Microelectronics and Unemployment in Austria

R. Dell'Mour
P. Fleissner
P.P. Sint

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INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

PREFACE

A joint seminar on flexible automation organized by IIASA and the Academy of Sciences of the German Democratic Republic took place in Berlin (East) in June 1982. In his paper, P. Fleissner from the Austrian Academy of Sciences presented an approach for assessing the economic consequences of microelectronics. During the discussion it was proposed that the model be applied to an economic assessment of robotization.

Heinz-Dieter Haustein

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INTRODUCTION

This paper presents the methodological background and some results of a study "Applications, Diffusion and Socio-Economic effects of Microelectronics in Austria", which was financed by the Austrian Ministry of Science and Research. The study was performed under the responsibility of the Austrian Institute of Economic Research and the Austrian Academy of Sciences (Bundesministerium für Wissenschaft und Forschung, 1981). The authors restrict themselves to their research work, which was done at the Institute of Socio-Economic Development Research of the Austrian Academy of Sciences.

The paper consists of two parts:

1. The description of the methodology how to measure the impact of technical change caused by microelectronics on the Austrian economy. For this purpose a mathematical simulation model was constructed which consists of an input-ouput-model, an econometric demand model and a model for linking technology and economy.

2. By means of socio-political scenarios the simulation model was used to produce conditional forecasts for the years 1985 and 1990 for the main economic indicators. Some of the results, in particular unemployment figures, are presented.

Although the presented approach was developed for the analysis of microelectronics, a special type of technology, the method could easily be used for any other type of technological change, robots etc., if this technology can be explicitly connected with certain economic indicators, like productivity, manpower, material inputs and outputs.

METHODOLOGICAL BACKGROUND

One of the typical difficulties in assessing the effects caused by new technology is the chronic lack of information. Although a lot of information on the technical level are available, the information about the link between technology and economy is rather scarce. On a highly aggregated level of the national account statistics in Austria no information of this type at all can be found. On this basis any method chosen should fulfil the following minimal properties:

- the method should allow to incorporate informations from different sources and different levels of aggregation

- the method should provide a framework for structuring and aggregating informations in a consistent and uniform way

- the method should be complex enough to reflect possible future states of the Austrian economy under different socio-economic side conditions

- the method should as well be simple enough that it is applicable under the constraints of rather limited resources (financial and manpower) and

- the method should produce results on the macrolevel of the economy to reduce the necessity of premature conclusions which are usually drawn from micro or meso (branch) level.

This imparatives in mind the authors decided to use an input-output concept as the core of a simulation model. The input-output framework allows for a simple and consistent sectoral and overall picture of an open national economy. To connect the framework with the labour market a simple extension was made: by a matrix of labour coefficients the vector of gross production was linked to the number of necessary hours of work. With the knowledge of the annual working hours per employee within one branch of production the number of employees can be computed.

But a major disadvantage remains at this stage of the model. Although the demand for labour is well defined, if the final demand is given, one cannot be sure if the final demand can be financed at all. To clarify this point, an econometric model for the determination of final demand was constructed. Both models are solved simultaneously (see figure 1).

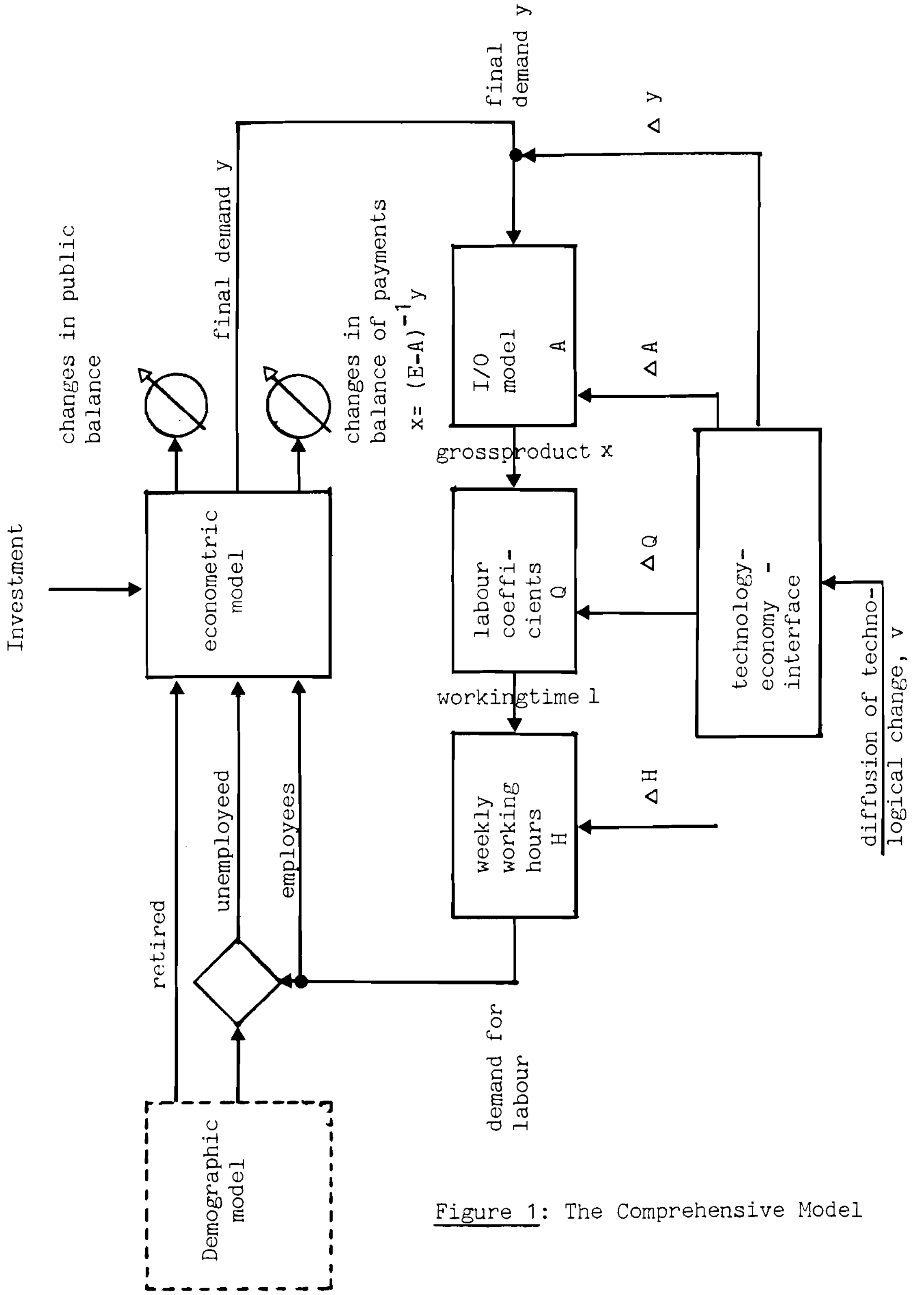

Figure 1: The Comprehensive Model

THE INTERFACE TECHNOLOGY-ECONOMY

So far the discussed model remains completely within the limits of usual economic model construction. To bring technology and its effects into this model, several additional considerations have to be made. At first the question arises at which variables or parameters of the described model the effects of changes in technology become visible. The authors have chosen the following subdivision of available parameters and variables:

a) changes in labour productivity per hour can be expressed in a change of the set of labour coefficients

b) a change of the input structure, e.g. energy saving, can be reflected by a change of technological coefficients and

c) effects of technology on final demand can be treated by changing the variables "consumption", "exports", "imports" and "investments".

All three changes have a single cause in common: the degree of diffusion of microelectronics. An hypothetical example shall illustrate the above concept: if one considers the consequences of the introduction of textprocessors into the office, productivity of labour may be increased by the factor 2. The input structure will not be influenced very much. One could assume that the necessary amount of paper will be changed in the type of forms (endless forms instead of single paper sheets), but there will be nearly no change in values. But one can expect a change of the balance of payments: let the mechanical typewriters completely be produced in Austria, while there is no home-production for wordprocessors. Therefore an increase of imports of this kind will be the result of the introduction of technology. If - on the other hand - wordprocessors will be produced in Austria, a shift from mechanical to electronic production will arise, which is reflected in a relatively increased value of investments as part of the final demand.

It is not difficult to generalize this example and to describe the verbal statements in mathematical terms: If one defines the following variables by

$\tilde{y} = y + \Delta y$	vector of final demand
$\tilde{A} = A + \Delta A$	matrix of input coefficients
$\tilde{R} = (E-\tilde{A})^{-1} = R + \Delta R$	Leontief-invers
$\tilde{x} = x + \Delta x$	vector of gross products
$\tilde{v} = v + \Delta v$	vector of value added
$\tilde{Q} = Q + \Delta Q$	matrix of labour coefficients
$\tilde{w} = w + \Delta w$	vector of number of workers
$w = Qx = QRy$	extended I/O - model

Additive changes are denoted by "Δ", resulting new values are characterized by "$\sim$".

By substitution one gets

$$\tilde{w} = \tilde{Q}\tilde{R}\tilde{y} = (Q + \Delta Q)\ (R + \Delta R)\ (y + \Delta y)$$

Matrix multiplication leads to the general result that the demand for labour can be split into additive partial effects of different order:

- the productivity effect
- the interaction effect
- the demand effect and
- combinations of the above effects resulting in higher order effects.

In mathematical terms:

$\tilde{w} =$	$w\ +$	old value	
	$\Delta QRy\ +$	productivity-	effect of first order
	$Q\Delta Ry\ +$	interaction	
	$QR\Delta y\ +$	demand	
	$\Delta QR\Delta y\ +$		effects of second order
	$Q\Delta R\Delta y\ +$		
	$\Delta Q\Delta Ry\ +$		
	$\Delta Q\Delta R\Delta y$		effect of third order

It becomes evident that the effects of first order can simply be added with one exception: total change by technological coefficients cannot be computed by simply adding the effects. A more complicated mathematical operation (inversion of a matrix) must be performed in this case.

ESTIMATING PARAMETER CHANGES

The discussion so far was done in very general terms. To be applicable, theory must be connected to the real world. Of course not every aspect of reality can be reflected in the model. The methodology hopefully cuts away unnecessary aspects and focusses on essential relations and variables. Therefore in this case, e.g. the creation of new firms, a special innovation process and its complications, the transfer of technology between firms etc. cannot be discussed within the model. The chosen methodology restricts oneself exclusively to these aspects of technology which can be linked to the parameters of the model. But on this level we have the same necessity to restrict the great variety of applied technology by a process of abstraction and generalisation to certain manageable types: The authors splitted the different types of innovations by microelectronics into three groups

- new production processes in the factory (e.g.CNC- machines)
- new production processes in the office (e.g. word processors) and
- new products where microelectonics is implemented (e.g.desk calculators)

Changes of these groupsshould be described by changes of the parameters of the model. One has to translate these innovations into their effects on the parameters and variables discussed above.

Let us discuss the estimation procedure in more detail by using the change of the labour coefficients by means of the introduction of word processors as an example. We consider one branch of production which is included in our input-output model. The labour coefficient q of this branch reflects the number of nesessary working hours per unit of output. If we look at the total number N of employees working in this branch of production, we can divide them into two complementary groups: one consists of the number of employees P, who are potentially affected by word processors, the other group consists of employees who are not affected by this type of innovation. s is the proportion of potentially affected employees with respect to N and a certain technology, the word processor.

After introduction of word processors we arrive at the following picture

<table>
<tr><td colspan="4">N ... total number of employees by branch</td></tr>
<tr><td colspan="3">P ... potentially affected employees</td><td>(N-P) not affectable</td></tr>
<tr><td>F'</td><td>R'</td><td>T'</td><td>N - P</td></tr>
<tr><td></td><td colspan="2">P'</td><td></td></tr>
</table>

$P' = R' + T'$

T' is the number of employees with innovated and more productive equipment,

R' the number of not yet affected employees and

F' the number of dismissed employees.

With p_0 ... productivity of labour before innovation and
p_1 ... productivity of labour after innovation, referring to employees with innovated equipment, and
$p = \frac{p_1}{p_0}$, ... the increase in productivity,

we get by definition

$$P = F' + R' + T'$$

$$R' = P - F' - T' \qquad (1)$$

By assumption of equal output before and after innovation

$$p_0 \cdot P + p_0 (N-P) = p_0 R' + p_1 T' + p_0 (N-P)$$

and by substitution of R' from (1)

$$p_0 P = p_0 P - p_0 F' - p_0 T' + p_1 T'$$

we end up with

$$\boxed{F' = (p-1)\,T'}$$

$$\boxed{R' = P - pT'}$$

For the numerical determination of the different parameters we used a variety of sources: to compute the value of s for each branch of production and type of technology we used the results of the national demographic account (Volkszählung 1971). There the working population is subdivided by sex, branch of production and by professions.[1] To determine p, the increase in productivity, we used different sources. Partly the p's were estimated empirically by questionnaires sent to 200 firms, partly they were fixed in accordance to international figures, especially derived by trade union institutes. Of course the authors are well aware that these figures are very rough ones, but at a first stage of assessment no other figures were available.

A very important parameter is the degree of diffusion v. It seems to be "natural" that v should remain within the limits of 0 and 1. v arrives at the value 1 if all the

1) Another approach was chosen by PROGNOS AG, Basel, Switzerland, in using a list of different types of human work activities instead of professions as a basis for the computation of possible effects of microelectronics to replace them (Prognos 1981).

workplaces which can be innovated are already innovated. For this purpose v was defined as follows

$$v = \frac{F' + T'}{P} = \frac{pT'}{P}$$

Under the additional assumption of constant output before and after the innovation one gets the change of the labour coefficient q

$$\Delta q = q \cdot s \cdot v \cdot \frac{1}{p} - q \cdot s \cdot v =$$

$$= q \cdot s \cdot v \left(\frac{1}{p} - 1\right)$$

In a similar way changes of technological coefficients can be estimated. Changes in final demand in the case of word-processors can be simply determined by multiplying the number of innovated workplaces with the costs of one wordprocessor in average. This gives the change in investment. If wordprocessors must be imported, this amount is equal to the change in imports as well.

FORMAL QUALIFICATION OF THE EMPLOYEES

By means of the three submodels, the expanded input-output model, the final demand model and the technology-economy interface, the number of workplaces and the main economic indicators can be computed under the assumption of a given level of investment, a certain lenght of the working week and a certain degree of diffusion of microelectronics in Austria. To estimate changes in the qualification of the labour force additional information about formal qualification was introduced into the model. For each branch of production the employees were subdivided by sex and formal degree of qualification (university, grammar school, vocational school and "others"). This structure was derived from the most recent available statistics. On the other hand by another detailed model of the qualification structure of the labour supply (as forecasted by the Institute of Socio-Economic Development Research) the available qualifications were compared with the qualifications of the workplaces as defined above. By this comparison bottlenecks or redundancies can be seen. This does not mean that in future this bottlenecks will really exist, but it indicates that some mechanism of adjustment will have to take place. Although the mechanisms itself need not to be defined in advance, nevertheless, possible frictions are indicated by this method.

Furthermore, the authors tried to determine very roughly the qualification structure of employees, which worked on redundant workplaces resp. of these employees, who work on newly created workplaces. Fig. 2 shows one example of this qualification vector, which consists of eight elements, by sex and formal degree of qualification. Negative figures indicate new workplaces, positive figures represent the percentage of workplaces which disappeared and were connected with a certain degree of qualification.

The resulting qualification structure consists therefore of changes in qualification, caused by changes in the production level of different branches, and of changes caused by the use of microelectronics

	"others"	vocational school	grammar school	university degree	
male	+ 50	+ 30	+ 25	- 5	= 100 %
female	+ 40	+ 45	+ 30	- 15	= 100 %

Figure 2: Qualification vector

SOME APPLICATIONS OF THE MODEL

The comprehensive model was used to illustrate several scenarios for the implementation of micro electronics in Austria. For this reason it was necessary to define basic or standard scenarios. These scenarios were modified by changing the degree of diffusion of microelectronics. Standard runs were computed for the years 1985 and 1990 under two different assumptions: constant working hours (40 hours per week as 1980) or decreasing workhours per week (37,5 hours 1985, 35 hours 1990). For the standard runs the model economy is governed by a growth in investment such that the average annual growth rate of gross domestic product amounts about 3 %, starting from an amount of investment like actual Austrian figures in 1980.

Three scenarios were created to define different sociopolitical developments as side conditions for the economy in the eighties. These scenarios were chosen in correspondence with the major economic interest groups in Austria:

1. Multinational scenario

   The interests of the multinational companies and the big enterprise in Austria result in a constant working week for 1985 and 1990, like 1980 (40 hours per week) and anaccelerated introduction of microelectronics(compared to the result of the questi onnaires) by importing the complete devices.

2. Trade Union scenario

   The Trade Union for Private Employees demands a reduced working week down to 35 hours. If the trend during the seventies is extrapolated for the eighties, one arrives at 35 hours per week in 1990. By means of collective contracts the speed of diffusion is reduced compared with scenario one. As in scenario 1 microelectronics is completely imported.

3. National scenario

   This scenario is based on the interests of the total national economy. It is similar to scenario two with one exception: the non-chip- hardware and the necessary software is not imported, but is produced inside the country. This scenario is similar to the Japanese approach to microelectronics

For these three scenarios the values for the following set of variables and the changes with respect to the corresponding standard runs are computed:

- main economic indicators on the macrolevel (consumption, investment, exports, imports, gross domestic product, average real wage rate, change in public expenditure, growth of productivity, growth of net real wages)

- economic indicators on the microlevel (degree of diffusion, number of innovated workplaces, redundant employees, investment for microelectronic goods in the shop floor, in products and office)

- labour market indicators (number of employees, self-employed, unemployed, changes in the number of workplaces by causes of this change)

- Formal qualification (number of employees and self-employed,resp. labour supply by degree of formal qualification and sex, qualification structure of dismissed).

In addition to these three scenarios special simulation runs were produced. One of them simulated the diffusion of microelectronics in Austria at saturation level (v = 1) for the year 1990, with constant working hours and completely imported technology (similar to scenario one). Another one computed the effects of an autonomous increase of exports by five percent applied on scenario 1. . A third run investigated the effects of an additional retirement of 50.000 employees applied on scenario 2.

SOME QUANTITATIVE RESULTS

Because of the limited space only the results of the standard runs and for scenario 1 are presented (see table 1 and 2). Scenario 1 results in a rate of unemployment higher than 10 % for 1985. For 1990 the basic unemployment of 220.000 is increased by 166.000 caused by microelectronics. This figure can be reduced by 133.000 if a 5 % autonomous increase in exports can be established.

Scenario 2 results in an unemployment of 224.000 for 1985. This means an unemployment rate of about 7 %. By the increase of homeproduction as a substitute for imports (scenario 3) compared with the standard run no additional unemployment is created. The labour saving effects of the application of microelectronics in the production is compensated by an increase in final demand.

An additional variant similar to scenario 1, simulating the effects of full degree of diffusion microelectronics for the year 1990 results in redundancies of 425.000 employees. This result seems unrealistic, because the actual speed of diffusion is much slower. Saturation will not be reached before the year 2000, more likely after 2010, if one takes into account the actual speed of diffusion as measured by the Austrian Institute for Economic Research.

With these results in mind one arrives at the conclusion, that by the introduction of microelectronics under Austrian conditions there will be a tendencv towards increased unemployment.None of the proposed policies (which seem to be realistic ones) are able to bring down unemployment to levels like in the seventies.

Table 1 : Standard Runs

	1976	STAND85/1	1985	STAND85/2	STAND90/1	1990	STAND90/2
Total Investment 1)	197	280		280	365		365
Priv.Consumption	416	555		529	654		596
Publ.Consumption	133	155		150	172		162
Exports	255	450		436	619		584
Imports	262	460		445	631		595
Exports-Imports	- 7,4	- 9,7		- 9,4	-10,9		-10,3
Gross Dom.Prod.	739	981		950	1.180		1.113
Net Wage per Capita (1000 AS)	101	129		121	150		131
Pot.Labour Force 1)	3.210	3.430	3.430	3.430	3.477	3.477	3.477
Working Hours p.W	42,1	39,9		37,6	39,6		35,2
Hyp.Unemployed (1000)	55	203		118	220		29
Unempl.Benefit	1,9	8,8		4,8	11,2		1,3
Working Pop.1000	3.222	3.191		3.276	3.221		3.413
male	1.936	1.380	2.130	1.934	1.883	2.175	2.004
Grad.(Univ.)	4,2	5,1	4,7	5,1	5,5	5,2	5,5
Upper Sec.Level	7,3	7,9	8,4	7,9	8,2	9,3	8,2
Voc.Training	5,8	5,7	6,1	5,7	5,7	6,3	5,7
Others	82,8	81,3	80,8	81,3	80,6	79,1	80,5
female	1.287	1.311	1.300	1.342	1.338	1.302	1.409
Grad.(Univ.)	1,8	2,1	2,6	2,1	2,3	3,5	2,3
Upper Sec.Level	6,9	7,7	9,9	7,8	8,2	11,6	8,3
Voc.Training	15,9	16,6	16,3	16,7	16,9	16,3	17,2
Others	75,4	73,6	71,2	73,4	72,6	68,6	72,2
Agriculture (%)	11,6	10,0	Erwerbspotential 1985	9,3	9,1	Erwerbspotential 1990	8,0
Industry (%)	40,8	37,9		38,3	39,6		37,5
Services (%)	47,6	52,1		52,4	54,0		54,5
GDP	229	307		290	366		326
Growth of Productivity 2)	-	+ 3,33		+ 2,66	+ 3,41		+ 2,55
Growth of GDP 2)	-	+ 3,20		+ 2,83	+ 3,40		+ 2,97
Growth of Empl. 2)	-	- 0,1		+ 0,18	0.		+ 0,41
Growth of Net Wage 2)	-	+ 2,76		+ 2,03	+ 2,87		+ 1,88

1) Exogenous Variable

2) Annual Percentage Rates of Change Referring to 1976

Economic Variables are measured in real terms, in Bio.AS.
The prices are based on 1976

Table 2 : Scenario 1: Effects Caused by Microelectronics

	STAND85/1 RASCH85/1 Abs.	Szenario 1 Relativ	STAND9o/1 RASCH9o/1 Abs.	Szenario 1 Relativ
Private Consumption	+ 7	+ 1,3 %	+ 21	+ 3,2 %
Public Consumption	- 1	- o,6 %	+ 2	+ 1,2 %
Exports	- 4	- o,9 %	+ 5	+ o,8 %
Imports	+ 9	+ 2,o %	+ 17	+ 2,7 %
Exports minus Imports	- 13,1	-	- 13,o	-
GDP	- 8	- o,8 %	+ 1o	+ o,8 %
Public Expenditure	- 11,3	-	- 17,5	- %
Net Wage per Capita (100 AS)	+ 5	+ 3,9 %	+ 9	+ 6,o %
Hyp.Unemployed	+137	+ 67,5 %	+166	+ 75,9 %
Unempl.Benefit	+ 6,6	+ 75 %	9,7	+ 86,6 %
Working Population (1000)	-137,7	- 4,3 %	-165,8	- 5,2 %
male	- 77,2	- 4,1 %	- 82,1	- 4,4 %
Graduated (Univ.)	+ o,8		+ 3,1	
Upper Sec.Level	+ o,7		+ 4,o	
Voc.Training	- 1,o		+ o,8	
Others	- 77,8		- 89,9	
female	- 6o,4	- 4,6 %	- 83,7	- 6,3 %
Graduated (Univ.)	+ o,4		+ 1,1	
Upper Sec.Level	- o,3		+ o,8	
Voc.Training	- 14,o		- 25,o	
Others	- 46,6		- 6o,6	
GDP per Capita	12	+ 3,9 %	+ 23	+ 6,3 %
Changes in Employment				
By Productivity	-12o,6		-2o1,8	
By Changes in Total Demand	+ 15,7		+ 37,7	
By Energy Saving	- 1,5		- 1,8	
By Effects of Interaction	o		+ o,1	

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