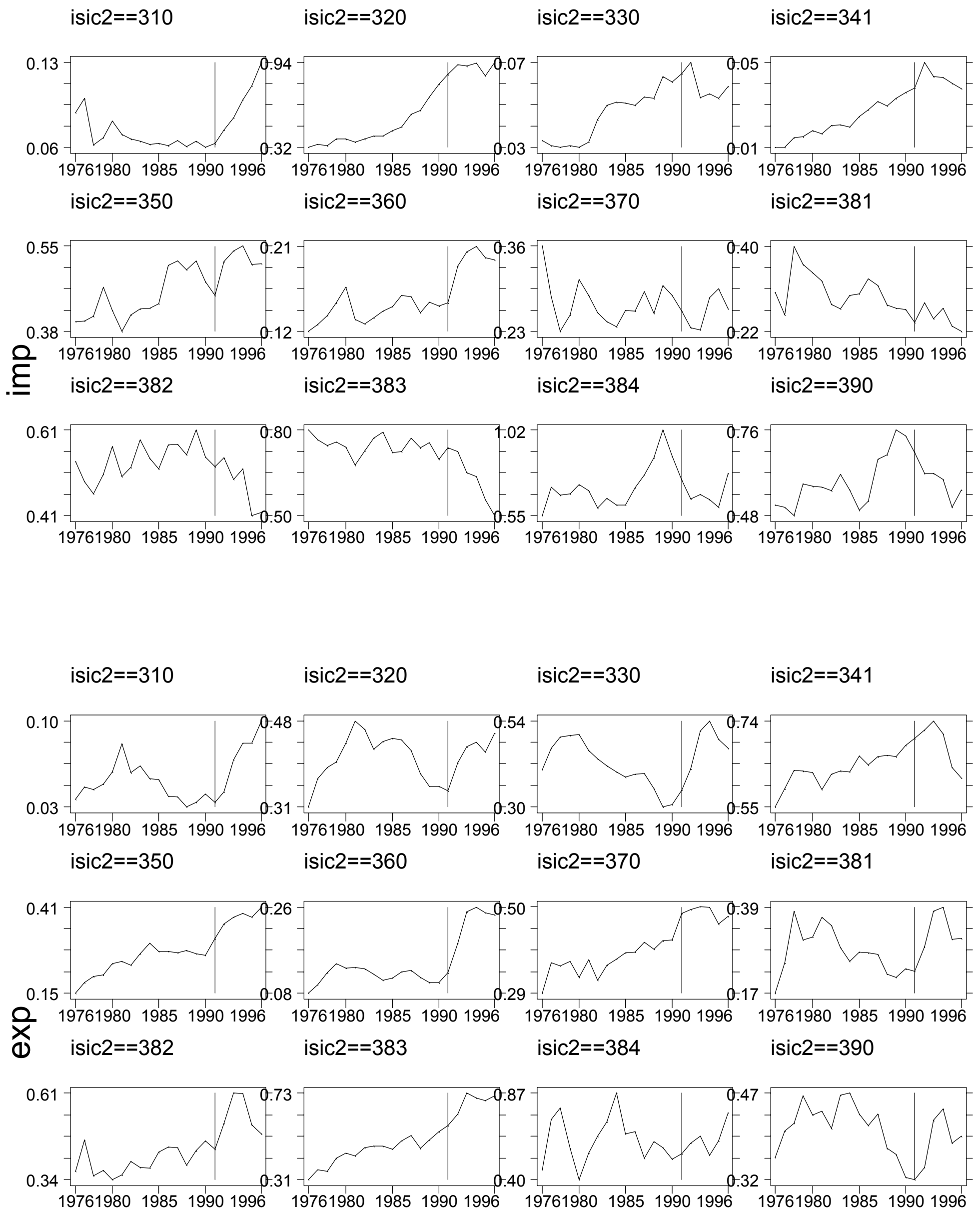
5.6 Exposure to global competition

Another potential stimulus to an increase in aggregate productivity through micro-level restructuring can be expected to arise from the increasing exposure to global competition. In order to explore this factor we have included two more variables in the analysis that are supposed to gauge the effect of international trade. Nominal imports per nominal gross output (*imp*)[31] can be expected to affect restructuring positively for two rea-

[31] Imports sum the value of those imported products that belong to the industry in question. The denominator, gross output, indicates, of course, the value of domestic production in that industry.

sons. First, imports may be a channel through which foreign best- or better-practise technology transfers into the country. Secondly, imports may affect positively the competitive pressure in the domestic markets, which in turn is likely to fuel mobility of resources in a productivity-enhancing way. We see that import intensity has increased in the 1990s markedly in a number of industries, in food industry and in manufacture of non-mineral products in particular.

Graph 5.6. Imports share (imp) and exports share (exp)



Notes: imports intensity (imp) is imports per nominal gross output and exports intensity (exp) is exports per nominal gross output. Data source is STAN database by OECD.

Nominal exports per nominal gross output (*exp*) is a variable that is quite commonly used in this type of context. High export intensity indicates that a substantial share of the production faces directly international competition. As argued by Maliranta (2001b), all foreign markets need not be challenging from the standpoint of productivity performance. Because of this concern Maliranta (2001b) focused on exports to Western markets (and ignored exports to the former Soviet Union) and found that is was clearly positively associated with the subsequent restructuring component of aggregate productivity. As it comes to industry level exports, however, it is not possible to distinguish exports by destination detailed enough. Therefore, our exports variable can be argued to be an insufficient indicator of the exposure to hard global competition.

Much of the increased orientation towards Western markets in the mid 1980's, for example, may be ascribed to the collapse of trade with the former Soviet union. It seems natural to think that this shock fuelled reshuffling among firms and plants, as only a proportion of them was able to meet the Western standards as it comes to the quality of products and production processes.[32]

When we are dealing with industry-level observations it may be more doubtful to what extent changes in export intensity reflect such exogenous factors that fuel productivity--enhancing restructuring and to what extent the success in export markets is a consequence of good productivity performance. At this point it may be useful to consider the developments in the Finnish electrical machinery industry. It is now successful to a large extent due to cell phone production that has emerged through restructuring within the electrical machinery industry.

[32] Several aspects that are relevant at this point are included in the analysis by Sener (2001).

6 ECONOMETRIC ANALYSIS OF THE RESTRUCTURING PROCESS

In Section 6.1 we first examine potential determinants of the between component of aggregate productivity change and the roles of R&D and international trade in particular. In order to obtain a more comprehensive picture about the process through which high R&D and other factors transform into higher productivity, we study in Section 6.2 the relationships between restructuring, productivity and wage dispersion, R&D efforts and international trade more carefully.

6.1 Explaining the between component of aggregate productivity growth

Econometric modelling of the between component of TFP

The effect of R&D on the aggregate productivity of industries or countries has been intensively investigated.[33] Typically the theoretical framework is based on Marshall's concept of a representative firm or Viner's concept of the average firm (see Baldwin, 1993).

Various stylised facts obtained from micro level data sets, however, seem to indicate that that type of framework is likely to miss something essential in the economic development. In particular, productivity decompositions have demonstrated that there may be substantial and sustained differences in the growth rates within firms (or plants) and in the growth rates at the aggregate level due to an effect arising from micro level restructuring.

Typically the basic econometric equation takes the form

$$\Delta P_i(t) = a + b \cdot \frac{RDEXP_i(t)}{NY_i(t)} + \varepsilon_i(t) \qquad (5)$$

where P is a productivity indicator, Δ is the difference operator, ε is an error term with the usual properties and $RDEXP$ and NY are nominal R&D expenditures and nominal output, respectively. Time is denoted by t and an industry or a country (or a firm) by i. In this specification parameter b indicates the rate of return to R&D investments. Of course, usually a number of other variables are also included in the equation in order to incorporate various other important factors of growth. International trade is quite frequently included. It is not very uncommon to examine the effect of the initial relative productivity, either. It is supposed to reflect the caching-up potential. The use of indicators for human capital in this context has become more popular in recent years (see, for example, Benhabib and Spiegel 1994, and Krueger and Lindahl 1999).[34]

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33 About the effect of R&D on productivity, see, for example, Gustavsson, Hansson, and Lundberg (1999); Cameron, Proudman, and Redding (1999) and Rouvinen (1999) and numerous other studies listed in Bassanini, Scarpetta, and Hemmings (2001).

34 Griffith, Redding, and van Reenen (2000), for example, find evidence that R&D and human capital enhance technology transfer and thus stimulate the catch-up process. They also study the role of trade and find it playing a more modest role in the productivity growth.

The novelty of this study is to focus on one of the components of aggregate productivity growth, defined in (4); that is the between component. On the basis of theoretical considerations we would expect that R&D improves aggregate productivity partly through the restructuring component and with some lag that is needed for selection, job creation and the destruction.

These hypotheses are tested with an econometric exercise by using a panel of 12 manufacturing industries covering the period from the mid-70's to the latter part of the 1990's.[35] We have included, in addition to the R&D intensity variable, export and import intensity as well as (log of) the total factor productivity level relative to the United States. As noted above, all these variables are widely used in analyses of aggregate productivity and all of them can be argued to affect or to be associated with the creative destruction process. The examination of still another potential determinant, human capital, is left for future work.

Table 6.1a reports estimation results for the determinants of the between component. All reported models include fixed industry effects. Furthermore, we have allowed different trends for each of the 12 industries. We have experimented with various specifications that are not reported here. For example, we have used a common trend or year dummies instead of using industry-specific trends.

Table 6.1a Determinants of the between component of aggregate productivity growth

	(1)		(2)		(3)		(4)	
bwbj	Coeff.	Std err.	Coeff.	Std err.	Coeff.	Std err.	Coeff.	Std err.
rd(t)	-0.095	0.054	-0.111	0.058	-0.115	0.061		
rd(t-1)	0.091	0.061	0.057	0.066	0.043	0.068		
rd(t-2)	0.109	0.065	0.102	0.069	0.094	0.070		
rd(t-3)	0.101	0.066	0.081	0.072	0.074	0.072		
rd(t-4)	**0.150**	0.074	**0.212**	0.078	**0.206**	0.080		
rd(t-5)	0.132	0.071	0.102	0.080	0.103	0.082		
rdav2_5							**0.503**	0.150
imp(t-2)			**0.069**	0.029	**0.067**	0.031	**0.061**	0.030
imp(t-2)^2			**-0.043**	0.021	-0.043	0.022	**-0.041**	0.021
exp(t-2)			-0.014	0.010	-0.015	0.010	-0.014	0.010
lntfp(t-2)					-0.002	0.005	-0.002	0.005
AR(1)	0.124		.114		0.112		0.121	
Log likelihood	820.2		817.4		815.0		813.4	
Nobs	228		228		228		228	

Notes: All models include fixed industry effects and trends that are allowed to vary between industries. Models are estimated by GLS where heteroskedasticity with cross-sectional correlation and common AR(1) error process are allowed. All models include a dummy for the year 1990 and for a possible outlier observation (isic2 383 in 1990). Coefficients in **bold** are significant at the 95% confidence level, underlined at the 90% level and those both **underlined and in bold** at the 99% level.

The theoretical considerations guide us basically up to the point that we can form expectations about the signs of the effects and that some lags in the effects can be anticipated. 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 adding additional lags as long as the new variable enters as significant in

35 The length of time-series may vary depending on how many lags are used in the specification and which variables are included in the model.

the model. Different model selection approaches resulted in more or less similar outcomes. For the main part the findings seem reasonably stable over the different alternatives. In addition, we have examined the determinants of the between component also by using differenced variables (see Table 6.1b).[36]

Table 6.1b Determinants of the between component of aggregate productivity growth, differenced specifications

dbwbj	(5) Coeff.	Std. err.	(6) Coeff.	Std. err.	(7) Coeff.	Std. err.
dbwbj(t-1)	**-0.577**	0.061	**-0.573**	0.058	**-0.571**	0.058
dbwbj(t-2)	**-0.509**	0.062	**-0.510**	0.057	**-0.509**	0.057
dbwbj(t-3)	**-0.318**	0.055	**-0.328**	0.053	**-0.323**	0.054
drd	**-0.153**	0.055	**-0.148**	0.058	**-0.132**	0.057
drd(t-1)	0.043	0.059	0.024	0.061	0.014	0.059
drd(t-2)	0.000	0.067	0.008	0.069	-0.005	0.068
drd(t-3)	0.099	0.068	0.113	0.069	0.101	0.067
drd(t-4)	**0.152**	0.072	**0.215**	0.074	**0.223**	0.073
drd(t-5)	0.137	0.082	**0.168**	0.085	**0.177**	0.083
dimp(t-2)			**0.103**	0.030	**0.099**	0.031
dimp(t-2)^2			**-0.065**	0.025	**-0.062**	0.026
dexp(t-2)			**-0.024**	0.012	**-0.025**	0.012
dlntfp(t-2)					-0.005	0.007
AR(1) if allowed	.056		.048		.044	
log likelihood	708.4		708.6		708.0	
nobs	204		204		204	

Notes: All models are estimated by GLS where heteroskedasticity with cross-sectional correlation is allowed. All models include a dummy for the year 1990 and for a possible outlier observation (isic2 383 in 1990). Coefficients in **bold** are significant at the 95% confidence level, underlined at the 90% level and those both **underlined and in bold** at the 99% level.

Results for R&D intensity

Basically all the models reported (and unreported) here provide a reasonably consistent and robust picture about the positive effect of the R&D intensity on the later productivity-enhancing restructuring. The findings obtained with this industry panel are closely in parallel with those obtained with manufacturing time-series by Maliranta (2001b).

As expected, the R&D intensity affects positively the between component of aggregate total factor productivity change with some lag. Models (1) - (3) suggest that it takes about four years of R&D efforts to stimulate productivity-enhancing restructuring with full intensity. While the innovation generating process consists of sustained efforts, we have also used the average R&D intensity in the past (*rdav2_5*, the average over the period from the two-year lag to five-year lag). This variable is used in Model (4).

[36] It should be noted that as the models shown in Table 6.1b include lagged dependent variables the results are subject to a bias in the presence of autocorrelation. If we allow the common AR(1) coefficient estimate it turns out to be quite small (less than 0.06), which suggests that at least autocorrelation of order one is not necessarily a serious problem (see Table 6.1b). However, these models should be considered mainly as robustness checks of the conclusions drawn from Models (1) - (4). When the lagged dependent variables are dropped (and the autocorrelation of errors is allowed) R&D intensity still has a positive but now statistically insignificant coefficient.

We have also regressed the between component on the *rdav2_5*-variable without industry effects and trends by using OLS (results are not reported in the tables). According to this model a one percentage point sustained increase in the R&D intensity increases the between component by more than one percentage point (coefficient estimate of the *rdav2_5*-variable is 0.114). Some diagnostics of this down-stripped OLS-model is provided in Graphs A6.1a and A6.1b in the Appendix. An adjusted added-variable plot (or adjusted partial residual plot) in Graph A6.1a suggests that at least outliers are not a very serious problem in this specification. To examine the functional-form assumptions of the model, we have generated a so-called augmented component-plus-residual plot. It does not give us much reasons for concern.

However, electrical machinery (isic2=383) jumps up in these graphs and one may be worried about the influence of this industry on the results. We have checked that the conclusions are not sensitive to the inclusion of this industry. All the models suggest a positive effect of R&D on restructuring also without this industry. For example, in the down-stripped OLS-model that was diagnosed in Graphs A6.1a and A6.1b the estimate was 0.119, compared to 0.114 with the inclusion of the electrical machinery industry.

We have made quite a bit of efforts to find proper functional forms for our models. As an experiment we have used log of R&D intensity as an explanatory variable, like Gustavsson, Hansson, and Lundberg (1999), when studying the effect of R&D on aggregate *TFP*. In this study that type of specifications seems to provide a somewhat poorer fit.

The models using differenced variables lend further support to the main conclusions made above. The models reported in Table 6.1b suggest again that it indeed takes a few years before R&D efforts stimulate plant-level restructuring. All these findings accord in an interesting way with the aggregate level results obtained by Rouvinen (1999) from an unbalanced panel of 14 industries in 12 OECD countries from 1973 to 1997. He observes that R&D affects TFP with a considerable lag. In most cases the fourth lag is the highest, which is by and large the time needed for plant-level restructuring according to our estimates.

International trade

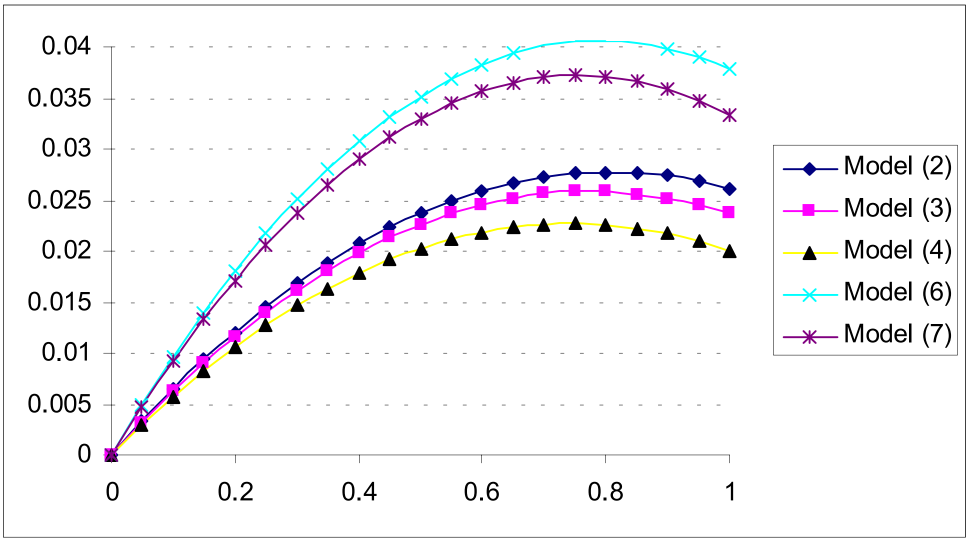
We have two variables for gauging the role of international trade, one for exports and one for imports. We have used a number of different formulations of our indicators and different functional forms to explore the role of international trade for restructuring. We report here the results obtained by using two-year lags. One reason for this choice is that we may obtain a spurious relationship between the trade intensity and productivity, when the output measure appears both in the dependent and the explanatory variable, as is the case when a one-year lag (or current values) is applied. The results reported here give a rather representative picture about our main findings.

We find reasonably robust evidence on a positive effect of imports.[37] The relationship between imports and restructuring does not, however, seem to be linear over the whole range. Graph 6.1 depicts the independent effect of the lagged imports share on the restructuring component of aggregate productivity growth according to Models (2) – (4) in Table 6.1a and according to Models (6) and (7) using differenced forms, reported in

[37] It should be noted that there are some specifications that do not indicate a significant positive effect for imports. For example, when we replace the industry specific trends by one common trend for all industries in Model (3), the effect is not statistically significant anymore. In most cases, however, the empirical evidence points to a positive effect.

Table 6.1b. All these models suggest that the effect is clearly positive within the usual ranges of imports share.

Graph 6.1. The effect of lagged imports share, IMP(t-2), on restructuring



Note: see text.

Regarding export orientation (*exp*-variable) we find no empirical evidence whatsoever of a positive effect on aggregate productivity through restructuring. This seems to be at odds with the findings by Maliranta (2001b). But as stated earlier, that study focused on the part of exports delivered to the Western markets. The endogeneity problem may be more serious here than in the case of imports. High exports may be a consequence of the fact that the industry is already competitive and there is no need for cleansing through restructuring anymore, for example.[38] We have also tried to instrument our exports variable with past values, but the results were still mixed and ambiguous.

Technology level

The impact of the initial technology level is studied here by including log of total factor productivity relative to the United States (*lntfp*) into the models. The danger of having a spurious relationship between the initial productivity and subsequent growth may be

[38] Maliranta (1996) provides empirical evidence that the Finnish and Swedish comparative productivity advantages (and disadvantages) relative to the United States were generally in the same manufacturing industries in the late 1980s. More precisely, there is a significant positive correlation in the industries' productivity levels (relative to the United States) between Finland and Sweden. Statistically significant correlation is found both at the 2-digit (14 industries) and 3-digit level (44 industries). Some other positive correlations are found in the multilateral industry-level (14 industries) productivity comparisons between the United States, Finland, Sweden, former West-Germany, France, Japan, Korea and the United Kingdom. A positive correlation is found between former West-Germany and France (significant at the 99 % level) and between Japan and Korea (90 %), in addition to Finland and Sweden (95 %). These findings give support to the view that the geographical location plays a role in the determination of comparative advantages. Not surprisingly, Maliranta (1996) finds very strong positive correlations in the industries' export shares between Finland and Sweden.

even bigger than in the case with exports. This is one of the reasons, why we have measured the initial productivity level with two years' lag.[39]

We were unable to find any solid evidence that the backwardness in the total factor productivity level leads to ensuing productivity-enhancing restructuring. Maliranta (2001b) provided some evidence in favour of the view that the large productivity gap is reflected in the subsequent high between component. Two problems in our indicator of technology level, especially when applied at the industry-level, raise some concern. Inaccuracy due to measurement error can be expected to be much larger at the industry level as compared to that at the total manufacturing level. Also the validity of our indicator, that is total factor productivity relative to the United States, as a measure of distance to the international technology frontier can be questioned for some industries. It is likely to be an appropriate indicator at the level of total manufacturing, but this may not be the case for every single industry.

6.2 Elements of the micro-level restructuring process

The creative destruction story about the role of R&D and trade for aggregate productivity needs some additional empirical support to be a coherent description of the process. We expect, for example, that productivity dispersion plays a role here. In this section we provide a more comprehensive analysis of the productivity-enhancing restructuring process.

Graph 6.2 illustrates how the rest of the investigation is organised. That is to say we examine what happens during those 3-5 years before the increased R&D efforts are reflected in the between component of aggregate productivity growth.

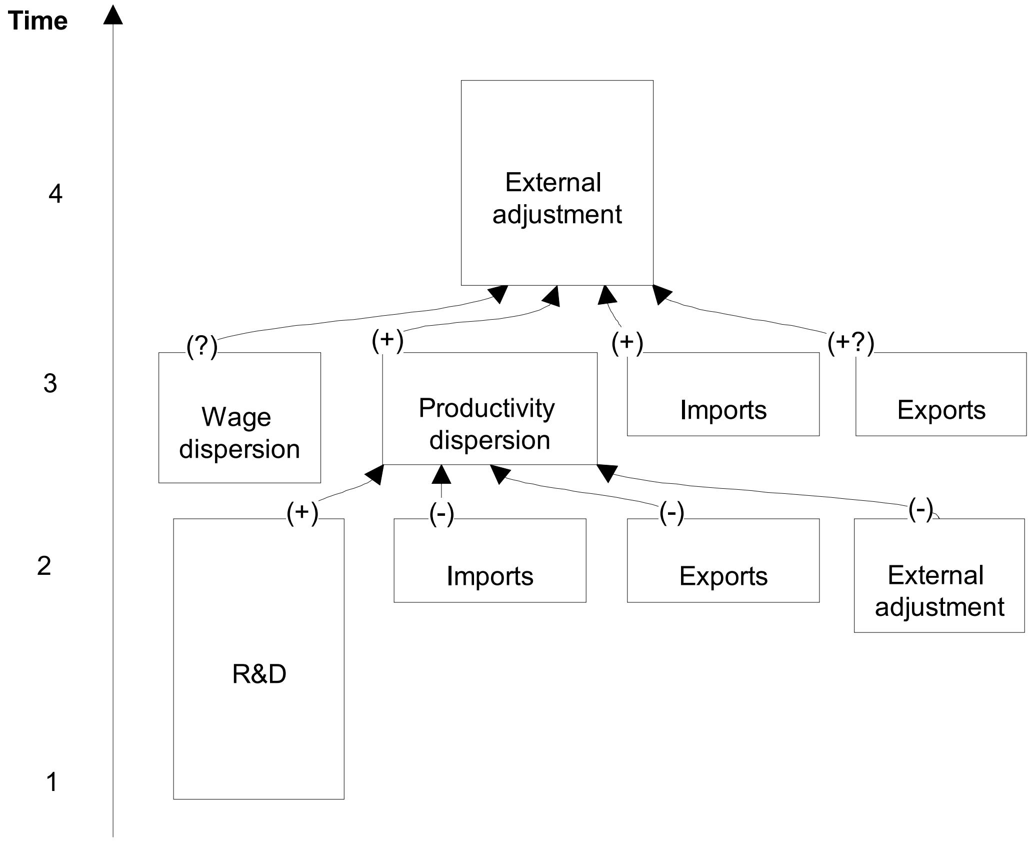
The intensity of the productivity-enhancing restructuring is dependent on two main factors; (1) the magnitude of heterogeneity between plants in terms of productivity levels and (2) the tightness of the relationship between initial performance level and subsequent growth in terms of input usage. The latter can be expected to be dependent on the conditions in both labour and product markets. Wage dispersion may also contribute to the process. The competitive pressure in product markets should affect restructuring positively.

To investigate these issues we perform an analysis, where the between component of aggregate productivity growth is explained by the productivity and wage dispersions, in addition to international trade. We expect that productivity dispersion is positively associated with the later between component, which is indicated by (+) in the Graph 6.2. With regard to wage dispersion various theoretical arguments are not unanimous whether the relationship between wage dispersion and productivity-enhancing restructuring is negative or positive. The conflict between different views is expressed by (?) in the graph.

Then we examine how R&D and international trade affect productivity dispersion. Furthermore, we will investigate whether we can find empirical evidence that micro-level restructuring does the job of cleansing productivity dispersion. This would be reflected in a negative coefficient of the between component. That is indicated by (-) in the arrow from external adjustment to productivity dispersion in Graph 6.2.

[39] We have tried different lags in the model as well as the use of lags as instruments, but the results were generally insignificant.

Graph 6.2. Channels of the creative destruction process



The roles of productivity and wage dispersions in productivity-enhancing restructuring

We obtain a great deal of evidence that productivity dispersion (labour and total factor productivity) has stimulated plant-level restructuring in a productivity enhancing way in the Finnish manufacturing industries. Models (8) and (9) reported in Table 6.2a suggest that variation in total factor productivity performance is quickly reflected in the between component. In models (10) and (11) we have used the labour productivity indicator which may be a less valid but a more reliable indicator of productivity performance than total factor productivity. This investigation indicates an even somewhat stronger relationship between productivity heterogeneity and the between component. Table 6.2b shows estimation results obtained by using differenced forms. Also these results point clearly to the important role of productivity heterogeneity for restructuring.

Quite interestingly, our empirical evidence in Models (8) - (15) is in support of the view that the state of product markets plays an important role in the restructuring process, too. International trade and imports in particular affect positively the between component. One explanation for this is that the harder competition reinforces the relationship between productivity performance and subsequent growth in terms of input use. A positive effect is also predicted by a theoretical model by Sener (2001).

In some specifications exports seem to have a positive and in some others a negative effect. But as pointed out above exports orientation may be a deficient indicator in some occasions and thus having conflicting findings is not very surprising.

Regarding labour markets, results of Models (8) - (15) concerning the effect of wage dispersion, measured here by the log of the hour weighted coefficient of variation of hourly wages (lnwhcv), are not very well in agreement with the view that higher wage differences between plants promote labour reallocation from low productivity to high productivity units. Neither are there indications that wage dispersion is negatively cor-

Table 6.2a Determinants of the between component of aggregate productivity growth

	(8) bwbj		(9) bwbj		(10) bwbjlp		(11) bwbjlp	
	Coeff.	Std err.	Coeff.	Std err.	Coeff.	Std err.	Coeff.	Std err.
lntfpcv(t-1)*	**.010**	.003	**.012**	.003	.001	.003	**.006**	.003
lntfpcv(t-2)*	.002	.003	.003	.004	.005	.004	**.011**	.003
lntfpcv(t-3)*	-.002	.003	.000	.004	**.008**	.003	**.012**	.003
lnwhcv(t-1)	.009	.005	.000	.006	.005	.006	-.002	.006
lnwhcv(t-2)	-.005	.005	**-.013**	.006	.002	.007	.000	.006
lnwhcv(t-3)	.006	.005	.005	.005	-.006	.006	-.003	.005
imp(t-1)	**.004**	.002	**.031**	.008	.001	.002	**.042**	.007
exp(t-1)	**.016**	.004	.003	.008	**.011**	.003	**-.033**	.006
trend	**.0005**	.0001	Industry specific		**.001**	.000	Industry specific	
Industry effects	No		Yes		No		Yes	
AR(1)	0.290		.079		.080		-.041	
log likelihood	793.8		819.8		784.3		825.2	
nobs	228		228		240		240	

Notes: * indicates that in Models (10) and (11) variable is the respective between component of labour productivity (lnlpcv). All models include intercepts. They are estimated by GLS where heteroskedasticity with cross-sectional correlation and a common AR(1) are allowed. Coefficient in **bold** are significant at the 95% confidence level, underlined at the 90% level and those both **underlined and in bold** at the 99% level.

Table 6.2b Determinants of the between component of aggregate productivity growth, differenced specifications

	(12) dbwbj		(13) dbwbj		(14) dbwbjlp		(15) dbwbjlp	
	Coeff.	Std err.	Coeff.	Std err.	Coeff.	Std err.	Coeff.	Std err.
dlntfpcv(t-1)*	0.000	0.002	0.003	0.002	**0.016**	0.004	**0.016**	0.004
dlntfpcv(t-2)*	**0.005**	0.002	**0.008**	0.002	**0.017**	0.003	**0.017**	0.003
dlntfpcv(t-3)*					**0.013**	0.003	**0.012**	0.003
dlnwhcv(t-1)	-0.006	0.006	-0.008	0.006	0.010	0.007	0.005	0.007
dlnwhcv(t-2)	-0.007	0.006	-0.009	0.006	0.005	0.007	0.004	0.007
dlnwhcv(t-3)					0.007	0.006	0.007	0.006
dimp(t-1)	**0.020**	0.010	**0.026**	0.010	**0.069**	0.012	**0.076**	0.012
dexp(t-1)	0.013	0.010	0.013	0.009	**-0.027**	0.009	**-0.025**	0.009
industry effects	No		Yes		No		Yes	
AR(1)	-0.278		-.282		-0354		-0.356	
log likelihood	764.8		768.5		725.4		727.2	
nobs	228		228		228		228	

Notes: * indicates that dlntfpcv is replaced by dlnlpcv, the difference of labour productivity dispersion measure. All models include intercepts. Models are estimated by GLS where heteroskedasticity with cross-sectional correlation and common AR(1) is allowed. Coefficient in **bold** are significant at the 95% confidence level, underlined at the 90% level and those both **underlined and in bold** at the 99% level.

related with the between component, as might be expected when wage dispersion reflects ex post bargaining over plant-specific (quasi-)rents.

All in all, these computations clearly provide further support to the view that technology shocks bringing about greater productivity dispersion between plants trigger a cleansing process that later improves aggregate productivity. More specifically, it seems to take a couple of years before the micro-level adjustment is at its highest intensity. Next we examine whether R&D is positively associated with productivity dispersion that can be considered as the first step in the route from R&D to higher aggregate productivity.

Productivity dispersion

The relationship between R&D intensity and productivity dispersion is the final missing link in the chain from R&D to the productivity enhancing restructuring that needs to be uncovered. The verification of this relationship completes the picture on the creative destruction process. Results reported in Tables 6.3a and 6.3b give support to the hypothesis that R&D is indeed positively associated with the later productivity dispersion, although it should be mentioned that these results are not quite as unambiguous as those obtained in the above analysis. Models (16) - (19) indicate that R&D efforts affect productivity dispersion positively with one or two years lag.[40] Estimations with differenced variables reported in Table 6.3b give further support to our conclusions.

Table 6.3a Determinants of productivity dispersion

	(16) lntfpcv		(17) lntfpcv		(18) lnlpcv		(19) lnlpcv	
	Coeff.	Std err.	Coeff.	Std err.	Coeff.	Std err.	Coeff.	Std err.
rd(t-1)	**2.132**	0.552	**2.349**	0.510	0.599	0.454	**1.897**	0.413
rd(t-2)	0.510	0.580	0.914	0.554	0.879	0.461	**1.648**	0.432
imp(t-1)	**-0.270**	0.043	-0.085	0.058	**-0.349**	0.051	**-0.431**	0.071
exp(t-1)	**-0.269**	0.063	-0.025	0.056	0.044	0.073	**0.190**	0.077
Industry effects	No		Yes		No		Yes	
Trend	**-0.011**	0.002	Industry specific		Dropped		Industry specific	
AR(1)	.559		.282		0.640		0.214	
Log likelihood	224.2		277.8		221.2		285.9	
Nobs	252		252		252		252	

Notes: * indicates that in Models (18) and (19) the variable is the respective between component of labour productivity (lnlpcv). All models include intercepts. Models are estimated by GLS where heteroskedasticity with cross-sectional correlation and common AR(1) is allowed. Coefficient in **bold** are significant at the 95% confidence level, underlined at the 90% level and those both **underlined and in bold** at the 99% level.

In models (21) and (23) we have included also the between components of total factor and labour productivity, respectively. The between component seems to have an immediate negative effect on productivity dispersion. In other words, the between component appears to do the job of cleansing low productivity input use. Moreover, controlling the ongoing cleansing process by the between component reinforces to some extent the independent heterogeneity-increasing effect of R&D.

[40] We have also estimated models that include current R&D intensity (results are not reported here). These models suggest, if anything, that the current R&D intensity is negatively correlated with the productivity dispersion.

Table 6.3b Determinants of productivity dispersion, differenced specifications

	(20) dlntfpcv Coeff.	Std err.	(21) dlntfpcv Coeff.	Std err.	(22) dlnlpcv Coeff.	Std err.	(23) dlnlpcv Coeff.	Std err.
drd(t-1)	**3.446**	0.892	**2.937**	1.010	**1.058**	0.423	**1.226**	0.504
drd(t-2)	1.813	0.984	**2.162**	1.079	1.892	0.435	**2.029**	0.506
drd(t-3)	1.853	1.196	1.491	1.274	0.603	0.503	**1.114**	0.556
drd(t-4)	**6.040**	1.189	**6.530**	1.310	**1.799**	0.631	**2.088**	0.629
drd(t-5)	**7.201**	1.269	**7.275**	1.399	0.671	0.729	1.182	0.659
dimp(t-1)	**-0.692**	0.126	**-0.784**	0.146	**-0.365**	0.084	**-0.289**	0.097
dexp(t-1)	**0.675**	0.102	**0.773**	0.121	**0.691**	0.083	**0.792**	0.096
bwbj*			**-2.414**	0.562			**-2.166**	0.202
Industry effects	Yes		Yes		Yes		Yes	
AR(1)	0.034		0.011		-0.277		-0.302	
Log likelihood	158.2		157.7		223.2		226.5	
Nobs	216		216		216		216	

Notes: * indicates that in Models (22) and (23) bwbj is replaced by bwbjlp, i.e. the between component of labour productivity. Models are estimated by GLS where heteroskedasticity with cross-sectional correlation and common AR(1) are allowed. Coefficient in **bold** are significant at the 95% confidence level, underlined at the 90% level and those both **underlined and in bold** at the 99% level.

7 CONCLUDING REMARKS

Economic growth entails a lot of experimentation and selection at the firm and plant level. Only a proportion of firms or plants is able to realise new technological opportunities that precede technological advances. Moreover, only a proportion of R&D efforts leads to such technological advances at the plants that expand production possibilities and improve profitability. In competitive markets those units proven successful in the market test are likely to expand and those found uncompetitive to shrink and vanish. This process constitutes an essential part of the dynamics of long-run economic growth.

Empirical evidence obtained from a panel of twelve Finnish manufacturing industries in the period from the mid-70s to the late 90s is in keeping with the conjecture that technology advances made in industries, generated for example by R&D efforts, initially tend to widen productivity dispersion between plants, but the plant-level restructuring needed to fully reap the fruits of technology improvements fully at the industry level simultaneously will compress the heterogeneity. Moreover, the empirical evidence indicates that competitive pressure is another important element of the 'creative destruction' process. This conclusion can be drawn from the finding that international trade and imports in particular are positively related with the between component of aggregate productivity, which gauges the productivity-enhancing part of the plant-level restructuring. In addition, international trade may fuel technology transfer and innovation and intensify restructuring also in this way. On the other hand, no evidence was found that wage dispersion between plants fuels reallocation in a productivity-enhancing manner.

These considerations are important from the policy point of view as well as when evaluating labour and other market institutions. First, the results indicate that a substantial technology advance in an industry is likely to entail both job destruction and job creation during the transition period. The challenging task of institutions and policy actions is to facilitate reallocation of resources and alleviate negative side effects of adjustment. Second, efforts to compress wages between firms and plants, that are often involved in the centralised bargaining, may stimulate the mobility of labour between low and high technology plants. Active labour market actions may be needed to avoid surging of 'Schumpeterian unemployment' a la Sener (2001) and the segregation of inhabitants. Third, capital markets have an important role as capital is another important factor of production and efficient allocation of capital between firms and plants is important for aggregate productivity performance as well. Fourth, competitive pressure in product markets is essential for economic progress. Inefficiency-lowering restructuring can be encouraged by exposing firms and industries to international competition through deregulation and reduction of tariffs. Public subsidies may in some cases reduce (as well as distort) competition with negative long-run consequences.

Besides having some policy lessons, these findings help us understand, for example, why productivity growth is usually relatively slow even among those countries far below the technology frontier. Catching up with the international productivity leader requires building new factories and relocation of resources to them. Furthermore, these findings provide an explanation to why R&D affects aggregate productivity with a considerable lag (see, for example, Rouvinen 1999), Finally, the intensive plant-level restructuring that have cleaned low productivity and low wage jobs in low technology plants offers an explanation to why we do not observe a widespread surge of the productivity and wage dispersions in Finnish manufacturing as a contrast to the United States, for example (see Dunne, Foster and Haltiwanger, 2000).

Various factors are likely to affect a sector's ability to become adjusted through restructuring. Obviously the education and skills of the workforce can be expected to be crucial. Highly skilled workers are able to learn quickly to use new technological opportunities in an efficient way.

However, there is some tentative evidence that an important part of the technology advances that have fuelled restructuring in Finnish manufacturing has been neutral in terms of skills demands. Namely, decomposition of aggregate hourly wage growth suggests that the between component has had a negligible effect (see Maliranta, 2001a). This is to say that those plants that expanded their labour input share usually did not seem to have above-average skills-levels, supposing that skills levels can be gauged by wage levels. All in all, the role of skills in the creative destruction process deserves further analysis in the future.

References

Acemoglu, D. (1996), 'A Microfoundation for Social Increasing Returns in Human Capital', Quarterly Journal of Economics, 111, 779-804.

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

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

van Ark, B., and Pilat, D., (1993), 'Productivity Levels in Germany, Japan, and the United States: Differences and Causes', Brookings Papers: Microeconomics 2, 1993, 1-69.

Bala, V., and Goyal, S. (1998), 'Learning from Neighbours', Review of Economic Studies (1998) 65, 595-621.

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

Bassanini, A. Scarpetta, S., and Hemmings P. (2001), 'Economic Growth: the Roles of Policies and Institutions. Panel Data Evidence from OECD Countries', OECD, Economics Department Working Papers No. 283.

Benhabib, J., and Spiegel, M. (1994), 'The role of human capital in economic development — evidence from aggregate cross-country data', Journal of Monetary Economics 34, 143-173.

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, 1929-35', Journal of Political Economy, vol. 104, No 2, 241-266.

Bertola, G., and Caballero, R. (1994), 'Irreversibility and Aggregate Investment', Review of Economic Studies (1994) 61, 223-246.

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.

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. (1996), 'On the Timing and Efficiency of Creative estruction', Quarterly Journal of Economics, 111(3), 805-852.

Caballero, R. J., and Hammour, M. L. (1996), 'On the lls of Adjustment', Journal of Development Economics, 51 (1), 161-192.

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

Cameron, G., Proudman, J., and Redding, S. (1999), 'Technology Transfer, R&D, Trade and Productivity Growth', CEP Discussion Paper 428, 1999.

Campbell, J. R. (1997), 'Entry, exit, technology, and business cycles', NBER Working Paper No. 5955, 1997.

Campbell, J. R., and Fisher, J. D. M. (1998), 'Organisational flexibility and employment dynamics at young and old plants', NBER Working Paper No. 6809.

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

Cohen, W. M. (1995), 'Empirical Studies of Innovative Activity", in (P. Stoneman, ed.), 'Handbook Innovation and Technological Change', Oxford: Blackwell.

Cooper, R., Haltiwanger, J. and Power, L. (1999), 'Machine Replacement and the Business Cycle: Lumps and Bumps', American Economic Review 89 (4): 921-46.

David, P. A. (1990), 'The dynamo and the computer: an historical perspective on the productivity paradox', American Economic Review, Papers and Proceedings, Vol. 80, 315-48.

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., and Haltiwanger, J. (2000), 'Wage and Productivity Dispersion in U.S. Manufacturing: The Role of Computer Investment', NBER Working Paper No W7465.

Ericson, R., and Pakes, A. (1995), 'Markov perfect industry dynamics: a framework for empirical analysis', Review of Economic Studies, Vol. 62, No. 1., 53-82.

Erixon, L. (2000), 'The Third Way' Revisited. A Revaluation of the Swedish Model in the Light of Modern Economics', Trade Union Institute for Economic Research FIEF, Working Paper Series 2000, No. 159.

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

Foster, Haltiwanger, and Krizan, (2000), 'Aggregate Productivity Growth: Lessons from Microeconomic Evidence', in Hulten, C. R., Dean, E. R., and Harper, M. J. (eds.), 'New Developments in Productivity Analysis', Chicago: University of Chicago Press (for NBER).

Greenwood, J., and Jovanovic, B. (2000), 'Accounting for growth', in Hulten, C. R., Dean, E. R., and Harper, M. J. (eds.), 'New Developments in Productivity Analysis', Chicago: University of Chicago Press (for NBER).

Griffith, R., Redding, S., and van Reenen, J. (2000), 'Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Countries', Centre for Economic Policy Research CEPR, Discussion Paper Series, No. 2457.

Guellec, D., and Van Pottelsberghe de la Potterie, B. (2001), 'R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries, OECD STI Working Papers 2001/3.

Gustavsson, P., Hansson, P., and Lundberg, L. (1999), 'Technology, Resource Endowments and International Competitiveness', European Economic Review 43 (1999), 1501-1530.

Haltiwanger, J. C., Lane, J. I., and Spletzer, J. R. (1999), 'Productivity Differences Across Employers: The Role of Employer Size, Age, and Human Capital', American Economic Review Papers and Proceedings, 94-98.

Haskel, J., and Sanchis, A. (2000), 'A Bargaining Model of Farrell Inefficiency', International Journal of Industrial Organisation, 18, 539-556.

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.

Hicks, J. (1935), 'Annual Survey of Economic Theory: The Theory of Monopoly', Econometrica 3, 1-20.

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

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.

Jovanovic, B. (1982), 'Selection and the Evolution of Industry', Econometrica, 50(3), 1982, 649-670.

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.

Klette, T. J., and Johansen, F. (1998), 'Accumulation of R&D capital and dynamic firm performance: a not-so-fixed effect model', Annales d'Economie et de Statistique, No. 49/50, 389-419.

Krueger, A. B., and Lindahl, M. (1999), 'Education for Growth in Sweden and the World', Swedish Economic Policy Review 6, 289-339.

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

Leiponen, A. (1995), 'Inhimillinen pääoma suomalaisissa yrityksissä', The Research Institute of the Finnish Economy ETLA, Series C71, Helsinki. (in Finnish)

Leiponen, A. (2000), 'Why do firms not collaborate? Competencies, R&D collaboration, and innovation under different technological regimes', Ch. 4 in Leiponen, A., 'Essays in the economics of knowledge: innovation, collaboration and organisational complementarities', The Research Institute of the Finnish Economy ETLA, Series A31, Helsinki. Forthcoming in Kleinknecht, A. and Mohnen, P. (eds.), 'Innovation and economic change. Macmillan, London.

Lerner, J. (1997), 'An empirical exploration of a technology race', RAND Journal of Economics Vol. 28, No. 2, Summer 1997, 228-247.

Lloyd-Ellis, H. (1999), 'Endogeneous Technological Change and Wage Inequality', The American Economic Review, March 1999, 47-77.

Mairesse, J., and Kremp, E. (1993), 'A look at productivity at the firm level in eight French service industries', Journal of Productivity Analysis 4, 211-234.

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

Maliranta, M. (1997), 'Suomen, Yhdysvaltojen ja Ruotsin metalliteollisuuden tuottavuusvertailu (A comparison of productivity between Finland, the United States and Sweden in metal industry)' in MET and McKinsey&Company, 'Metalliteollisuuden tuottavuus kansainvälisestä näkökulmasta (An international perspective on productivity in metal industry', Metalliteollisuuden Keskusliitto MET, Helsinki.

Maliranta, M. (2000), 'Job Creation by Supporting Technology Advances? Evidence from Finnish plants', in Asplund, R. (Ed.), 'Public R&D Funding, Technological Competitiveness, Productivity, and Job Creation', The Research Institute of the Finnish Economy, B 168 Series.

Maliranta M. (2001a), 'Funktionaalisen tulonjaon muutos toimipaikkatasolla', Kansantaloudellinen aikakauskirja, 3/2001, 398-407. (in Finnish)

Maliranta, M. (2001b), 'Productivity Growth and Micro-Level Restructuring. Finnish Experiences during the Turbulent Decades', The Research Institute of the Finnish Economy ETLA, Discussion Papers No. 757.

Pakes, A., and Schankerman, M. (1984), 'An Exploration into the Determinants of Research Intensity', in (Z. Griliches, ed.), 'R&D, Patents and Productivity', Chicago: Chicago University Press.

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

Sener, F. (2001), 'Schumpeterian Unemployment, trade and wages', Journal of International Economics 54 (2001) 119-148.

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

Stein, Jeremy, C. (1997), 'Waves of Creative Destruction: Firm-Specific Learning-by-Doing and the Dynamics of Innovation', Review of Economic Studies, 64, 265-288.

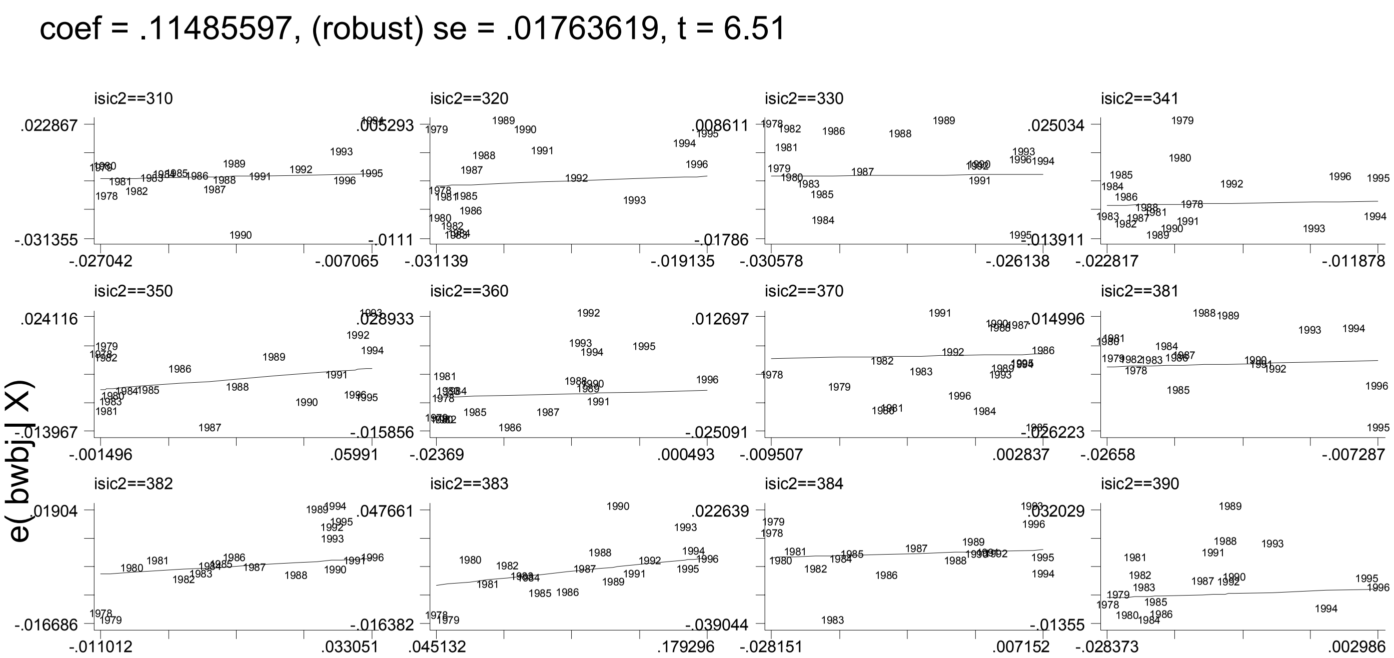
Stigler, G. (1947), 'Trends in output and employment, New York : Herald Square Press (for NBER), 1947

Thesmar, D., and Thoenig, M. (2000), 'Creative Destruction and Firm Organizational Choice', The Quarterly Journal of Economics, November 2000.

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

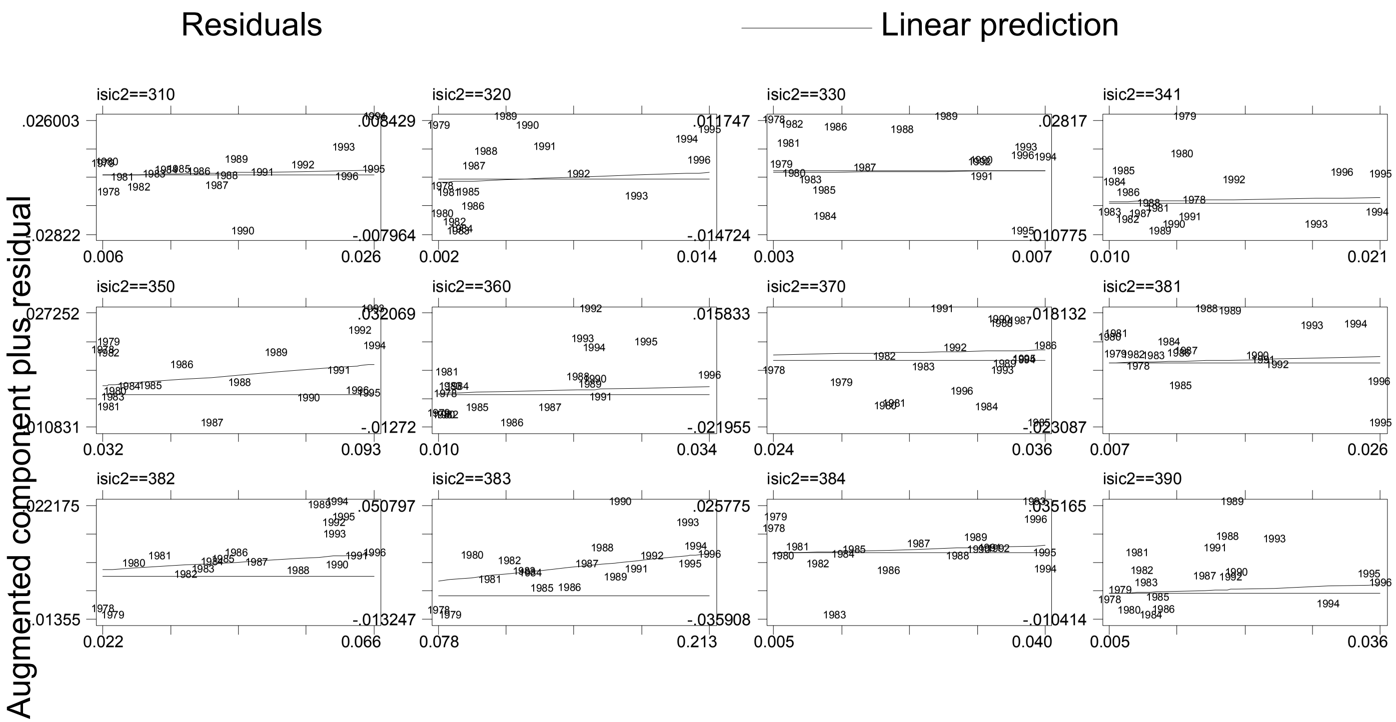
APPENDIX

Graph A6.1a. Added-variable plot for rdav2_5-variable



Note: see text.

Graph A6.1b. Augmented component-plus plot for rdav2_5 variable



Note: see tex

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