ETLA

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

Keskusteluaiheita – Discussion papers

No. 1168

Mika Maliranta* – Tuomo Nikulainen**

LABOUR FLOW PATHS AS INDUSTRY LINKAGES: A PERSPECTIVE ON CLUSTERS AND INDUSTRY LIFE CYCLES

* ETLA

** ETLA/Etlatieto Oy

Corresponding author: Mika Maliranta, ETLA (The Research Institute of the Finnish Economy), Lönnrotinkatu 4 B, 00120 Helsinki, Finland.
Phone: +358 9 6099 0219. Fax: +358 9 601753. E-mail: mika.maliranta@etla.fi

ACKNOWLEDGEMENTS: We thank Pekka Ilmakunnas and Pekka Ylä-Anttila for insightful comments, and Anni Nevalainen for excellent ground work. The usual disclaimer applies. The research is a part of ETLA's "*Finland in Global Competition*" project. This study makes extensive use of data tabulations computed at Statistics Finland in the context of a joint project involving Helsinki School of Economics (HSE), Statistics Finland and ETLA that is funded by the Academy of Finland (project 114827).

ISSN 0781-6847 08.12.2008

MALIRANTA, Mika – **NIKULAINEN**, Tuomo, **LABOUR FLOW PATHS AS INDUSTRY LINKAGES: A PERSPECTIVE ON CLUSTERS AND INDUSTRY LIFE CYCLES.** Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2008, 18 p. (Keskusteluaiheita, Discussion papers, ISSN 0781-6847; No. 1168).

ABSTRACT: We make several findings related to the dynamics of labour markets and industry life cycles in our analysis, which makes use of longitudinal employer-employee data that cover the whole working age population in Finland. Firstly, we find that across industry transitions of the employed are common. Secondly, employment transitions portray a network of industry linkages where specific industry clusters can be identified, as well as labour flow paths with long backward and forward linkages. Thirdly, most of the upstream labour mobility linkages are end up in the education industry, which thus seems to be an "ancestor" of the most of the industries. On the other hand, we find eight totally isolated industries that had no distinct backward or forward linkages in the labour markets. Finally, we show that the labour flows are a significant indicator for industry life cycles.

JEL-codes: J23; J63; L16

Keywords: Employment transitions, industry clusters, industry life cycle

MALIRANTA, Mika – **NIKULAINEN**, Tuomo, **LABOUR FLOW PATHS AS INDUSTRY LINKAGES: A PERSPECTIVE ON CLUSTERS AND INDUSTRY LIFE CYCLES.** Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2008, 18 s. (Keskusteluaiheita, Discussion papers, ISSN 0781-6847; No. 1168).

TIIVISTELMÄ: Tutkimuksessa teemme useita työmarkkinoiden dynamiikkaa ja toimialojen elinkaarta koskevia havaintoja käyttämällä yhdistettyä työntekijät-työnantaja–paneelia, joka kattaa Suomen koko työikäisen väestön. Ensiksi, havaitsemme, että työllisten siirtymät toimialojen välillä ovat yleisiä. Toiseksi, näistä siirtymistä hahmottuu toimialalinkkien verkosto, josta voidaan tunnistaa erityisiä toimialaklustereita sekä työntekijävirtapolkuja pitkine linkkeineen sekä eteen- että taaksepäin. Kolmanneksi, useimpien polkujen yläpäässä on koulutuksen toimiala, joka on siis eräänlainen useimpien toimialojen "kantaäiti". Toisaalta tunnistamme kahdeksan täysin eristynyttä toimialaa, joilla ei ole linkkejä ylös- eikä alaspäin. Lopuksi, työntekijävirtojen todetaan olevan tärkeä toimialojen elinkaaren indikaattori.

JEL-koodit: J23; J63; L16

Avainsanat: työllisten siirtymät; toimialaklusterit; toimialan elinkaari

1. Introduction

Rapidly increasing literature on labour mobility has shown that the intensity and the patterns of worker flows have important implications not only for the labour markets, but also for the productivity growth and overall industrial renewal in general. Worker mobility is a part of the productivity-enhancing restructuring, or the "creative destruction", that has been found to have a crucial role to play in Finland (Maliranta, 2003) and many other countries (see e.g. OECD, 2003). Furthermore, employment mobility constitutes a channel for knowledge and technology diffusion between academia, firms and industries, a point frequently emphasised ever since the seminal contribution by Arrow (1962, page 615).

The focus in this study is, in addition to measuring the intensity of inter-industry labour mobility, in establishing the employment transition linkages (or labour flow paths) between industries. We examine the directions of the labour flows, that is, from where to where the transitions are made, as well as the strength of these linkages, that is, how common it is in relative terms that a worker in an industry moves to a different industry (or to non-employment). These aspects are then reflected in the discussion of labour market shocks and industry life cycles, where the entry and exit of workers is a significant indicator of the growth and decline of industries.

By using rich longitudinal employer-employee data that in principle covers the whole working age population (16-70 years old) in Finland several findings have been made about the dynamics of labour markets. Firstly, the same observation made in some earlier studies has been made that across industry transitions of the employed are common. 17.2% of the workers in 2000 had moved to another of the 38 industries in the economy by 2004. This flow is bigger than the flow to the non-employment, which is 14.6% over the period 2000-2004. Secondly, relatively strong linkages between some industries have been identified. Thirdly, employment transitions portray a network of industry linkages where specific industry clusters can be relatively easily identified, as well as labour flow paths with long backward and forward linkages. Most of the upstream labour mobility linkages end up in the education industry (NACE 80), which thus seems to be some kind of an "ancestor" for most of the industries. On the other hand, eight totally isolated industries (e.g. agriculture and forestry, public administration, and health and social services) were found that had no distinct backward linkages or forward linkages in the labour markets (except possibly a downstream linkage to non-employment).

This analysis contributes to the literature by showing the "closeness" and interaction of the different industries from the perspective of labour markets. In existing research the hierarchy and delineations of the industries in the standard industry classification schemes are constructed on the basis of final goods. There is a wide literature looking at the backward and upward linkages between industries by using input-output tables. This literature analyses how much intermediate inputs a certain industry receives from other industries and how much intermediate input it delivers to other industries. This approach has been used to analyse how tangible technology inputs, and thereby productivity effects, are transmitted between industries in the course of economic growth (see e.g. Domar, 1961; Jorgenson et al., 1987; Oulton, 2001; Daveri & Silva, 2004). The input-output tables have also been used to identify industry clusters in the analysis of competitive advantages (see e.g. Feser & Bergman, 2000; Hill & Brennan, 2000). Though the purpose of these studies is to examine the links between industries based on output and input flows, the role of labour input is essentially bypassed.

Ignoring industry linkages (and clusters) based on human capital is potentially a serious shortfall, not least because arguably labour embodies productive intangible capital that is increasingly important as a factor of economic growth (Corrado et al., 2005). To give an example, the analysis by Daveri and Silva (2004) suggests that "Nokia industry" (i.e. the manufacture of telecommunication equipment) has not had important productivity spillover effects in the other industries (in the IT-related service industries, for example). One strand of the argument is the weak inter-industry linkages according to the input-output tables between the Nokia industry and the rest of the Finnish economy in the 1990s. However, the present results show a relatively strong upstream labour flow link from the Nokia industry through the research industry up to the education industry. In addition, interesting and important downstream links through the computer service industry to the telecommunication and business service industries (and still further) are also found. The downstream industries of the Nokia industry arguably have an important direct and indirect role to play in the future economic growth. Thus this study complements the earlier analysis of Nokia's role in the economy by looking at the employment transitions and the associated spread of know-how in the economy.

The Finnish labour mobility has been studied by Ilmakunnas and Maliranta (2002) who examined the sources of worker inflows and the destinations of worker outflows in the Finnish business sector in 1988-1996. It was found that roughly one third of the annual labour mobil-

ity takes place within the 2-digit industries and the same proportion flows across the 2-digit industries. The remaining one third of flows includes unemployment, schooling etc.[1] More recently, Frederiksen and Westergaard-Nielsen (2007) examine the destinations of the employment transitions and, in particular, the cyclicality and other determinants of these shifts in the Danish private sector in greater detail. One more study examining across-industry worker reallocation is by Golan et al. (2007), which finds, among other things, that workers who had previously made a move across industries have a high propensity to do so in the future. Neal (1999; 2004) associates a sectoral transition of a worker with a career change, which, following the terminology by Parnes (1954), is a complex job shift as distinct from a simple shift involving firm-to-firm transitions within sectors. If the industry transitions are interpreted as career shifts, like Parnes (1954) or Neal (1999), the results suggest that some shifts are clearly more complex than others.

Identification of salient labour flow paths between industries is useful for recognising how a labour demand shock in an industry is likely to be transmitted as labour supply shocks to its downstream industries. This is also an issue of great interest when trying to anticipate how industry life cycles are mutually coupled. The value of the "knowledge inheritance" of declining industries for the new growing industries is likely to vary a lot. Human capital, which has developed from the manufacture of telecommunication equipment, may provide a more solid stepping stone for the new growing industries than the human capital left behind from the manufacture of textiles and clothing or paper and pulp, for example.

The labour market shocks can be seen as indicators of industry life cycles, where labour entry to an industry indicates a growing industry and labour exit suggests a declining industry. Traditionally industry life cycles have been analysed through firm entry and exit (e.g. Klepper, 1996, 1997) and by studying high growth firms (for discussion of Finnish high growth firms see Deschryvere, 2008). The present results show that in some industries the total employment is declining while at the same time there is a significant labour flow into these industries. For example, the electrical and telecommunication equipment and the pulp and paper industries have a declining total employment in the period of this analysis, while at the same

[1] Ilmakunnas and Maliranta (2002) found some specific cyclical patterns in the labour mobility. The proportion of inter-industry labour mobility exhibits clear pro-cyclical and unemployment flows in counter-cyclical patterns whereas the proportion of intra-industry mobility is reasonably stable over business fluctuations.

time they have a relatively strong link to other upstream industries. This finding shows that aggregate industry level measures may hide important aspects of micro-structural change. An obvious explanation for this finding is that these aggregated industry classifications in fact consist of several different industries, where industry life cycles are in different phases.

2. Data description

This study uses the Finnish longitudinal employer-employee data (FLEED) that is constructed in Statistics Finland by linking various administrative registers on the individuals and firms that practically cover all working age individuals (16-70 years) and firms. The data are described in various different studies (see e.g. Korkeamäki & Kyyrä, 2000; Ilmakunnas et al., 2001; Maliranta & Nurmi, 2004). Here the focus is on some main aspects relevant to the current analysis.

In this study an individual's employment is defined on the basis of the main activity during the year. In practice this means that the employed have been employed usually at least 6 months during the year. The analysis covers also the self-employed. Part-time workers and some outliers have been eliminated by imposing minimum and maximum thresholds for the average monthly earnings.[2] In this analysis the focus is on the employment transitions between 2000 and 2004. The number of the employed persons in the data with the definitions described above is 2.04 and 2.07 millions in 2000 and 2004, respectively. In other words, this is a period of moderate employment growth (1.6%).[3]

The industry group for the individuals employed is determined based on the main employer during the year. Basically the 2-digit industry NACE classification has been adopted with some exceptions. Some industries have been combined for practical reasons and on the basis of the findings of the experimentations. On some occasions, however, there is a need to go deeper. This is the case with NACE 74 industry that has been split into three parts (see Table 1).

---

[2] In year 2000 the minimum and maximum thresholds are 715 and 13 408 euro per month, respectively. The corresponding numbers in year 2004 are 815 and 15 652 euro.

[3] According to the National Accounts of the Statistics Finland the number of people engaged (employees and entrepreneurs) was 2.30 and 2.37 millions in 2000 and 2004, respectively (growth 3.0%). The differences in these figures reflect differences in the employment concept, for example.

TABLE 1: Industry classification

NACE	NACE definition	Abbreviation
1-5	Agriculture, hunting and forestry; Fishing	Agriculture & forestry
10-14	Mining and quarrying	Mining
15-16	Manufacture of food products, beverages and tobacco	Food & tobacco
17-19	Manufacture of textiles and textile products; Manufacture of leather and leather products	Textiles & leather
20	Manufacture of wood and wood products	Wood products
21	Manufacture of pulp, paper and paper products	Pulp & paper
221	Publishing	Publishing
22x	Printing and service activities related to printing; Reproduction of recorded media	Printing and recording
23	Manufacture of coke, refined petroleum products and nuclear fuel	Energy sources
24	Manufacture of chemicals and chemical products	Chemicals
25	Manufacture of rubber and plastic products	Plastics
26	Manufacture of other non-metallic mineral products	Other non-metal
27	Manufacture of basic metals	Basic metals
28	Manufacture of fabricated metal products, except machinery and equipment	Metal products
29	Manufacture of machinery and equipment n.e.c.	Machinery
30-31	Manufacture of office machinery and computers; Manufacture of electrical machinery and apparatus	Electrical machinery
32-33	Manufacture of radio, television and communication equipment and apparatus; Manufacture of medical, precision and optical instruments, watches and clocks	Telecommunication equipment
34	Manufacture of motor vehicles, trailers and semi-trailers	Vehicles
35	Manufacture of other transport equipment	Other transport
36-37	Manufacture of furniture; manufacturing n.e.c.; Recycling	Furniture & recycling
40-41	Electricity, gas and water supply	Energy production
45	Construction	Construction
50-52	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	Trade & repair
55	Hotels and restaurants	Hotels & restaurants
60-63	Land transport; transport via pipelines; Water transport; Air transport; Supporting and auxiliary transport activities; activities of travel agencies	Transport & travel
64	Post and telecommunications	Post and telecommunications
65-67	Financial intermediation	Financial services
70	Real estate activities	Real estate
71	Renting of machinery and equipment without operator and of personal and household goods	Leasing
72	Computer and related activities	Computer services
73	Research and development	R&D
741	Legal, accounting, book-keeping and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy activities	Business services
742-3	Architectural and engineering activities and related technical consultancy; Technical testing and analysis	Technical services
744-8	Advertising; Labour recruitment and provision of personnel; Industrial cleaning; Miscellaneous business activities n.e.c.	Other services
75	Public administration and defence; compulsory social security	Public administration
80	Education	Education
85	Health and social work	Health and social work
90-93	Other community, social and personal service activities	Other social services

3. Identification of labour flow linkages by employment transitions

The employment transitions between 2000 and 2004 are examined. A 38 X 39 transition matrix is created, where each cell l_{ij} gives the number of people who worked in industry i ($i = 1, 2, ..., 38$) in 2000 and were in destination j ($j = 1, 2, ..., 39$) in 2004. The final 39th destination is the non-employment. A labour outflow matrix (38 X 39) is derived that consists of the coefficients:

$$x_{ij} = \frac{l_{ij}}{\sum_{j=1}^{j=39} l_{ij}} \quad (1)$$

The coefficient indicates the proportion of workers in destination j ($j = 1, 2, ..., 39$) in 2004 by industry group i ($i = 1, 2, ..., 38$) in 2000.

The interest is in the propensity of a worker in a job in industry *i* to make a move to a job in industry *j* relative to other alternatives. To this end the fact that the number of jobs (or positions) varies between the destinations needs to be taken into account. In order to derive a suitable measure for the relative transition probability from industry i to destination *j* the elements of labour outflow matrix, that is, x_{ij}, need to be proportioned to the relative size of destination j in 2004. The size of each industry destination is the number of jobs in 2004 that is l_j when $j \neq 39$. The size of the non-employment destination is defined here as the number of workers that worked in 2000 but do not work in 2004, more formally $l_{39} = \sum_{i=1}^{i=38} l_{i,39}$. The relative size of destination *j* is measured by labour share (*lsh)*:

$$lsh_j = \frac{l_j}{\sum_{j=1}^{j=39} l_j} \quad (2)$$

By using (1) and (2) the ratio of the relative transition probability (*rtp*) between industry i and destination *j* can now be derived:

$$rtp_{ij} = \frac{x_{ij}}{lsh_j} \quad (3)$$

It measures the probability for a worker in industry i to switch to destination j relative to all alternatives on average. For each industry i the average relative transition probability over all 39 destination (weighted by the size of the destination) is one, that is, $\sum_{j=1}^{j=39} lhs_j \cdot rtp_{ij} = 1$ for all $i = 1,...,38$. If all workers of 2000 are randomly distributed to the positions (including non-employment) in 2004 the expected relative transition probability is one in all cases, that is, $E\left(rtp_{ij}\right) = 1$ for all i ($i = 1,2,...,38$) and j ($j = 1,2,...,39$).

4. Empirical analysis

The following presents the different dimensions of the analysis and highlights some key descriptive statistics. Table 2 summarises results for the labour mobility within the same industry, to non-employment and to other industries, and indicates the most important destinations both in absolute (shares) as well as in relative terms. In addition, the total employment (in 2000) and the employment growth (from 2000 to 2004) are reported for each industry.

As shown in the bottom line of Table 2, 68.2% of the people stayed in the same industry four years later.[4] This proportion varies substantially between industries. The largest "stayer" shares can be found in the health and social work, and the pulp and paper industry. The industries of low stayer shares include the business services, leasing, and hotel and restaurant industries. The share of employed who made an industry switch is 17.2 %, which is higher in the same industries where the stayer share is low, that is, in the business services (39.7%), leasing (33.8%), and hotel and restaurant (28.8%) industries. The remaining 14.6% of the employed have made a transition to the non-employment.

[4] In a related study, Maliranta (2008) finds that in the Finnish Business Sector 54.1% of the employees in 2000 stayed in the same establishment in 2004. Although the coverage of Maliranta's (2008) study is somewhat different from this study, which also covers the public sector, the results of these two studies together imply that there is a substantial amount of both intra and inter industry mobility within a 4-year window.

TABLE 2: Labour flows

NACE	Abbreviation	*Same industry*	*Non-employment*	***Other industry***	***Most important destination (lsh)***	***Relative to industry size(rtp)***	***Employment in 2000, 000s***	***Employment growth, %***
1-5	Agriculture & forestry	72.9	16.5	10.6	90-93 (1.4)	10-4 (0.5)	100.7	-11.9
10-14	Mining	62.4	14.1	23.5	45 (6.1)	26 (2.0)	4.3	0.7
15-16	Food & tobacco	66.6	14.5	18.9	50-52 (4.6)	20 (0.5)	38.6	-3.4
17-19	Textiles & leather	61.6	20.2	18.2	50-52 (5.0)	25 (0.7)	15.6	-18.5
20	Wood products	69.5	13.9	16.6	45 (2.7)	36-7 (1.6)	27.8	-4.4
21	Pulp & paper	76.7	13.7	9.6	29 (2.8)	29 (1.2)	35.3	-8.9
221	Publishing	62.2	14.8	22.9	22x (3.3)	22x (5.8)	16.4	-6.4
22x	Printing and recording	69.0	15.9	15.0	50-52(2.2)	221 (2.6)	14.5	-8.3
23	Energy sources	66.7	12.2	21.1	60-63 (7.4)	60-63 (1.5)	2.2	31.6
24	Chemicals	70.8	12.9	16.2	50-52 (4.8)	73 (1.5)	17.3	-2.0
25	Plastics	61.6	12.7	25.7	30-33 (7.8)	30-33 (3.0)	17.9	-9.5
26	Other non-metal	71.4	12.3	16.3	45 (3.0)	10-4 (3.3)	15.2	-3.6
27	Basic metals	75.5	14.3	10.3	45 (1.8)	28 (1.1)	15.4	-0.2
28	Metal products	64.3	14.4	21.3	29 (4.4)	29 (1.8)	38.4	0.3
29	Machinery	68.9	11.4	19.7	28 (3.8)	28 (2.3)	56.2	1.3
30-31	Electrical machinery	60.9	15.4	23.7	32-33 (4.4)	32-33 (2.3)	17.3	-9.1
32-33	Telecommunication equipm.	65.5	12.4	22.1	72 (3.3)	30-31 (2.8)	48.0	-4.0
34	Vehicles	62.8	14.1	23.0	50-52 (6.1)	28 (1.9)	7.5	-11.5
35	Other transport	65.0	18.6	16.4	45 (2.8)	28 (0.9)	13.7	-15.2
36-37	Furniture & recycling	62.7	15.6	21.8	50-52 (4.3)	20 (1.8)	16.3	-6.8
40-41	Energy production	61.5	14.0	24.5	45 (4.5)	23 (9.4)	15.1	-19.7
45	Construction	68.9	15.7	15.5	50-52 (1.9)	71 (1.1)	118.5	3.3
50-52	Trade & repair	66.1	14.3	19.6	60-63 (2.2)	71 (0.7)	249.5	2.7
55	Hotels & restaurants	54.0	17.2	28.8	50-52 (7.6)	744-8 (1.2)	60.6	5.9
60-63	Transport & travel	73.7	13.5	12.8	50-52 (2.1)	23 (2.8)	111.2	3.6
64	Post and telecommunications	62.6	16.0	21.4	50-52 (3.2)	72 (1.4)	42.7	3.3
65-67	Financial services	75.9	12.6	11.4	72 (1.7)	72 (1.1)	43.6	-2.5
70	Real estate	58.9	16.9	24.3	45 (3.4)	744-8 (0.9)	31.7	9.1
71	Leasing	51.0	15.2	33.8	50-52 (7.6)	45 (1.1)	3.3	34.9
72	Computer services	64.6	10.6	24.8	50-52 (3.9)	741 (1.8)	34.4	10.5
73	R&D	58.6	11.6	29.8	30-33 (8.4)	23 (4.5)	15.1	-5.7
741	Business services	46.2	14.1	39.7	50-52 (5.3)	23 (7.6)	30.5	-12.2
742-3	Technical services	67.3	11.3	21.4	45 (2.9)	29 (0.9)	46.8	1.5
744-8	Other services	47.5	19.1	33.3	50-52 (5.4)	70 (1.5)	65.4	23.0
75	Public administration	70.7	13.5	15.8	85 (5.2)	85 (0.4)	120.9	1.4
80	Education	71.9	13.5	14.6	85 (2.8)	73 (1.3)	141.2	4.0
85	Health and social work	77.9	14.6	7.6	75 (1.6)	75 (0.3)	294.3	5.8
90-93	Other social services	63.0	17.5	19.5	85 (2.8)	221 (0.7)	98.8	4.6
Average		65.3	14.5	20.2				-0.2
Wgh. aver.		68.2	14.6	17.2				1.6

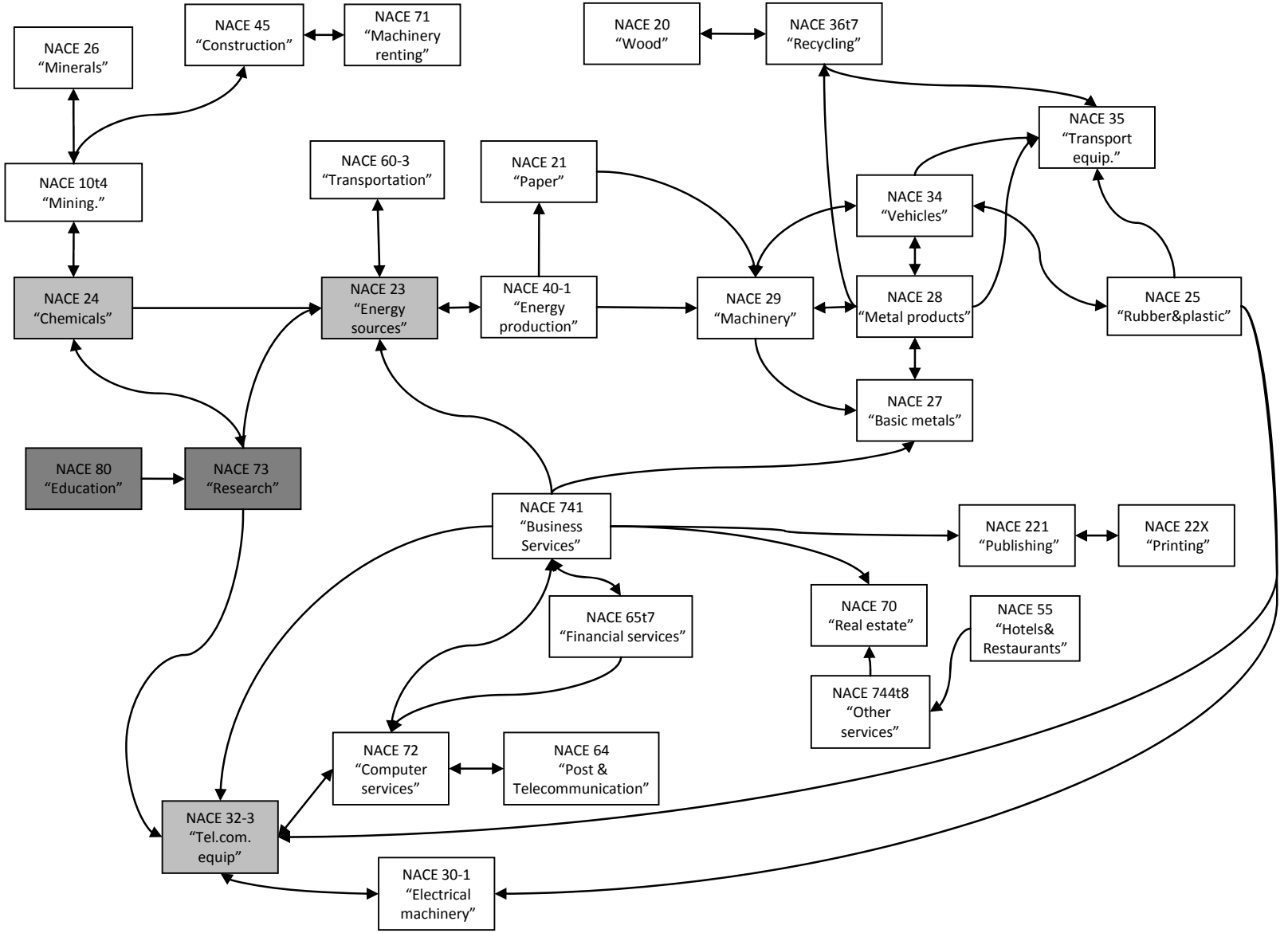
The third column of Table 2 indicates the most important destination industry (excluding the current industry and the non-employment). It is not surprising that the trade and repair industry is a significant destination industry for a large number of the industries. This can be largely explained by the large size of this service-orientated industry (the employment share is 12.4% of the total for 2004). To control for the potential impact of the different industries, the relative transition probability was used (see equation (3)) as an indicator of the closeness of each industry pairs. The fourth column of Table 2 reports the closest destination industry (and the value of *rtp* in parenthesis). The results indicate that most industries have at least one relatively close destination industry. If the ratio is above one, it means that this transition is more probable than the other alternatives on average (including staying in the same industry and making a transition to the non-employment). In all cases the most probable case by a wide margin is, as expected, that the person will stay in the same industry in both periods. For some industries the second common destination (after staying) is a transition to non-employment (e.g. food and tobacco, textiles and leather, and public administration). The fifth and sixth columns of Table 2 report the total employment and the employment growth rate by industry.

The matrix of the relative transition probabilities is reported Table 3. The focus is on the occasions when the relative transition probability from one industry to another is relatively high. As the patterns of the relative transition probabilities between the pairs of industries are somewhat difficult to discern from the numeric presentation, Table 3 is followed by Figure 1, which shows all the transition linkages between the pairs of industries where the *rtp* indicator is higher than one.

TABLE 3. Matrix of the relative transition probabilities

2000\2004	1t5	10t4	15a6	17t9	20	21	221	22x	23	24	25	26	27	28	29	30t1	32t3	34	35	36a7	40a1	45	50t2	55	60t3	64	65t7	70	71	72	73	741	742a3	744t8	75	80	85	90t3	A_out
1t5	**20**	0.50	0.21	0.12	0.31	0.12	0.06	0.03	0.02	0.04	0.10	0.12	0.04	0.12	0.09	0.05	0.02	0.11	0.07	0.14	0.09	0.21	0.12	0.10	0.17	0.08	0.10	0.13	0.12	0.04	0.18	0.11	0.07	0.10	0.14	0.09	0.09	0.32	**1.31**
10t4	0.78	**343**	0.06	0.00	0.23	0.07	0.04	0.08	0.38	**1.11**	0.07	**1.97**	0.62	0.29	0.48	0.04	0.01	0.34	0.05	0.33	0.32	**1.17**	0.15	0.04	0.81	0.06	0.10	0.18	0.25	0.04	0.31	0.10	0.23	0.08	0.08	0.06	0.03	0.18	**1.13**
15a6	0.18	0.20	**42**	0.14	0.16	0.11	0.14	0.13	0.23	0.45	0.25	0.22	0.07	0.15	0.35	0.16	0.10	0.21	0.15	0.19	0.16	0.17	0.42	0.41	0.34	0.16	0.11	0.31	0.35	0.10	0.22	0.42	0.10	0.40	0.13	0.11	0.13	0.15	**1.16**
17t9	0.13	0.18	0.25	**115**	0.21	0.08	0.12	0.27	0.00	0.25	0.69	0.26	0.21	0.30	0.25	0.20	0.19	0.37	0.09	0.61	0.08	0.12	0.46	0.16	0.10	0.13	0.06	0.51	0.14	0.09	0.04	0.16	0.08	0.34	0.07	0.14	0.16	0.24	**1.60**
20	0.28	0.91	0.15	0.17	**62**	0.28	0.04	0.09	0.06	0.11	0.35	0.50	0.17	0.48	0.28	0.14	0.07	0.48	0.35	**1.63**	0.27	0.53	0.19	0.08	0.26	0.08	0.06	0.31	0.19	0.08	0.05	0.35	0.21	0.20	0.11	0.06	0.05	0.09	**1.11**
21	0.04	0.03	0.06	0.21	0.19	**57**	0.06	0.52	0.07	0.25	0.66	0.14	0.10	0.07	**1.16**	0.08	0.14	0.09	0.05	0.04	0.98	0.07	0.08	0.03	0.08	0.05	0.05	0.05	0.06	0.09	0.63	0.20	0.12	0.07	0.04	0.05	0.02	0.05	**1.09**
221	0.04	0.07	0.07	0.06	0.07	0.01	**96**	**5.82**	0.05	0.09	0.14	0.05	0.08	0.04	0.04	0.06	0.11	0.02	0.04	0.11	0.11	0.08	0.25	0.20	0.11	0.58	0.32	0.26	0.33	0.76	0.17	0.78	0.10	0.85	0.17	0.28	0.10	0.67	**1.18**
22x	0.04	0.04	0.15	0.18	0.14	0.25	**2.64**	**123**	0.17	0.14	0.24	0.06	0.04	0.16	0.12	0.17	0.09	0.05	0.11	0.05	0.04	0.12	0.21	0.09	0.14	0.16	0.14	0.21	0.45	0.45	0.09	0.44	0.15	0.57	0.11	0.11	0.07	0.16	**1.27**
23	0.02	0.00	0.03	0.00	0.00	0.03	0.14	0.00	**537**	0.81	0.00	0.00	0.00	0.08	0.15	0.00	0.16	0.00	0.18	0.00	**1.40**	0.03	0.66	0.00	**1.53**	0.12	0.07	0.06	0.24	0.67	0.30	0.20	0.38	0.11	0.08	0.04	0.01	0.02	0.98
24	0.03	**1.14**	0.28	0.15	0.11	0.20	0.09	0.23	**1.02**	**99**	0.49	0.27	0.25	0.15	0.27	0.18	0.26	0.19	0.12	0.48	0.21	0.11	0.44	0.06	0.13	0.09	0.09	0.18	0.22	0.23	**1.50**	0.34	0.24	0.18	0.07	0.11	0.08	0.10	**1.03**
25	0.07	0.18	0.17	0.58	0.31	0.71	0.07	0.39	0.18	0.88	**90**	0.34	0.24	0.72	0.93	**1.72**	**3.44**	**1.15**	**1.10**	0.65	0.13	0.23	0.26	0.09	0.16	0.10	0.07	0.21	0.30	0.16	0.09	0.17	0.15	0.22	0.11	0.09	0.07	0.11	**1.01**
26	0.13	**3.30**	0.14	0.09	0.47	0.14	0.06	0.07	0.11	0.23	0.55	**116**	0.31	0.34	0.44	0.28	0.10	0.31	0.32	0.72	0.13	0.58	0.17	0.08	0.23	0.09	0.07	0.30	0.71	0.06	0.04	0.50	0.25	0.19	0.08	0.06	0.04	0.11	0.98
27	0.04	0.22	0.06	0.05	0.07	0.05	0.05	0.03	0.16	0.26	0.19	0.15	**117**	**1.05**	0.40	0.18	0.11	0.26	0.29	0.57	0.14	0.35	0.10	0.06	0.09	0.04	0.01	0.07	0.11	0.09	0.14	0.09	0.18	0.09	0.06	0.05	0.02	0.03	**1.14**
28	0.13	0.39	0.12	0.17	0.25	0.12	0.05	0.15	0.06	0.24	0.89	0.51	**1.25**	**40**	**1.84**	0.66	0.56	**1.04**	**1.21**	**1.13**	0.21	0.60	0.19	0.08	0.18	0.08	0.07	0.24	0.34	0.07	0.06	0.15	0.26	0.21	0.08	0.08	0.04	0.10	**1.14**
29	0.08	0.27	0.20	0.13	0.28	0.15	0.04	0.07	0.16	0.22	0.52	0.19	**1.82**	**2.34**	**29**	0.67	0.53	**1.48**	0.39	0.22	0.24	0.41	0.26	0.05	0.12	0.06	0.06	0.18	0.46	0.25	0.10	0.22	0.72	0.17	0.07	0.07	0.03	0.07	0.91
30t1	0.07	0.16	0.21	0.12	0.20	0.11	0.13	0.11	0.14	0.21	0.54	0.29	0.22	0.73	0.95	**92**	**2.26**	0.83	0.21	0.26	0.26	0.28	0.30	0.14	0.12	0.18	0.09	0.15	0.31	0.53	0.19	0.42	0.84	0.30	0.10	0.09	0.08	0.11	**1.23**
32t3	0.04	0.08	0.14	0.14	0.11	0.13	0.08	0.17	0.13	0.40	0.48	0.15	0.16	0.53	0.48	**2.84**	**34**	0.28	0.15	0.20	0.14	0.17	0.30	0.14	0.13	0.32	0.11	0.19	0.32	**2.04**	0.40	0.51	0.73	0.32	0.10	0.14	0.10	0.11	0.99
34	0.14	0.30	0.18	0.05	0.13	0.03	0.08	0.07	0.22	0.28	**1.57**	0.24	0.27	**1.90**	**1.11**	0.34	0.13	**226**	**1.56**	0.36	0.92	0.33	0.56	0.01	0.24	0.02	0.07	0.14	0.36	0.04	0.09	0.25	0.25	0.19	0.09	0.05	0.04	0.07	**1.13**
35	0.06	0.20	0.09	0.08	0.10	0.09	0.06	0.01	0.35	0.11	0.33	0.12	0.14	0.95	0.70	0.23	0.08	0.50	**133**	0.58	0.34	0.55	0.13	0.04	0.58	0.09	0.02	0.28	0.28	0.16	0.01	0.09	0.32	0.21	0.06	0.07	0.03	0.06	**1.48**
36a7	0.08	0.41	0.26	0.51	**1.81**	0.07	0.53	0.11	0.05	0.20	0.86	0.39	0.25	0.76	0.43	0.18	0.15	0.49	**1.42**	**98**	0.07	0.42	0.40	0.12	0.23	0.10	0.08	0.24	0.30	0.10	0.07	0.27	0.21	0.30	0.12	0.13	0.07	0.16	**1.24**
40a1	0.12	0.15	0.06	0.04	0.18	**1.90**	0.10	0.06	**9.45**	0.30	0.13	0.05	0.11	0.15	**1.72**	0.13	0.12	0.10	0.09	0.04	**120**	0.86	0.12	0.10	0.11	0.10	0.08	0.37	0.21	0.21	0.15	0.30	0.68	0.18	0.21	0.17	0.09	0.27	**1.11**
45	0.18	0.88	0.08	0.06	0.44	0.07	0.05	0.05	0.13	0.11	0.13	0.44	0.17	0.58	0.36	0.24	0.06	0.22	0.40	0.25	0.44	**13**	0.18	0.09	0.33	0.12	0.07	0.78	**1.08**	0.09	0.04	0.15	0.71	0.27	0.12	0.07	0.04	0.19	**1.25**
50t2	0.11	0.14	0.43	0.33	0.19	0.10	0.36	0.19	0.26	0.35	0.25	0.23	0.10	0.21	0.23	0.28	0.20	0.33	0.14	0.38	0.12	0.26	**6**	0.42	0.46	0.34	0.33	0.37	0.70	0.56	0.14	0.56	0.19	0.46	0.15	0.18	0.14	0.27	**1.14**
55	0.09	0.12	0.56	0.14	0.14	0.09	0.28	0.13	0.12	0.17	0.17	0.15	0.06	0.09	0.08	0.10	0.09	0.08	0.07	0.15	0.10	0.17	0.71	**20**	0.32	0.26	0.27	0.46	0.52	0.16	0.15	0.46	0.10	**1.20**	0.23	0.33	0.29	0.43	**1.37**
60t3	0.14	0.81	0.11	0.07	0.14	0.08	0.08	0.06	2.78	0.16	0.11	0.20	0.16	0.13	0.11	0.06	0.06	0.21	0.17	0.15	0.14	0.28	0.19	0.30	**15**	0.47	0.12	0.20	0.49	0.20	0.05	0.23	0.12	0.21	0.12	0.10	0.04	0.17	**1.07**
64	0.08	0.04	0.15	0.09	0.09	0.06	0.47	0.16	0.09	0.15	0.11	0.11	0.05	0.09	0.09	0.11	0.26	0.09	0.03	0.10	0.11	0.36	0.30	0.22	0.35	**34**	0.45	0.31	0.44	**1.39**	0.17	0.65	0.15	0.68	0.20	0.16	0.10	0.24	**1.27**
65t7	0.09	0.08	0.04	0.08	0.02	0.03	0.22	0.13	0.06	0.06	0.10	0.03	0.02	0.03	0.06	0.06	0.08	0.05	0.04	0.04	0.09	0.05	0.13	0.10	0.08	0.20	**42**	0.37	0.26	**1.05**	0.10	**1.02**	0.08	0.26	0.23	0.09	0.05	0.12	**1.01**
70	0.09	0.17	0.15	0.14	0.15	0.06	0.19	0.12	0.10	0.57	0.31	0.24	0.10	0.13	0.12	0.13	0.07	0.07	0.12	0.19	0.25	0.65	0.23	0.30	0.18	0.17	0.40	**40**	0.72	0.16	0.13	0.69	0.58	0.97	0.38	0.18	0.17	0.36	**1.34**
71	0.08	0.68	0.10	0.00	0.19	0.07	0.33	0.22	0.50	0.26	0.05	0.10	0.24	0.38	0.42	0.28	0.17	0.77	0.31	0.24	0.00	**1.13**	0.71	0.51	0.78	0.27	0.65	0.36	**276**	0.25	0.05	0.57	0.20	0.70	0.11	0.16	0.10	0.42	**1.21**
72	0.03	0.02	0.06	0.05	0.04	0.06	0.73	0.28	0.07	0.15	0.11	0.08	0.08	0.07	0.16	0.21	**1.03**	0.05	0.03	0.08	0.15	0.12	0.36	0.06	0.10	**1.63**	0.54	0.20	0.16	**40**	0.47	**1.77**	0.93	0.65	0.25	0.32	0.05	0.24	0.84
73	0.19	0.18	0.13	0.04	0.06	0.09	0.11	0.07	**4.54**	**2.50**	0.10	0.48	0.11	0.20	0.12	0.34	**4.21**	0.02	0.01	0.06	0.25	0.03	0.12	0.10	0.06	0.13	0.11	0.10	0.07	0.92	**98**	0.43	0.73	0.16	0.50	0.72	0.16	0.21	0.93
741	0.08	0.76	0.36	0.38	0.25	0.40	**1.55**	0.40	**7.63**	0.98	0.43	0.39	**1.03**	0.29	0.83	0.78	**1.11**	0.13	0.11	0.35	0.37	0.23	0.49	0.30	0.34	0.43	**1.18**	**1.04**	0.74	**1.69**	0.46	**41**	0.43	0.90	0.36	0.37	0.12	0.43	**1.12**
742a3	0.06	0.33	0.07	0.05	0.11	0.09	0.11	0.10	0.40	0.26	0.17	0.19	0.47	0.34	0.88	0.78	0.39	0.25	0.38	0.13	0.75	0.56	0.14	0.09	0.11	0.10	0.09	0.77	0.14	0.48	0.46	0.33	**34**	0.38	0.55	0.16	0.06	0.27	0.90
744t8	0.08	0.10	0.35	0.26	0.17	0.09	0.86	0.80	0.36	0.25	0.28	0.19	0.14	0.20	0.19	0.27	0.32	0.16	0.22	0.29	0.12	0.34	0.50	0.92	0.36	0.67	0.33	**1.52**	0.79	0.73	0.22	0.84	0.32	**14**	0.36	0.33	0.28	0.53	**1.52**
75	0.13	0.08	0.06	0.08	0.08	0.04	0.14	0.05	0.11	0.06	0.07	0.08	0.08	0.08	0.07	0.06	0.06	0.08	0.06	0.05	0.13	0.11	0.08	0.12	0.12	0.11	0.16	0.19	0.08	0.24	0.25	0.35	0.36	0.21	**14**	0.35	0.40	0.29	**1.07**
80	0.09	0.02	0.06	0.07	0.04	0.04	0.21	0.06	0.05	0.16	0.07	0.05	0.06	0.05	0.06	0.09	0.18	0.03	0.05	0.07	0.17	0.04	0.08	0.39	0.05	0.09	0.11	0.34	0.07	0.34	**1.33**	0.30	0.23	0.21	0.48	**12**	0.21	0.35	**1.08**
85	0.08	0.02	0.05	0.06	0.03	0.01	0.06	0.02	0.13	0.06	0.03	0.02	0.02	0.02	0.01	0.02	0.03	0.01	0.02	0.03	0.03	0.02	0.07	0.20	0.04	0.04	0.04	0.14	0.04	0.04	0.27	0.07	0.06	0.17	0.31	0.24	**6**	0.17	**1.16**
90t3	0.15	0.11	0.14	0.11	0.07	0.04	0.67	0.12	0.03	0.10	0.10	0.08	0.06	0.07	0.06	0.06	0.07	0.08	0.05	0.24	0.46	0.16	0.24	0.30	0.18	0.19	0.16	0.42	0.53	0.25	0.21	0.39	0.23	0.50	0.37	0.44	0.21	**14**	**1.39**

FIGURE 1. Employment transition linkages (from 2000 to 2004; between industries when relative transition probability is above one)



It is convenient to start to look at the figure from the education industry (NACE 80), which turns out to be an "ancestor" for the most of the industries. It is not an employment destination of any industry but it is the relatively important source for the research industry (*rtp*=1.33*)*. The research industry in turn is a major source for three important industries in the Finnish economy; 1) the energy sources (*rtp*=4.5), 2) chemical (*rtp*=2.5), and 3) telecommunication equipment (*rtp*=3.2) industries. The latter has a downstream employment link to the computer services industry (*rtp*=1.6), which both have a downstream link (*rtp*=1.6) and an upstream link (*rtp*=1.4) to the post and telecommunication industry. In other words, employment flows seem to portray a Finnish ICT cluster. The figure indicates the two important roots of this cluster; one of which is the research industry and the other is the rubber and plastic industry (*rtp*=3.0).

In the far downstream of labour flows from the education and the research industries is the machinery cluster that consists of traditional industries with thick mutual links consisting of the machinery, basic metal, metal products, vehicle, transport equipment, and in some sense the rubber and plastic industries. Interestingly, there is a link from the last mentioned rubber and plastic industry to the telecommunications equipment and the electrical machinery industries. The underlying reason for this link is that the rubber and plastic industry is a sub-contractor industry for the latter industries (e.g. manufacture of mobile phone covers).

Earlier Finnish cluster analysis has analysed the links between the forest cluster (including the manufacture of paper and pulp, and manufacture of wood products) and the machinery cluster (Hernesniemi et al., 1995). No strong labour market links were found between these clusters except that the paper industry is an employment source for the machinery industry (*rtp*=1.2).

The third cluster is the energy cluster, which consists of two industries the energy sources, and the energy production industries with two-sided links (from energy production (*rtp*=9.4) and from energy sources (*rtp*=1.4)). The energy production industry has downstream links to the paper (*rtp*=1.9) and the machinery (*rtp*=1.7) industries. Finally, employment flows show, at least vaguely, a fourth cluster, the construction cluster that has direct or indirect links with the mining, mineral, chemical and the machinery renting industries.

As can be seen, all 30 industries shown in Figure 1 are mutually linked either directly or indirectly (sometimes very remotely). It is worth noting that there are 8 other industries that have no significant downstream or upstream employment links (that is, *rtp* is less than one with all other industries). These industries are listed in Table 4.

TABLE 4. Industries with no significant labour flow channels

NACE	Industry	Highest downstream	Highest upstream
10-15	Agriculture & forestry	0.5	0.8
15-16	Food & tobacco	0.5	0.6
17-19	Textiles & leather	0.7	0.6
50-52	Trade & repair	0.7	0.7
742-3	Technical services	0.9	0.9
75	Public administration	0.4	0.6
85	Health and social work	0.3	0.4
90-93	Other social services	0.7	0.7

The following examines the labour flows in the ICT and machinery clusters in greater detail. Industries in the ICT cluster consist of the electrical machinery (30-31), telecommunication equipment (32-33), post and telecommunications (64), and computer services (72) industries. The machinery cluster consists of the basic metal (27), metal products (28), machinery (29), vehicle (34), and other transport (35) industries.

TABLE 5. Employment and inter- and intra-cluster worker flows in ICT and Machinery cluster, 2000-2004, %

ICT (NACE)	*Emp. 2000*	*Emp. 2004*	*NETR*	*WIFR*	*WOFR*	*WIFR (wh)*	*WIFR (bw)*	*WIFR (out)*	*WOFR (wh)*	*WOFR (bw)*	*WOFR (out)*
30t1	17 275	15 697	-9.6	31.4	41.0	6.0	14.9	10.5	5.9	19.0	16.2
32t3	48 003	46 075	-4.1	31.2	35.3	3.5	16.8	10.8	5.9	16.7	12.7
64	42 658	44 055	3.2	40.0	36.8	3.2	15.0	21.8	2.8	18.3	15.7
72	34 424	38 038	10.0	43.6	33.7	7.4	24.4	11.8	4.9	18.7	10.1
Total	**144 360**	**145 869**	**1.1**	**37.0**	**36.0**	**4.7**	**18.0**	**14.3**	**4.7**	**18.0**	**13.3**

Machinery (NACE)	*Emp. 2000*	*Emp. 2004*	*NETR*	*WIFR*	*WOFR*	*WIFR (wh)*	*WIFR (bw)*	*WIFR (out)*	*WOFR (wh)*	*WOFR (bw)*	*WOFR (out)*
27	15 350	15 321	-0.2	24.4	24.6	6.5	9.5	8.4	2.9	7.4	14.3
28	38 403	38 524	0.3	35.9	35.6	7.4	14.5	14.1	6.1	15.2	14.3
29	56 192	56 932	1.3	32.2	30.9	4.0	17.9	10.3	5.5	14.0	11.4
34	7 452	6 595	-12.2	27.3	39.5	5.3	12.3	9.7	7.1	17.3	15.0
35	13 696	11 617	-16.4	21.5	37.9	3.3	10.4	7.9	3.7	14.0	20.2
Total	**133 093**	**130 993**	**-1.6**	**31.1**	**32.7**	**5.3**	**14.9**	**10.9**	**5.3**	**13.8**	**13.6**

Note: *NETR* is the net employment growth, *WIFR* is worker inflow rate, *WOFR* is worker outflow rate, *WIFR(wh*) is the within cluster worker inflow rate, *WIFR(bw)* is the between clusters worker inflow rate, *WIFR(out)* is worker inflow rate from the non-employment, *WOFR* is worker outflow rate, *WOFR(wh)* is worker outflow rate within the cluster, *WOFR(bw)* is worker outflow rate between the clusters, and *WOFR(out)* is the worker outflow rate to the non-employment.

The first and second columns of Table 5 give the employment in 2000 and 2004, respectively. The ICT cluster is slightly bigger than the machinery cluster when measured by the employment

(145 869 vs. 130 993 in 2004). The third column (*NETR*) reports net employment growth, measured as a change in employment per average employment in 2000 and 2004, following the convention of job and worker flow literature (see Davis & Haltiwanger, 1999). The fourth column (*WIFR*) is the worker inflow rate, which is the number of people who have made a transit to the industry per average employment in 2000 and 2004. The fifth column (*WOFR*) is the worker outflow rate, which is, analogously to the above, the number of people who have left the industry per the average employment. By definition *NETR = WIFR – WOFR*.. The following three columns report the composition of the worker inflow rate. The sixth column (*WIFR(wh)*) is the "within" cluster worker inflow rate, which is the number of workers who have moved to the industry from another industry of the same cluster. The seventh column (*WIFR(bw)*) measures the worker inflow from the industries outside the cluster. The eighth column gives the inflow rate from the non-employment. Note that *WIFR = WIFR(wh) + WIFR(bw) + WIFR(out)*. Finally, *WOFR(wh*), *WOFR(bw)* and *WOFR(out)* gives the analogous components of the worker outflow rate distinguished now by the destination.

A couple of findings emerge from Table 5. Firstly, both clusters have experienced a substantial restructuring. The more manufacturing-orientated part of the ICT cluster (the first two industries) has declined and the more service-orientated part (the last two industries) have grown. As a whole, the ICT cluster has seen a moderate increase during the period. The machinery cluster has decreased, but the greatest decline has been in the transportation equipment industries.

Industries of both clusters have experienced considerable worker inflow and outflow, but the industries of the ICT cluster stand out as particularly dynamic in this regard. The within cluster worker inflow is important for the electrical machinery industry, which is a declining industry, and for the computer services industry, which is an expanding industry. In the ICT cluster, the within cluster worker inflow (WIFR(wh)) is 21% (4.7%/18.0) of the total employment worker inflow (that is WIFR(wh)+WIFR(bw)), which is a relatively large number given that the ICT cluster accounts for about 7% of the total employment (the average in 2000 and 2004). The corresponding numbers for the machinery cluster are even more outstanding, 26% and 6%.

5. Avenues for future research

This was a first step in the examination of human-capital-based links between industries and industry clusters. The aim of this study was to complement the earlier analysis of job and worker flows, which have been found to involve intensive within industry worker flows between plants or firms, by looking at the patterns of worker flows between industries. A number of interesting aspects were left for future research.

First, this analysis could be tied more closely with the earlier analysis of firm demography by identifying firm (or plant) entries and firm exits as destinations and sources of inter-industry worker mobility. Such analysis could contribute to the analysis of industry life cycles that so far have paid much attention to firm entries and exits but less to the sources and destinations of the associated worker flows.

Second, this analysis has covered all workers without making any distinction between the worker's occupation or education, for example. Thus occupational mobility and occupational restructuring, which are also interesting aspects of economic development, have been ignored (see e.g. Jovanovic & Nyarko, 1997; Bauer & Bender, 2004; Maliranta, 2008).

Third, while the role of human capital as a potential carrier of knowledge has been considered, an obvious direction to extend the analysis is to focus on the highly educated workers. In fact, some experimentation in this area shows that a large proportion of the links identified here by means of all workers could also be established by looking at just the flows of the university educated workers. On the other hand, the links of the university educated were found to be fewer than those of all the workers. Industry specificity may be an attribute of human capital that is, in relative terms, more important for less educated workers.

Finally, the econometric methods could be used for looking at the transition links between industries, and in addition, for examining the factors underlying these paths in greater detail.

6. Conclusions

This study analyzed how industries are linked together based on labour flows. By using the Finnish Longitudinal Employer-Employee Data (FLEED) covering the total working age population a number of one-way or two-way labour paths between industries have been established that portray a network of industries where some specific industry clusters can be identified. The approach used in this paper sheds light on various policy-relevant issues such as how knowledge, in the form of human capital, spreads in the economy and how the life cycles of industries are mutually linked in the labour markets. Hence the analysis gives information on one potentially important, but often neglected mechanism of productivity spillovers and helps to understand and anticipate the dynamics of the economic development.

References

ARROW, K. J. (1962). Economic Welfare and the Allocation of Resources for Invention. In R. R. Nelson (Ed.), *The Rate and Direction of Inventive Activity: Economic and Social Factors* (pp. 609-626). Princeton: Princeton University Press.

BAUER, T. K. and BENDER, S. (2004). Technological change, organizational change, and job turnover. *Labour Economics, 11*, 265-291.

CORRADO, C. A., HULTEN, C. R. and SICHEL, D. E. (2005). Measuring Capital and Technology: An Expanded Framework. In C. Corrado, J. Haltiwanger & D. Sichel (Eds.), *Measuring Capital in the New Economy*. NBER Studies in Income and Wealth Volume 65. Chicago and London: University of Chicago Press.

DAVERI, F. and SILVA, O. (2004). Not only Nokia: what Finland tells us about new economy growth. *Economic Policy, 19*(38), 117-163.

DAVIS, S. J. and HALTIWANGER, J. (1999). Gross Job Flows. In O. C. Ashenfelter & D. Card (Eds.), *Handbook of Labor Economics, Volume 3B*. Elsevier.

DESCHRYVERE, M. (2008). *High Growth Firms and Job Creation in Finland*. The Research Institute of the Finnish Economy (ETLA), Discussion papers No. 1144.

DOMAR, E. D. (1961). On the Measurement of Technological Change. *The Economic Journal, 71*(284), 709-729.

FESER, E. J. and BERGMAN, E. M. (2000). National Industry Clusters Templates: A Framework for Applied Regional Cluster Analysis. *Regional Studies, 34*(1), 1-19.

FREDERIKSEN, A. and WESTERGAARD-NIELSEN, N. (2007). Where Did They Go? Modelling Transitions Out of Jobs. *Labour Economics, 14*(5), 811-828.

GOLAN, A., LANE, J. and MCENTARFER, E. (2007). The Dynamics of Worker Reallocation within and across Industries. *Economica, 74*(293), 1-20.

HERNESNIEMI, H., LAMMI, M. and YLÄ-ANTTILA, P. (1995). *Kansallinen kilpailukyky ja teollinen tulevaisuus*. ETLA B 105. Helsinki: Taloustieto Ltd.

HILL, E. W. and BRENNAN, J. F. (2000). A Methodology for Identifying the Drivers of Industrial Clusters: The Foundation of Regional Competitive Advantage. *Economic Development Quarterly, 14*(1), 65-96.

ILMAKUNNAS, P. and MALIRANTA, M. (2002). *The Turnover of Jobs and Workers in Finland*. Ministry of Labour, Labour Policy Studies No. 236. Helsinki.

ILMAKUNNAS, P., MALIRANTA, M. and VAINIOMÄKI, J. (2001). Linked employer-employee data on Finnish plants for the analysis of productivity, wages and turnover. In T. Jensen & A. Holm (Eds.), *Nordic labour market research on register data* (pp. 205-246). Copenhagen: Nordic Council of Ministers. TemaNord 2001:593.

JORGENSON, D. W., GOLLOP, F. M. and FRAUMENI, B. M. (1987). *Productivity and U.S. Economic Growth*. On the Measurement of Technological Change: Harvard University Press.

JOVANOVIC, B. and NYARKO, Y. (1997). Stepping-Stone Mobility. *Carnegie-Rochester Conference Series on Public Policy, 46*(0), 289-325.

KLEPPER, S. (1996). Entry, Exit, Growth, and Innovation over the Product Life Cycle. *American Economic Review, 86*(3), 562-583.

___. (1997). Industry Life Cycles. *Industrial and Corporate Change, 6*(1), 145-181.

KORKEAMÄKI, O. and KYYRÄ, T. (2000). *Integrated Panel of Finnish Companies and Workers*. Government Institute for Economic Research, VATT-Discussion Papers No. 226.

MALIRANTA, M. (2003). *Micro Level Dynamics of Productivity Growth. An Empirical Analysis of the Great Leap in Finnish Manufacturing Productivity in 1975-2000*. Series A 38 (available at http://www.etla.fi/files/1075_micro_level_dynamics.pdf). Helsinki: Taloustieto Oy.

___. (2008). *Työpaikka- ja työntekijävirrat ja tehtävärakenteiden dynamiikka Suomen yrityssektorilla*.Unpublished manuscript, Helsinki

MALIRANTA, M. and NURMI, S. (2004). *Analyzing entrepreneurship with the Finnish linked employer-employee data FLEED. Matching and qualitative properties of the data*. The Research Institute of the Finnish Economy (ETLA), Discussion papers No. 920. Helsinki.

NEAL, D. (1999). The Complexity of Job Mobility among Young Men. *Journal of Labor Economics, 17*(2), 237-261.

___. (2004). Erratum: The Complexity of Job Mobility among Young Men. *Journal of Labor Economics, 22*(2), 523-524.

OECD. (2003). *Understanding economic growth*. Paris.

OULTON, N. (2001). Must the Growth Rate Decline? Baumol's Unbalanced Growth Revisited. *Oxford Economic Papers, 53*(4), 605-627.

PARNES, H. (1954). Research on Labor Mobility, *Bulleting no. 64*. New York.