SIMULATING THE LONG-TERM LABOUR MARKET EFFECTS OF AN INDUSTRIAL INVESTMENT

A microsimulation approach

With 4 figures and 3 tables

URBAN LINDGREN

Zusammenfassung: Simulation langfristiger Arbeitsmarkteffekte einer industriellen Investition – Ein Mikrosimulationsansatz

Ziel der Studie ist es, die langfristigen Auswirkungen der Investition eines Unternehmens der Holz- und Papierindustrie auf den regionalen Arbeitsmarkt und seine sektorale Gliederung zu untersuchen. Zu Beginn der 90er Jahre führte ein schwedisches Unternehmen (SCA) eine neue Technologie zur Produktion hochwertiger Druckpapiere (LWC-Papier) in seiner Papiermühle in Ortviken bei Sundsvall, Nordschweden, ein.

Die regionalökonomischen Effekte dieser Investition in Höhe von $ 320 Millionen wurden empirisch untersucht (KLINT a. LINDGREN 1992; 1993). Es konnte gezeigt werden, daß der Hauptanteil der Investitionen in der Region bzw. in der Kommune Sundsvall verblieb (47%). Eine ex-ante Analyse der Langzeiteffekte der mit der Investition eingeführten Technologie auf die Teilarbeitsmärkte in der Kommune während der Einsatzzeit ist nicht möglich. Daher wird versucht, mittels eines Simulationsmodelles auf der Mikroebene verschiedene Szenarien zu entwickeln, um durch deren Vergleich einen Einblick in mögliche Langzeiteffekte zu erhalten. Als Basishypothese wird formuliert, daß nur bei anhaltender höherer Produktivität der Papiermühle die Konkurrenzfähigkeit sichergestellt werden kann. Ohne weitere Investitionen ist diese in absehbarer Zeit nicht mehr gewährleistet und die Papiermühle wird langfristig schließen.

Verglichen werden die Langzeiteffekte, die durch die Investitionen für die Herstellung von LWC-Papier eintreten mit denen, die ohne Investitionen zu erwarten wären. Zu diesem Zweck wurde ein Mikrosimulationsmodell entwickelt, mit dem die eintretenden Effekte auf die Teilarbeitsmärkte der Kommune abgeschätzt werden können. In diesem Modell werden für alle Einwohner die wahrscheinlichen Lebenspfade simuliert. Die Wahl der Mikroebene für das Modell erlaubt es, mögliche Auswirkungen eines Beschäftigtenrückgangs in der Papiermühle durch ausbleibende Investitionen und deren Auswirkungen auf andere Teilarbeitsmärkte, die Arbeitslosenzahlen sowie auf Wanderungs- und Pendlermuster zu simulieren.

Das Mikrosimulationsmodell basiert dabei auf der Verwendung von individuellen Attributen von ca. 103 000 Personen, die im Zeitraum 1990 bis 1993 in der Kommune Sundsvall lebten und arbeiteten sowie auf zahlreichen Wahrscheinlichkeitsverteilungen, die aus weiterem sekundärstatistischen Material und landesweiten Prognosen abgeleitet wurden. Das Ergebnis der Simulationsstudien zeigt die nachhaltigen indirekten Arbeitsmarkteffekte, die durch eine Schließung der Papiermühle zu erwarten sind.

Summary: The aim of this article is to investigate the long-term local labour market impacts of an industrial investment. In the beginning of the 1990s the Swedish forest-based company SCA introduced a new technology for the production of high-quality paper (LWC-paper) in the Ortviken papermill, which is situated in Sundsvall (northern Sweden).

The regional income injection in connection with the implementation of the investment has previously been investigated empirically by KLINT and LINDGREN (1992, 1993) and it was shown that a major share of the income injection trickled down locally in the municipality of Sundsvall.

The ex-ante analysis of the investment's long-term labour market effect throughout the economic life of the paper machine cannot, however, be carried out empirically. In this study the problem has been approached by means of simulation methodology and the comparisons between different possible future scenarios. The basic hypothesis is that papermills, which are resource-intensive operations and mainly compete by means of high productivity, cannot survive without high investment rates. This implies that the papermill will have to close if the upgrading of the production process is not continued. The long-term impacts are obtained by comparing a baseline scenario, in which the LWC-investment is implemented, and a counterfactual scenario of non-implementation.

In order to fulfill this task, a calibrated systems model based on microsimulation methodology has been developed. The model represents the population of Sundsvall individually, i.e. it simulates future life paths of every single person in the municipality. By using micro-orientated modelling the impacts of employment reduction at the papermill can be traced to other partial local labour markets (changed unemployment levels) and to the local population (changed migration and commuting patterns). The microsimulation model is calibrated on a micro dataset that contains a number of attributes on individuals who lived or worked in the municipality at some time between 1990 and 1993 (N = 103,000). The simulation results show that there are substantial indirect labour market effects, i.e. there are many occupation categories, not related to the papermill, that meet with increased unemployment in the case of the closure of Ortviken.

1 Introduction

One of the central research topics in economic geography and regional economics concerns local impacts of economic activities. The pioneering works of BARFOD (1938), NORTH (1955), MYRDAL (1957), ISARD (1967) and LOWRY (1964) have propelled a wide range of theoretical and methodological development carried out within numerous empirical settings. Some studies have especially focused on impacts generated by temporally discrete income injections in terms of, for example, the upgrading of the manufacturing processes or the construction of entirely new operations (e.g. GREIG 1971; BROWNRIGG 1974; MCGUIRE 1982; GLASSON, VAN DER WEE a. BARRETT 1988; BERGDAHL, HOLM a. ÖBERG 1988; KLINT a. LINDGREN 1992; 1993 and ARMSTRONG 1993).

The local economic impacts of an investment project are multi-dimensional, i.e. the effects are nested at different levels. As regards the time perspective there are short-term and long-term effects. During the implementation phase of the investment project suppliers are contracted and their operations benefit from increased activities which, in turn, leads to enhanced income and additional employment. When the investment has been carried out the new facility is put into production and another type of effect appears. The use of the new equipment over a long period generates employment and income in the local economy via those who work at the plant.

The empirical point of departure for this study is a major investment programme carried out at the Ortviken papermill in Sundsvall, which is situated on the coast of Norrland (northern Sweden). The new production line was directed towards the manufacture of LWC-paper (Light Weight Coated) which is a form of thin paper covered initially with clay and then glazed to create a surface with good printing qualities. The investment amounted to $ 320 million and was carried out 1989 and 1990 (KLINT a. LINDGREN 1992; 1993).

1.1 Aim of the study

The investment in the upgrading of the manufacturing process at the papermill has been shown to generate local economic impacts during the implementation phase. The economic life of a paper machine is here assumed to be 15 years, which hints at there also will be a long-term effect induced by its operation. The aim of this study is to investigate the long-term labour market effects of the LWC-investment in the municipality of Sundsvall by employing microsimulation methodology (the SIMSUND-model). The central question concerns how unemployment in different partial local labour markets is affected by the closure of the Ortviken papermill.

1.2 Sources

Data used in this article stems from a database with individual attributes for the whole of Sweden's population during the period 1990 to 1993. The database is a result of linking and matching different registers at Statistics Sweden (e.g. Statistics on Regional Employment and Housing Census 1990) and enables every single, but unidentified, individual to be followed with respect to a number of attributes (Year of birth, Sex, Profession/occupation, Employment status, County, municipality and parish code of tenure, Educational level, County and municipality code of the place of work and Year of death). For the calibration of the SIMSUND-model a sample has been used containing all those individuals who ever lived and worked in the municipality of Sundsvall during 1990 to 1993 (103,000 persons).

2 Theoretical and methodological approach

In this study of the long-term effects of pulp and paper industry investments on employment within different local labour markets, the central question is related to the major field of regional modelling. Efforts made by geographers, demographers, economists and others, have resulted in a large number of models for policy-making and impact analyses. Most of them are macro-orientated representations of the regional economic system, production, employment and population (SNICKARS 1984). The methodological approach in this study is microsimulation, which is a modelling technique that can be used for the same purposes as conventional models.

Major advantages of microsimulation models include their possibilities for incorporating individual behaviour and micro-processes in the models, and for using theories of individual behaviour on the same level at which they are observed and formulated. Moreover, the heterogeneity of information can be fully represented in the model and maintained during the simulation. The output will consequently contain a great variety of information about general and specific conditions on the micro-level, information that can easily be aggregated up to the levels suitable for answering research and applied questions. This facilitates a detailed analysis of micro-processes or sequences of individuals' actions and provides opportunities for a more thorough understanding of the mechanisms behind the macro-processes and of the consequences on aggregated or disaggregated levels.

In some cases the microsimulation approach has been used as a tool for systematically exploring and investigating the ideas of time geography (HÄGERSTRAND 1970; 1982), which focuses on the interaction between different individuals and between individuals and stations within a time-space context (HOLM, MÄKILÄ a. ÖBERG 1989; FRANSSON 1997). A person is not simply employed, living in a town, living in a detached house and living in a household of five members, but is specifically employed in a certain position in a specific corporation, living in a named town, in a specific dwelling and he/she recognises his/her partner, parents and children among all other individuals. If any of these circumstances are altered it will cause particular effects. For example, specific vacancies emerge on the labour, housing and 'partner' markets and these vacancies become available to other individuals who are about to change job, residence or partner. In such situations a microsimulation approach provides possibilities for modelling a segmented labour market, in which all applicants have individually assigned attributes and all vacancies require a certain skill and education.

The conceptual ideas behind the microanalytic modelling approach were originally developed by ORCUTT (1957). Four years later, together with three other colleagues, he wrote a book in which they presented the first implemented microsimulation model (ORCUTT et al. 1961). Since then, many microanalytic models have been designed and run. Activity within this field has gradually increased and today it is not out of place to assert that the approach has become a major framework.[1)]

3 Outline of the SIMSUND-model

The SIMSUND-model is intended to answer questions concerning the long-term impacts of the LWC–90 investment in the Ortviken papermill on employment and redistribution of unemployment in the municipality of Sundsvall. Presumably stemming from the heyday of the industrial era, a widespread view is that production investments generate increased employment. However, longitudinal statistics indicate decreasing employment within Swedish manufacturing industries and, more specifically, a survey addressed to the pulp and paper companies also indicates negative employment changes in connection with investment projects (LINDGREN 1997). Against this background it is assumed that the number of employees at the mill will diminish regardless of the implementation of the investment.[2)]

In the model, the effect is calculated by comparing how much more employment would be reduced if the investment is not carried out (counterfactual scenario) in comparison to an alternative scenario containing the investment. It is reasonable to argue that a production unit which stops carrying out investment projects will, sooner or later, face a situation of weakening competitiveness and will eventually shut down. This is especially true with regard to resource-intensive industries like the pulp and paper industry, in which companies mainly compete by means of high productivity based on high investment rates. The time perspective in the simulation is 15 years, which is assumed to reflect the probable economic life of a paper machine. Continuous re-investments may, however, extend the years of production beyond the end of this time period, but without regular investment activities the operation would soon become unprofitable.

The fundamental notion of analysing partial effects is based on the idea that the 'cause' factor can only have impact on the 'effect' factor in a way anticipated by the modeller. If the 'cause' factor cannot be varied in isolation it is rather pointless to say anything about partial effects. FOLMER and NJKAMP (1985) provide a broad discussion on this theme and review different methodological approaches. In order to be able to say something about the long-term economic impacts of investments, two different scenarios have to be compared. The reference scenario in which continuous investments are carried out, has to be matched against an alternative scenario that lacks investment activities. The difference between these scenarios provides a measure of the effect.

As in most microsimulation models the basic entity of the SIMSUND-model is individuals, i.e. individuals who live and work in the municipality of Sundsvall (approximately 103,000). The point of departure for the simulation is the information embedded in the

[1)] An overview of some microsimulation models developed in the 1970s and 80s is provided in ORCUTT, CALDWELL a. WERTHEIMER II (1976); BERGMANN, ELIASSON a. ORCUTT (eds.) (1980); HAVEMAN a. HOLLENBECK (eds.) (1980); ORCUTT, MERZ a. QUINKE (eds.) (1986) and CLARKE, M. a. HOLM, E. (1987). Newly published contributions on the recent advances within the field can be found in CLARKE (ed.) (1996). See also MALMBERG a. MÄKILÄ (1996).

[2)] A comparison between the number of employees at the mill in 1990 and 1999 shows that the workforce has decreased from 1,200 to 1,000.

micro-database, and the model calibrations have been carried out using this source. The transition rates (of, for example, getting an occupation, changing occupation, migrating, dying) are compared to a stochastic variable X drawn from a rectangular probability distribution (0,1). If the variable X falls between zero and the rate, then the event occurs and the population is ageing.[3)]

3.1 Labour demand

Ranging from private companies to public authorities, employers demand labour at their places of work; this is expressed in terms of a demand pool, subdivided here into 240 occupational categories. Within the model framework these categories are regarded as partial labour markets, which correspond to homogeneous competence spheres (e.g. doctors, lawyers, fishermen, construction carpenters, firefighters). The generation of labour demand is carried out for 28 industries, which corresponds approximately to the two-digit level within the Swedish industrial classification code (SNI). By employing NUTEK's national estimates of annual industry change and demand changes due to investments at the Ortviken mill, the number of required employees within the partial labour markets can be calculated for every year during the simulation. The annual employment change assumptions applied in NUTEK's growth scenario have also been employed here.[4)]

The starting point for the calculation is provided by a cross-tabulation displaying the number of individuals falling into each combination of industry and occupational category (28 * 240). Unfortunately, the available database only includes occupational information for one point in time, based on the Population and Housing Census from 1990 (FoB–90). The matrices for 1991, 1992 and 1993 are therefore calculated on the basis of data from 1990. The changing numbers of employees within the different industries are assumed to have a fixed occupation distribution.

The impacts connected with the specific production investment at the mill are also included in the construction of the labour-demand module. These effects are based on two sources: (1) the employment effects on different industries induced by the purchasing process carried out during the investment period, and (2) the long-term effects of the implemented investment on employment at the mill.

A detailed analysis of the investment process is provided in KLINT a. LINDGREN (1992; 1993). The empirical data used in that study have also been employed here for exploring the short-term effects on other industries. By compiling every business transaction (i.e. purchase) and by determining to which industry the local suppliers belong, the purchased amount per industry is obtained.

The second source influencing labour demand is the long-term effects of the operation. As mentioned above, the papermill will not survive without investments. Sooner or later such a strategy would result in reduced employment. Thus, the central question concerns the difference between implementing an investment and not doing so. In the latter case, there are difficulties in estimating how many employees would lose their jobs, and at what rate. It could be argued that only the personnel working at the LWC production line would be affected. However, the reductions could diffuse to the rest of the mill, which implies a shut-down of the entire plant (the worst scenario). Even though the question of how many employees would lose their jobs does not have an exact answer, the discussion nevertheless provides two estimates for the following analysis of the impacts on the municipal partial labour markets.

Another problem, even more difficult to estimate, is the rate of employment reduction in case of the non-implementation of an investment. One possible solution is to assume that the rate of decline is linear, i.e the same number of employees stop working each year. The impacts of this assumption can be tested within the labour-demand module. However, this does not seem to be a very realistic hypothesis. A papermill in which no investments are carried out may well manage to maintain output and production costs in order to satisfying demand for quite some time, but at a certain point its deteriorating competitiveness will lead to a rapid decline. The problem has been simplified in such a way that the two scenarios start at the same level, but the non-investment one declines according to either a strong or a weak non-linear function ($a + X^b$). In contrast to the linear alternative, most employees are laid off during the last years of the simulation period.

3.2 Labour supply

The supply side consists of several components, the main one being the group of people who were working in 1990. This comprises the bulk of the individuals em-

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[3)] HOLM, LINDGREN, MÄKILÄ a. MALMBERG (1996) provides a discussion of different methods for ageing populations within dynamic simulations (e.g. annual transition probabilities, survival functions, rule-based transitions).

[4)] The Ministry of Finance is continually publishing forecasts for the Swedish economy in *Långtidsutredningen*.

ployed in Sundsvall, and will be more or less marginally altered over time by other factors. Another component is the number of young people who gradually enter the different partial labour markets. The allocation of individuals is estimated by using the labour market distribution of the younger cohorts, which means that the newcomers are assumed to behave in accordance with previously revealed patterns. More specifically, the partial labour market distribution of young people (between 16 and 19) is not equivalent to the distribution of the total working population. This is not surprising, as most of them have not yet finished secondary school, which means that they cannot reasonably be working in any partial labour market. Within the model individuals enter the labour market at these ages, but when are they supposed to shift to the general pattern? This shift is obtained by relating education requirements to the various labour markets. Three levels have been identified: secondary school, short higher education (≤ 2 years) and long higher education (> 2 years). In this way, the point in time when young people join the general distribution depends on which professions they choose.

Retirements is another factor that has an impact on the supply of labour. Most people stop working at 65. However, there is also a quite large number of people who, for different reasons, leave the work force before their 65th birthday. It is hard to find exact information about how many and when, so the early retirement pensions have been roughly estimated by means of age- and sex-specific participation rates (defined as how many persons in a population group who are working in relation to all the individuals in that group).

The investment activities at the Ortviken mill affect labour demand and supply. The recruiting of new personnel to the mill has a positive impact on labour demand at the partial labour markets. Analogously, the dismissal of people at the mill adds to the pool of labour supply – more people will be on the look-out for work.

3.3 *Market clearing*

The current states of all individuals are changed annually by the model, in which labour supply and demand are matched in the market clearing process. The outcome of this process for each partial labour market could result in either excess demand or unemployment. On the basis of existing empirical knowledge a situation of labour shortage is not likely to occur. However, in some specialised labour markets it is conceivable that there are too few professionals to satisfy the demand from the employers. Within the modelling context such a deficit situation is solved by immigration or inflows from other partial labour markets, according to an empirically observed distribution.[5]

In case of unemployment, individuals are assumed either to find a new job in their current partial labour market, try to find a job in an adjacent partial labour market, commute, or move out from the municipality. Within each simulation year all individuals are confronted with these alternatives.

The matrix of occupational changes used here provides information about which occupations they may go to, and the probability of the above alternatives. The number of commuters is constrained by the ability of the neighbouring municipalities to receive, so the number cannot exceed their capacity according to the empirical data. A possible solution to the disequilibrium which arises is to let the unemployed gradually move out from the municipality. However, people are not likely to move to unemployment elsewhere, especially when considering the rules of unemployment benefits and the small difference between benefits and reservation wages, i.e. the lowest wage the individual is willing to accept for taking a job (HARKMAN 1997). On the other hand, it is unreasonable to assume that all of the unemployed stay in Sundsvall year after year. Some of them will probably leave, but this group is a part of the overall moves from the municipality generated by the model. In this way, the level of out-migration is determined by the demographic module and, according to a parameter, some of the 'places' are assigned to unemployed individuals.

3.4 *A formalised outline of the model*

Figure 1 shows a condensed version of the structure of the model in terms of a flow chart. The arrows represent flows and, for the sake of simplicity, no distinction is made between causalities and flows.

The SIMSUND-model has two modules: a disaggregated macro-module and a microsimulation module. The first one generates labour demand and the second one takes care of demography, labour supply and the market clearing process. The boxes with rounded corners are exogenous variables, defined by empirical data or assumptions based on forecasts and qualified guesses. Some of them are empirical distributions (out-migration frequency, in-migration frequency, fertility

[5] Information about partial labour market changes is obtained by comparing the occupation variable in the Population and Housing Censuses carried out in 1985 and 1990. This material includes the entire nation.

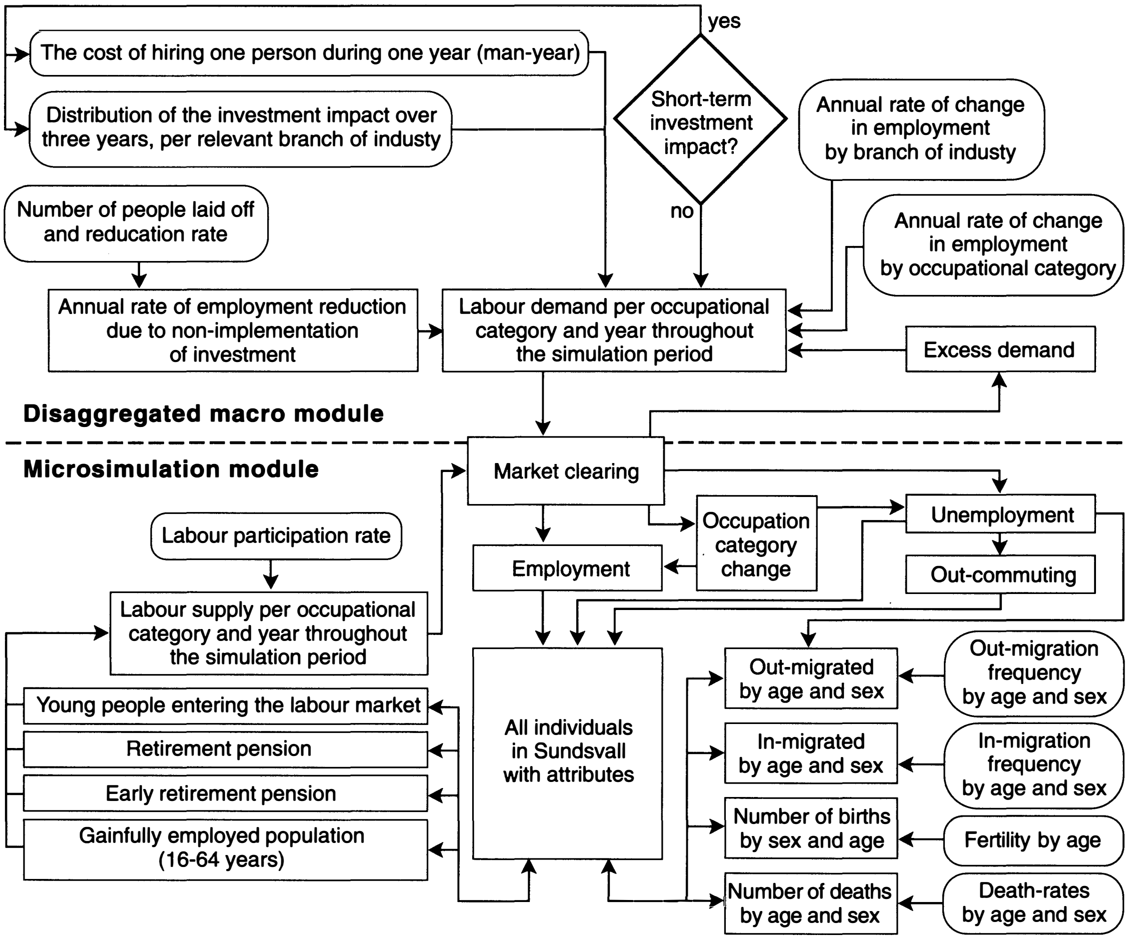

Fig. 1: The flow chart for the SIMSUND-model
Strukturdiagramm des SIMSUND-Modells

and death-rates) that regulate the probability of different events occurring. The remaining boxes are endogenous variables.

Labour demand is provided by the disaggregated macro-module which produces time series throughout the simulation period. The numbers of working individuals and unemployed are added up at the beginning of every year, and the number of available jobs is obtained by calculating the difference between labour demand and the number of active individuals. Within the model the annual processing of all the individuals has two phases: (1) the summation of the number of active individuals and a check against labour demand; (2) the simulation.

As a first stage in phase (1), a summation is carried out in every occupation, in which either a deficit or a surplus arises. Any deficit that may occur is aggregated to numbers of available jobs. Any possible surplus is reduced to zero by going through all individuals a second time and letting randomly chosen individuals lose their jobs. In the second phase (2) all individuals are simulated, which means that they go through demographic and labour market transformations. Demographic transformations refer to birth, death, migration, allocation of educational level and completion of education. These events are entirely individual. They are controlled by exogenously-given distributions, and they are not affected by job changes or changes related to other individuals (except for in- and out-migration which clearly have an impact on labour market situation). Labour market transformations refer to alterations in employment status and/or occupation. These transformations are designed as events that are directly connected to specific individuals, but there is an interaction (job competition) through the aggregates that represent labour supply.

In the simulation all individuals go through this process every year, and they may – according to conditions

Tabelle 1: Events occurring to the individuals in the model

Ereignisse, die den Individuen im Modell widerfahren können

Event	Description/Motivation
Start an education	Occupations have to be assigned to young people.
Get a job in his/her occupation	Every year individuals are confronted with the market clearing process in which some of them get/continue their jobs.
Get a job in a new occupation	Statistics on occupational changes provide probability distributions of every occupation.
Get a job after being outside the labour force	Individuals who have been studying, giving birth etc. have to be able to get a job again.
Return to the labour force	Some people choose to re-enter the labour force and start looking for work.
Leave the labour force temporarily	Individuals who start education, go into military service etc. may return.
Become unemployed	If the individual does not get a job in either his/her current occupation or any other possible occupation, then he/she remains unemployed.
Start commuting to another municipality	Unemployed individuals may start commuting.
Emigrate from Sundsvall	Neither the numbers of out-commuters nor unemployed can increase infinitely. At a certain point individuals will out-migrate.
Retire	Individuals may be retired anytime during their active period (16–64).
Die	Dying must be introduced in order to maintain a consistent population throughout the simulation.
Vacancy occurs	This is not an event from the individual point of view. If somebody dies a vacancy occurs and he/she has to be replaced.
Children and retired individuals die	The model has to distinguish between the deaths of active people on the labour market and the deaths of others.
Immigrate to Sundsvall	The flow of immigrants is based on empirical distributions in the database.
Immigrant gets a job	The same procedure as for local individuals.
Immigrant gets a job in a new occupation	The same procedure as for local individuals.

and probabilities based on sex, age, employment status and occupation – encounter a number of events that are described in Table 1. Throughout the simulation period individual events and aggregated events are registered, as well as the stocks of individuals and jobs.

New individuals enter by in-migration and they are assigned an occupation according to empirically estimated distributions. When the number of available jobs in a specific occupation exceeds a certain level a temporary modification of these distributions occurs (i.e. through the in-migration of individuals with demanded competence). In- and out-migration are also controlled by empirical distributions, which are based on database estimations by sex, age (six age groups) and occupation (the 30 most frequent plus the remainder).[6]

Figure 1 provides a general outline of the model, but it does not capture the underlying mechanisms related to the different boxes. For example, the mechanisms that control the market clearing process and its impacts on the individuals' employment status can be displayed more explicitly. Figure 2 shows the model structure for market clearing. Individuals endowed with a set of attributes enter and, later on, they exit with perhaps an altered set of attributes (i.e. they may get/lose a job, change labour force participation status or retire). An individual who is within the labour force and applies for a job is firstly confronted with the situation of whether or not he/she succeeds getting a job in his/her current occupation (everybody goes through this annual procedure). It should be observed that most individuals keep their current jobs for a period longer than one year. Employing a labour-market reproduction system in which everybody is dismissed once a year is not a

[6] The reason for aggregation is due not to technical constraints but, rather to the combination of matrix size and total flows. As the total in- and out-migration amounts to approximately 1,000 individuals per year, most cells in the matrix would be empty if all 240 occupations and one-year classes were used.

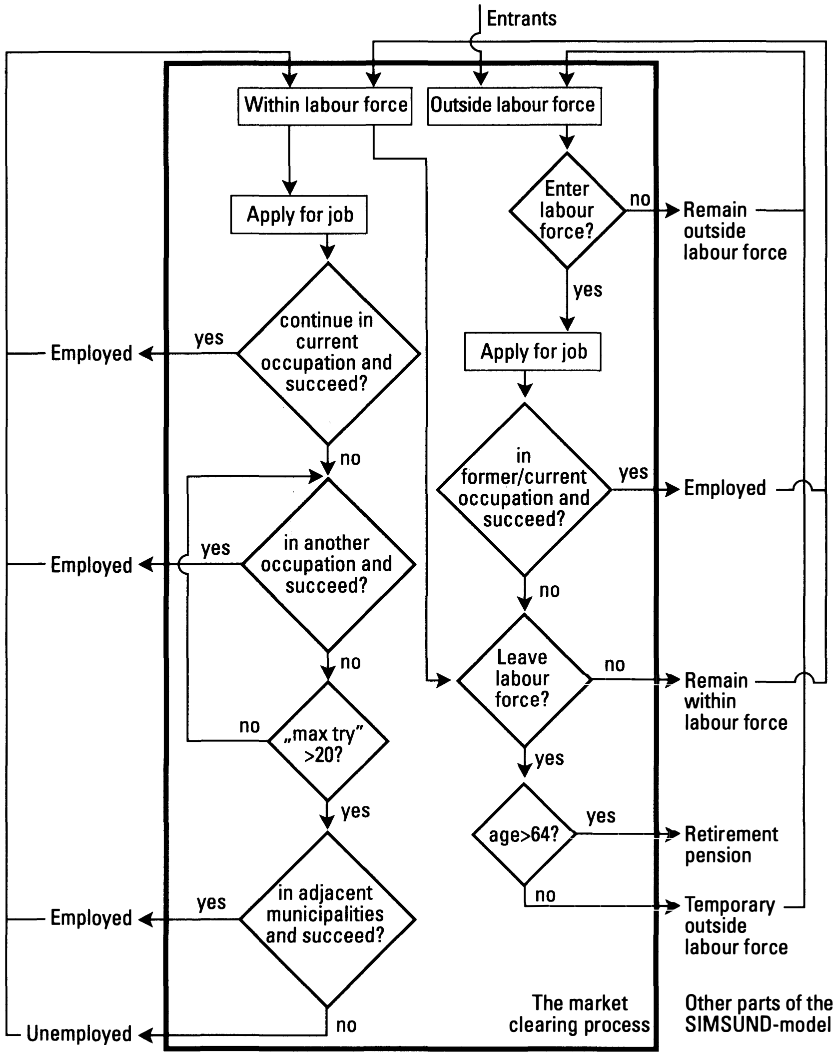

Fig. 2: The market clearing process
Der Arbeitsvermittlungsprozeß

satisfactory solution. Nevertheless, if an individual manages to get employment he/she exits from the market clearing process; if not, he/she is assumed to consider working in another occupation. The "max-try" parameter controls the number of chances the individual will have to find a job in another occupation ("max-try" = 20). The failure of this attempt brings him/her to the last opportunity which is commuting to an adjacent municipality. If none of these three possibilities turn out positively he/she will become unemployed till the next simulation year.

An individual who is within the labour force may also choose not to apply for a job. If he/she leaves, the outcome depends on his/her age – 65 years old or more implies retirement pension, other ages are considered to be temporarily outside the labour force. An individual who is outside the labour force has the chance of entering. If he/she manages to do that he/she is placed in the same position as those who are already within the labour force and apply for a job.

Another way of elucidating the structure of the model is to focus on events. There are 16 possible events that may occur and these are described in Table 1.

3.5 A technical description of the model

The computer programme that controls the SIMSUND-model is written in C++ and consists of 2,300 rows. It is easily interchangeable between Mac-

Tabelle 2: Model scenarios
Modellszenarios

Scenario characteristics
S1: Implementation
S2: Implementation plus short-term investment effect
S3: No implementation; employment reduction: the LWC-line; strong non-linear function
S4: No implementation; employment reduction: the LWC-line; weak non-linear function
S5: No implementation; employment reduction: the LWC-line; linear function
S6: No implementation; employment reduction: the Ortviken mill; strong non-linear function
S7: No implementation; employment reduction: the Ortviken mill; weak non-linear function
S8: No implementation; employment reduction: the Ortviken mill; linear function

intosh (Code Warrior 11), different unix computers, and PCs (Windows or NT) equipped with Visual C++. The programme is moderately object-orientated and it is based on the premise that a number of large aggregates (e.g. the population of Sundsvall amounting to over 100,000 individuals) can be stored in the core memory. Currently, 15 megabytes of RAM are required.

3.6 Outcomes

As the model is based on microsimulation methodology, results can be obtained in numerous dimensions. The model simulates possible paths for individuals in Sundsvall for 15 years ahead. Their biographies can be analysed and aggregated according to specific research questions. The central question in this study concerns the effects on the different local labour markets of employment and unemployment induced by an investment in the Ortviken mill. One of the qualities of the model is that it is able to distribute the primary change caused by the investment among individuals in different occupations and through time. The outcomes of the simulations will make it possible to elaborate the model with regard to which of the 240 identified partial labour markets will change and which of them will have substantial imbalances resulting in unemployment.

4 *Model scenarios and simulation output*

4.1 Model scenarios

Table 2 provides an outline of the different scenarios in the SIMSUND-model. The point of departure for the simulation consists of two reference scenarios in which the annual industry changes in terms of employment have been used. The first reference scenario (S1) involves the implementation of the investment, i.e. simulating population and employment dynamics by simply using the annual employment changes provided by NUTEK. As is shown in KLINT a. LINDGREN (1992; 1993) the LWC-investment also brought about a short-term economic effect during the implementation, which is taken up in the second scenario (S2).

The following six scenarios mirror alternative paths into the future without the investment implementation. Scenarios three to five (S3–S5) elaborate on the possibility of closing the LWC production line (approximately 250 employees), whereas scenarios six to eight (S6–S8) involve the shut-down of the entire Ortviken papermill (approximately 1,000 employees). All these scenarios imply employment reductions, but the rates vary.

4.2 Simulation output

The industry change estimates provided by NUTEK imply that the number of employed in Sundsvall increases from 49,300 (1991) to 51,100 in (2008). Figure 3 shows the development of the number of employed for ten replications of the first reference scenario and for the alternative scenarios (2–8). As the model is imbued with probability distributions it is pertinent to investigate the impact of the stochastic variation in comparison to the systematic variation (caused by changed assumptions, i.e. alternative scenarios). In order to get a grip on the stochastic variation the reference scenario (S 1) has been replicated ten times. Mean and standard deviations for the last simulation year (2008) have been calculated and compared to the outcomes of the alternative scenarios (S 2–S 8). By using confidence limits ($p \leq 0.05$) it is shown that the alternative scenarios differ significantly from the reference scenario, and these differences are clearly visualized in Figure 3. However, these results are strongly related to the level of aggregation. The employment numbers run up to about 51,600 in the end of the simulation, which is roughly half of the popula-

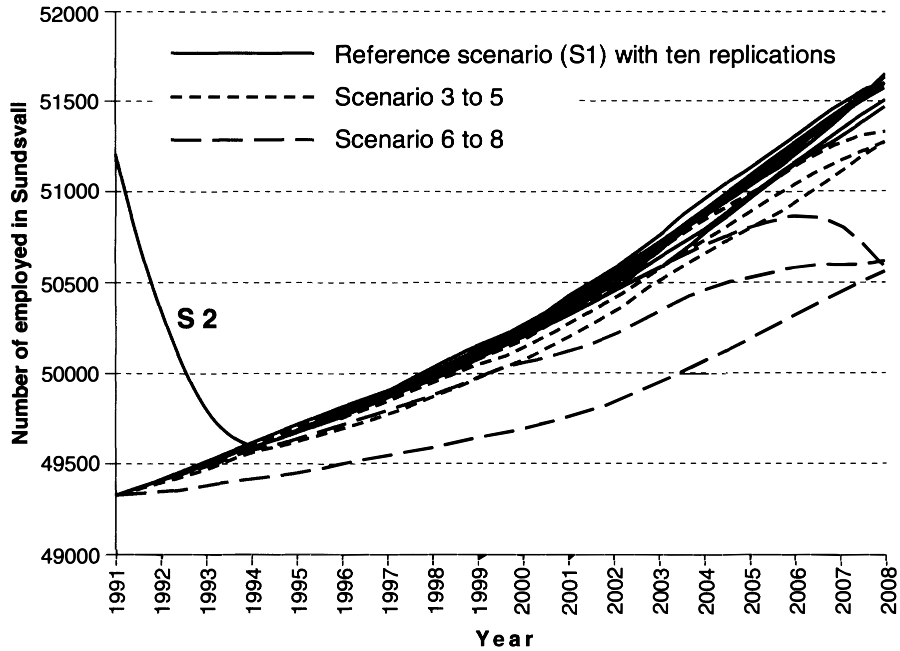

Fig. 3: Simulated development of the number of employed in Sundsvall
Simulierte Entwicklung der Beschäftigtenzahlen in Sundsvall

tion in Sundsvall. The same calculation is carried out on other model results; the number of unemployed (5,000) and the number of available jobs (50). In the former case there are still significant differences, but the result is not found as far out in the tails of the distribution. In the latter case the stochastic variation is much larger than the systematic variation, i.e. no visual distinction can be made between the replications and the alternative scenarios.

The second scenario (S 2) is also a reference scenario, but here the short-term impact has been added. There are, of course, problems connected to such a comparison, especially with regard to the straightforward calculation of employment impacts based on payment flows; but there are also problems due to its theoretical nature – for the employment developments in the other scenarios are based on empirical employment data, whereas the short-term impact is not. Nevertheless, scenario 2 hints at the magnitude of the short-term impact in comparison to the long-term impact. Scenarios 3 to 5 show the outcomes on employment if the LWC-line was closed in the beginning of the simulation and scenarios 6 to 8 reflect three possible course of events if the Ortviken mill was shut down at the same point in time. The direct effect of a total mill closure would mean a 2% employment reduction within the municipality in 2008. Similarly, closure of the LWC-line would reduce employment by 0.6%.

In order to analyse local employment and unemployment impacts induced by a closure of the Ortviken mill in 2008 (the last year of the simulation), the outcomes of scenarios 1 and 6 have been compared. Clearly, the employment reduction is distributed among 240 occupations, some being more affected by the change than others. Approximately 60% of the employment reduction and 40% of the unemployment increase take place within 10 occupations. Similarly, 65 of the occupations face 95% of the employment reduction caused by the closure. This implies that relatively few of the 240 occupations are strongly connected to the papermill. Calculated Gini-coefficients (I_G) of the occupation and the unemployment increase distributions, and of the occupation and the employment reduction distributions amount to 34 and 50, respectively.[7] As the measures of dissimilarity are different the shut-down of the Ortviken mill seems to give rise to imbalances on partial labour markets, i.e. unemployment changes that are not corresponding to the employment reduction.

Figure 4 shows in absolute numbers employment and unemployment differences between the scenarios

[7] The Gini-coefficient compares the distribution of an attribute with a hypothetical equal distribution. The value of the index goes from 0 (exact correspondence) to 100 (maximum inequality) (Robinson 1998).

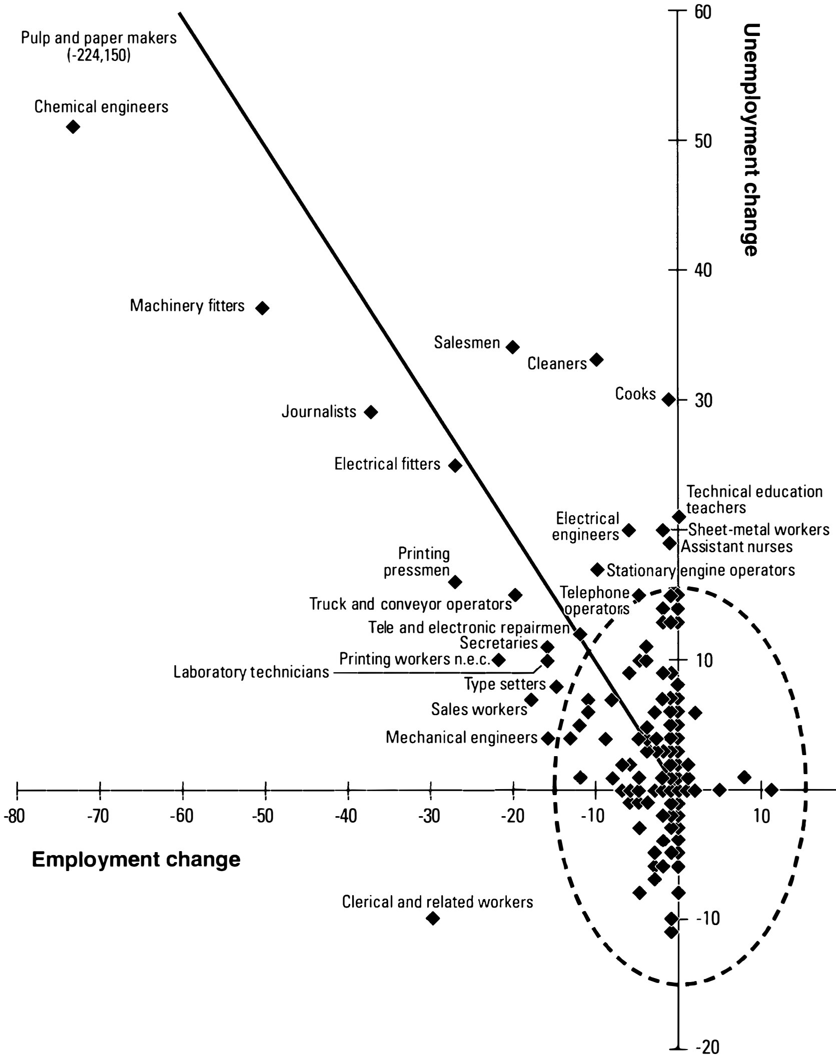

Fig. 4: Simulated employment and unemployment differences in Sundsvall, due to the closure of the Ortviken papermill (in absolute numbers in 2008) and comparing scenarios S 1 and S 6

Simulierte Beschäftigungs- und Arbeitslosigkeitsunterschiede in Sundsvall nach einer Stillegung der Papierfabrik (in absoluten Zahlen für 2008) und den Vergleichsszenarien S 1 und S 6

(S 1 and S 6) in the occupations (2008). Due to the stochastical process, some caution has to be used when interpreting occupations situated within the oval in Figure 4. Occupations below the diagonal line meet with larger employment reductions than unemployment increases, whereas the opposite condition prevails above the line. Most occupations (located around origo) are not affected at all, since they are not, or are only weakly, related to the pulp and paper industry. However, it is interesting to note that several occupations beyond the direct effect (employment reduction equals zero) do have unemployment changes. This is a sign of the indirect effect of the closure of the Ortviken mill (see Tab. 3).

It is hardly unexpected that the pulp and paper makers experience the biggest employment reduction, and 224 (54%) fewer individuals will work in this occupation as a result of shut-down of the mill. Some of the occupations in Figure 4 are not intuitively associated with the pulp and paper industry (e.g. journalists and precision-instrument makers), but they are nevertheless represented.[8] So, what are the possible explanations for the findings related to the occupation dynamics within

[8] Statistics on occupational affiliation are provided by the Population and Housing Census (FoB-90). For a more thorough presentation of data quality and comparability see FoB-90, part 5.

Tabelle 3: Occupations with the largest indirect effects
Berufe mit den größten indirekten Effekten

Occupation	Unemployment change
Technical education teachers	21
Childrens nurses	15
Railway conductors and yardmen	15
Bank tellers and finance clerks	14
Horticultural workers	13
Machine assemblers and engine mechanics	13
Attendants in psychiatric care	8
Midwives	–8
Insurance clerks	–8
Coaches and horse trainers	–8

the model? The outcomes in Figure 4 are the result of a comparison between two scenarios (S 1 and S 6) in which the conditions are the same in the model, except for a certain reduction of labour demand distributed among occupations in the pulp and paper industry. Hence, the dynamics cannot be entirely due to increasing or decreasing industry change estimates. It seems more likely that these dynamics are connected to the occupation change mechanism within the market clearing process.

In order to illustrate the impact of occupation transitions on unemployment, journalists and cleaners have been chosen. By relating the number of working individuals in these occupations as distributed among industries to the industry change estimates, a measure of 'standing' is obtained. It was shown that cleaners have a lower measure of standing than journalists, which implies that journalists are more likely to change to occupations that are well represented within expanding industries. Cleaners, on the other hand, are less likely to change to such occupations. The same mechanism (i.e. the combination of occupation transitions and industry change estimates) explains occupations that meet with no employment reduction but nevertheless register unemployment change (see Tab. 3). The closure of Ortviken releases manpower that will apply for other jobs on the local labour market. The combined process of occupation transitions and industry change generates the indirect effect.

5 *Concluding remarks*

The outcome of the microsimulation model has thrown light on the local labour market effects of closing the Ortviken papermill. It has been shown that linkages between different partial labour markets give rise to indirect impacts in terms of changed unemployment in occupations not represented in the pulp and paper industry. It would not have been possible to trace such imbalances arising on individual partial labour markets without a micro representation of the local socio-economic system. The SIMSUND-model may be further improved by employing a more thorough time-geographic design – the introduction of households and full interaction between individuals. In this type of model, actions performed by individuals can be connected to information, search and decision processes. Microsimulation modelling appears to be a powerful tool for impact studies and the analysis of labour market development, which should be elaborated in future studies.

Acknowledgement

The programming of the SIMSUND-model would not have been possible without the expertise of KALLE MÄKILÄ. He is a computer scientist with many years' experience of elaborating and programming microsimulation models, especially ones influenced by the time-geographical perspective.

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