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Labor Demand, Capital Mobility and R&D Investment in a Multiregional Context

Paper

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I I R - DISCUSSION 25 1985

1. Introduction

The present contribution is to be seen in the framework of an ongoing research effort in the field of urban and regional labor market modeling for Austria. The basic spatial unit for which at least some relevant data are available is the county. Some results of this effort can be found e.g. in Schubert (1982), Maier and Schubert (1984); Baumann, Fischer & Schubert (1983). This paper is focused on problems of regional labor demand and investment in the secondary sector. Previous work on this topic is reported in Schubert (1981).

The hypothesis of regional disparities due to different intensities of R&D are a widely discussed subject these days. A first attempt at formulating a model which, in principle could be tested econometrically, dealing with R&D investment is included into the present contribution. Unfortunately the data available for the empirical work are not yet suitable for this task.

The aims of this paper can be summarised to be:

- the improvement of the already existing model of regional investment and labor demand for Austria (secondary sector without construction)

- a first attempt to formulate a model of R&D activities at a regional scale consistent with the investment and labor demand approach mentioned above

- a discussion of some empirical regional investment and labor demand phenomena in the light of the modeling results

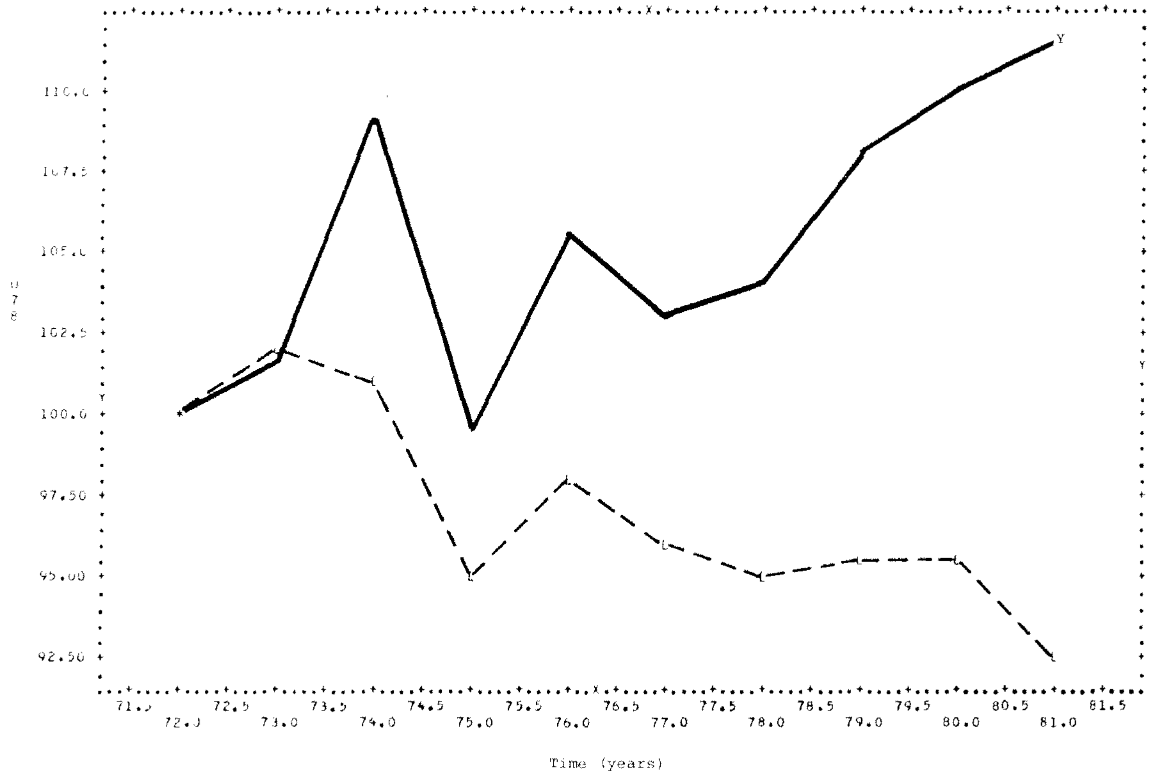
- a brief discussion of the usefulness of regional classifications of Austrian regions in connection with the labor market problems touched upon here. (For various classification schemes of regions in Austria, see J. Kaniak, 1983; Maier & Weiss, 1985)

Let us start by looking at the development of industrial employment and production in Austria since 1972 as well as the development of the capital stock in relation to production and employment (see figures 1a and 1b).

The graphs reveal clearly that, besides cyclical influences, a more or less continuous substitution process has taken place.

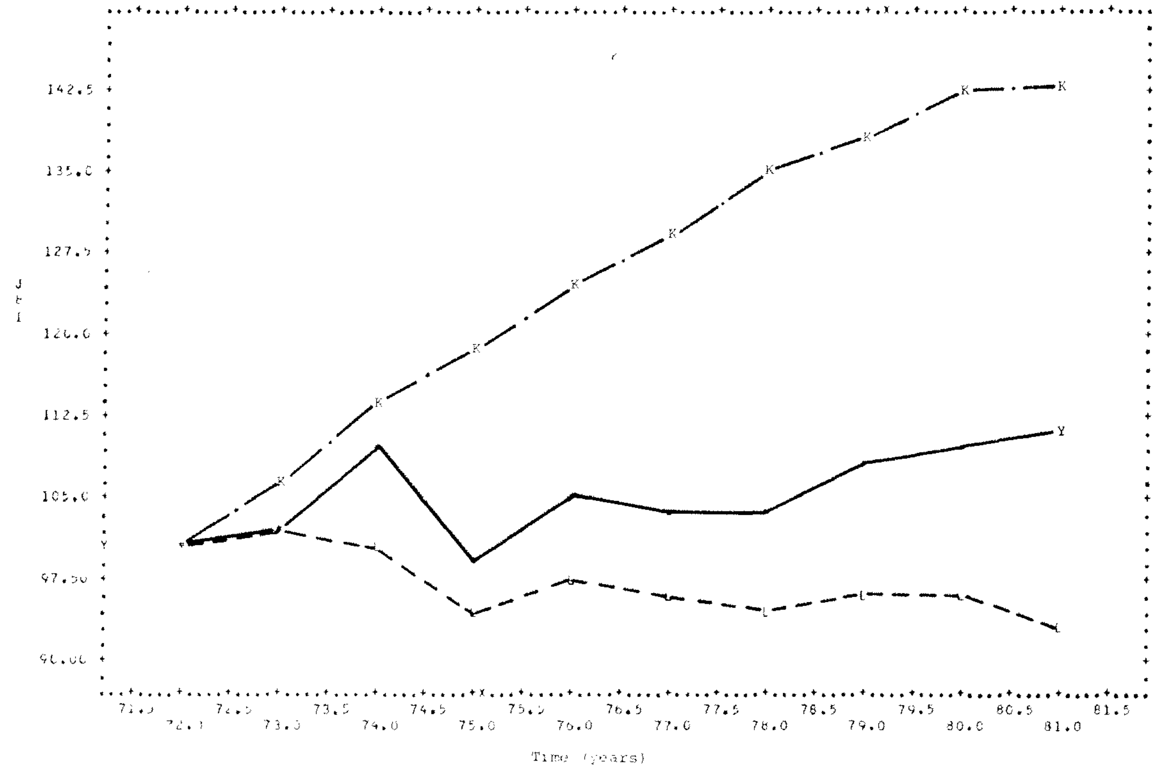
Secondary sector (without construction)

INDEX (1972 = 100) National total of net production value (real) and labor FIGURE 1 a



VARIABLE 2 Time VERSUS VARIABLE labor SYMBOL=L
VARIABLE 2 VERSUS VARIABLE NPW (real) SYMBOL=Y Net production value deflated with GNP-deflator

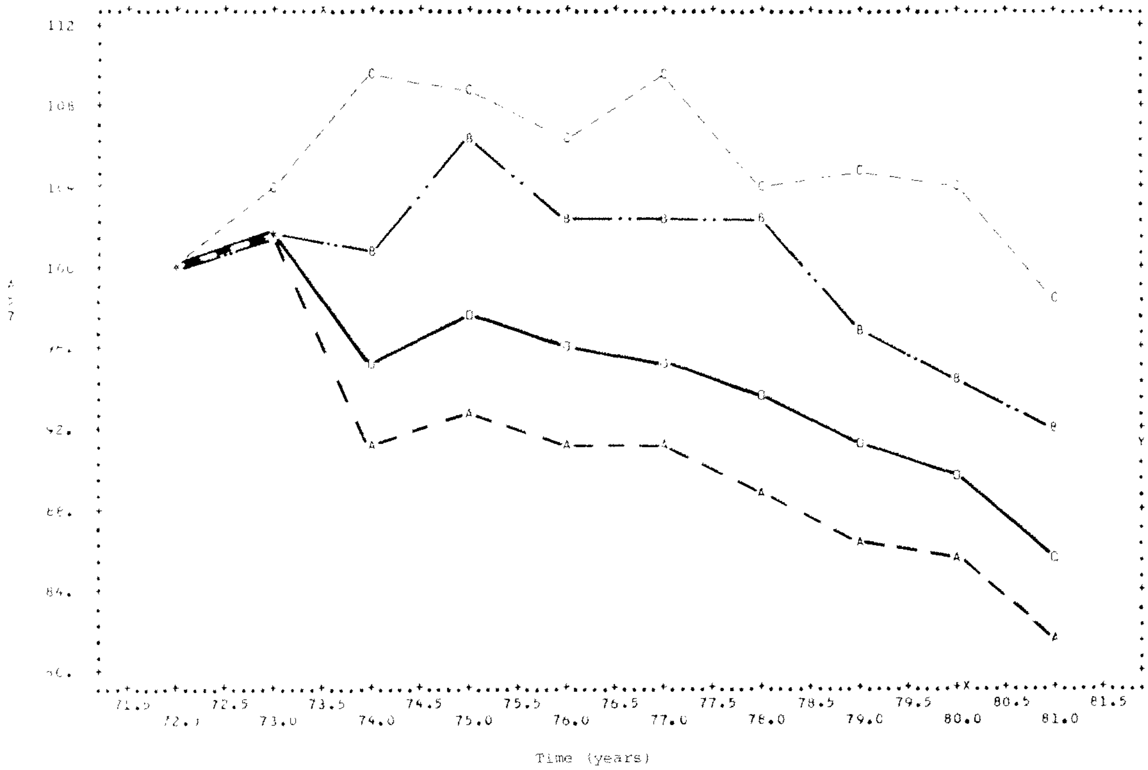
INDEX (1972 = 100) National total of capital stock (real), net production value (real), labor FIGURE 1 b



VARIABLE 2 Time VERSUS VARIABLE capital stock SYMBOL=K
VARIABLE 2 VERSUS VARIABLE NPW (real) SYMBOL=Y Net production value deflated with GNP-deflator
VARIABLE 2 VERSUS VARIABLE labor SYMBOL=L

Secondary sector (without construction)

INDEX (1972 = 100)   Labor input coefficients (real, secondary sector without construction)   FIGURE 2 a



VARIABLE 2 VERSUS VARIABLE labor SYMBOL=A Regions with high level of development
VARIABLE 2 Time VERSUS VARIABLE input SYMBOL=B Regions with medium level of development
VARIABLE 2 VERSUS VARIABLE coefficients SYMBOL=C Regions with low level of development
VARIABLE 2 VERSUS VARIABLE (real) SYMBOL=O National total

employees per 100 000 AS NPW (real)   Labor input coefficients (real, secondary sector without construction)   FIGURE 2 b

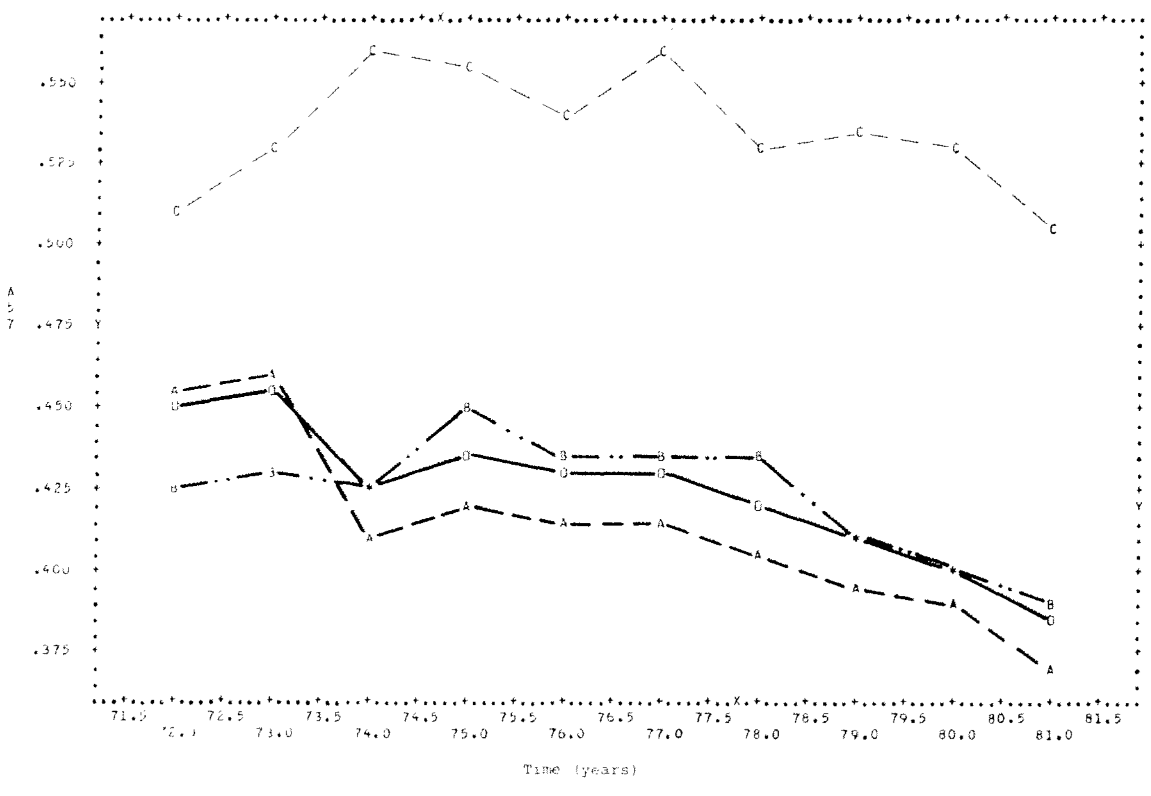


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Table 1. Interregional differences in R&D 1981

	R&D expenditure in Mill.AS absolute	R&D expenditure in Mill.AS representative firm	no of R&D-employees in a representative firm	Equipment in Mill.AS
variable names in R&D model		R	S	E
federal state				
Vienna	2484,8	16,8	26,6	5,3
Lower-Austria	517,3	5,6	9,6	2,3
Uper-Austria	1777,6	10,6	15,6	4,2
Burgen-land	27,3	2,3	3,7	1,0
Austria	6572,9	9,9	15,4	3,7

Computing labor input coefficients by dividing employment by production value (in real terms) leads to the next graphs (figures 2a and 2b). They show that there are significant differences between the average national development of this indicator compared to the regional time paths. Three types of regions are distinguished, the classification criteria being the level of development, accessibility, etc. (see Maier & Weiss, 1985). (Appendix A displays a map of Austria with all counties grouped into three types of regions) Differences between the levels as well as the time patterns emerge and it appears that a clear lag structure can be observed).

Economic theory in general and regional growth theory in particular views "technological progress" as the driving force causing the rise in productivity and providing the potential for new investment possibilities. This process of technological change is fed by various dynamic factors, among which R&D activities tend to rank high as engines of progress. The next table shows R&D expenditures for four federal states of Austria (Vienna, Lower Austria, Upper Austria, Burgenland) which roughly represent the types of regions mentioned above. Unfortunately the data used are at the moment only available for one point in time (1981), and at the rather coarse spatial scale of the federal state. The data set represents the results of a sample based survey of firms in Austria, so that a direct comparison or superimposition of data is not possible at present.

Even the rough estimates for a "representative firm" presented in table 1 show significant interregional differences and deviations from the national average, hence these indicators seem to warrant an approach based on various types of regions.

The theoretical question now arises what the determinants of investment, labor demand and R&D expenditures are and to what extent their weights vary when different types of regions are considered. These differences in reaction to changes in the decision variables can have two basic causes. There may be genuine differences in the perception and evaluation of those changes that correlate with the development level, or, the regional aggregates we are dealing with, conceal significant structural differences. The given data set makes a clear distinction of these effects impossible, hence, this question remains unsolved.

The paper proceeds by first looking briefly at the accounting framework underpinning the macro-approach taken in this study (section 2) and the modeling constraints imposed by the data limitations. Section 3 is devoted to a very brief presentation of a micro-economic model of a hypothetical "representative" multi-regional firm, the planning problem of which is to solve a multi-regional investment budget allocation problem over time. The optimal control approach adopted here is based on the pioneering work done by Rahman (1963), later modified and operationalised by de Bruyne & v.Rompuy (1977). Previous work by Schubert & Hampapa (1979) and Schubert (1981) follows the same lines. The tentative modeling attempts to come to grips with R&D expenditures owes thanks to a recent survey by Malecki (1984) and some considerations by Nijkamp & Schubert (1985).

In section 4 the theoretical model is transformed into an operational form which allows econometric work. The data restrictions already mentioned obviate an empirical treatment of the R&D expenditure hypotheses. The results of the regression analyses are briefly discussed in this section as well. In section 5 a few possibilities for further work related to R & D investment are briefly discussed and a short summary is provided.

2. Prerequisites for macro - modeling - data and some accounting problems.

As mentioned in section 1 the smallest basic spatial unit at which most of the necessary economic data are available is the county. Since 1972 annual information (for the secondary sector excluding the construction sector) on employment, net and gross production values, investment expenditures as well as the sum of wages are available. Estimates of the capital stock consistent with the regional investment data as well as the national estimates of the capital stock in Austria were made by E. Brunner. Information on various price levels is only obtainable at the national scale. A graph of the Austrian interregional transportation system (Kaniak, 1983) provides the average travel times used in the calculation of distance effects. The limitations of the R&D related data set were already hinted in section 1.

The micro-model of a hypothetical multiregional firm below acknowledges the fact that the interregional mobility of capital has to be taken into account. Especially in the period 1972-1981 considerable suburbanisation of production facilities took place as well as some significant changes in the investment propensities of small towns in several areas (see e.g. Maier & Tödtling, 1984). A direct test of the model outlined in the following section requires information at the micro-level about interregional capital flows. This information is not available, only data on the total volume of productive investment at the county level are given. A reduced form approach is hence chosen which makes use of the marginal distribution of a hypothetical capital flow matrix, in which the sum over the rows yields all the investment arriving in the respective region (the sum over the columns represents all investment emanating from a given region).

(1) $$I^{\cdot k} = \sum_{k=1,n} I^{jk}$$

The theoretical model of section 3 attempts to clarify the determinants of I^{jk} for a "representative firm", in section 4 the accounting identity shown in figure 3 is utilised to derive a testable macro-model, for which data on (I) for the period 1972-1981 for all 98 counties in Austria are available.

3. Planning at the micro level - the allocation problem of a multiregional firm

3.1. The decision problem

In this study only the production factors capital (K), labor (L) and knowledge (T), treated as stock variables, are considered. The equivalent flows are investment (I), hiring and firing of labor (H), patents (P) and R & D investment (R). Specific combinations of these factors represent "technologies", by means of which goods (Y) can be produced.

In standard economic analysis it is often assumed that changes in the stocks of the production factors cause no internal frictions, often implying temporary losses in output. The installation of new machines or the introduction of a new technology takes time in which productivity suffers, however, new labor has to be trained to acquire the specific skills necessary, it usually takes time to find the extra labor required, the expansion of a productive facility on new land takes time in which production is partly even impossible, etc.. Due to lack of data the land market issue will not be dealt with in this contribution. These "production detours" (Böhm - Bawerk, 1889; Hicks 1973) imply that a "production sacrifice" has to be made now, to be able to reach higher production in the future. These considerations lead us to the formulation of the following production function (leaving out time subscripts):

(2) $$Y = f(K,L,T,I,H,P,R), \; f_K, f_L, f_T \geq 0, \; f_I, f_H, f_P, f_R \leq 0$$

The f. denoting partial derivatives.

To simplify the analysis we will assume, that the productivity losses, due to changes in the productive capacity last only one period, i.e. Y does not depend on:

(3) $$I_{t-\tau}, \; H_{t-\tau}, \; P_{t-\tau}, \; R_{t-\tau} \; ; \quad \tau = 1,2,\ldots,\bar{\tau}$$

Investment can be positive or negative (disinvestment). Using an interregional accounting framework, we can (at least theoretically) keep track of all the investment expenditure originating in region j and indicate to which regions (k) it goes.

I^{jk} is the volume of investment goods placed in other regions in a given time period.

Pooling this information for all regions yields an interregional "investment flow" table (similar to an input-output table, see e.g. Klaassen and Molle, 1981 a), at the level of the individual firms. We will make use of this accounting framework again when we turn to the macro economic situation.

As actual, physical transfers of investment are only an exception, a different concept of "investment flows" underlies this model. The region of origin (j) is to be interpreted mainly as the region where the decision is made and multiregional investment is controlled. The region of destination (k) is equivalent to the location of actual investment. This concept finds expression in a hypothetical table analogous to figure 3.

Investment causes a change in the capital stock, i.e. the "internal production conditions" of the firm are different because of a decision taken in the past. K stands for the productive capital in region k controlled by the firm resident in j. The decision maker has to take dynamic stock-flow conditions into account.

The net change of the capital stock is equal to gross investment minus replacement. Assuming that capital depreciates at a constant rate and measuring time continuously we obtain:

$$(4) \qquad \dot{K}^{jk} = I^{jk} - \delta K^{jk}$$

To produce goods, labor and knowledge are required besides capital (see (1)), hence analogous dynamic constraints have to be observed for labor and knowledge as well:

The net change of labor employed is equal to the number of laborers hired and fired minus the number of laborers leaving the firm (because of retirement, change of job, accidents, etc.).

(5) $\dot{L}^{jk} = H^{jk} - \gamma L^{jk}$

where γ is the labor turnover rate.

The stock of technological and organisational know-how (T) changes when the firm either buys patents (P) and/or invests in research (R). It is assumed that a constant fraction of this stock of knowledge becomes obsolete in each period.

(6) $\dot{T}^{jk} = (P^{jk} + R^{jk}) - \varepsilon T^{jk}$

One allocation problem to be solved by the decision makers is whether to invest in already available knowledge in the form of patents or to engage in the risky business of paying for research. At this point no distinction is made between research done in the firm itself or whether it is contracted out. The change in the stock of knowledge is considered as an output of a knowledge production process, the inputs into which are "scientists and other personel" (S), "equipment" (E) and the stock of knowledge given at the time. This production of knowledge is a risky enterprise, hence the production volume is basically a stochastic variable, whereas buying a patent is practically risk free.

(7) $R^{jk} = g(S^{jk}, E^{jk}, T^{jk}, \sigma^{jk}), \; R_S, R_E, R_T \geq 0,$

where σ is a stochastic disturbance term, reflecting risk.

(Note that we have assumed that E and S are flow variables and that the change of knowledge is friction less in this simplified model).

We further postulate that the labor turnover rate (γ) as well as the rate of capital depreciation (δ) and (ε) are constant and not regionally differentiated.

Profits at each period of time (π) are defined as revenue minus cost.

As we are only considering a one-product firm, which can sell its single product at a given price p^k, total revenue from the sales of the goods produced in several regions are:

(8) Total revenue= $\sum^{k} p^k Y^{jk}$

where Y^{jk} represents the production volume of a firm located in k and controlled from j.

The price level p^k signalizes the demand for the product to the multiregional firm and is assumed to depend on the disposable income in the demanding regions.

Total factor cost of the production process constitutes total cost. Let us consider capital and investment expenditures first. Investment goods are usually bought in a very large market (the world or the national market) in which prices are usually fairly uniform. We suppose then, that the aggregate investment good can be purchased at a spatially invariant price q_I. The total sum to be spent for investments located in several regions is:

(9) Total investment goods' cost = $q_I \sum^{k} I^{jk}$

For the existing capital stock at time t opportunity costs have to be paid. Let the interest rate (r) be uniform over the national system, thus implying that the financial markets in a country are "regionally integrated".

(10) Total capital cost = $rq_I \sum^{k} K^{jk}$

Besides these direct costs, there are the indirect costs of transferring investment to other locations and the transaction costs of investment in general. There are many components of these, such as the cost of information, which especially for new investment in a region different from the control location, can be quite substantial. Empirical studies, based on surveys (Klaassen & Molle, 1981) have shown, that for this reason only very few potential locations are investigated in any detail to find out whether an investment there would be worth while. Usually "nearby" locations are the prime candidates.

Relocation implies that there may also be costs of the physical transfer to be reckoned with, etc.. We postulate hence, that the total transaction cost of investment is positively related to the total volume of investment and to the distance of the region of destination from the region of origin, on which information cost as well as physical transfer costs depend.

(11) Transaction cost of investment $= \sum^{k} TI(I^{jk}, d^{jk}), \; TI_I, \; TI_d \geq 0$

Turning to labor now, new labor often has to be trained to acquire the necessary skills, there are filing fees, social security expenses, etc. (Scanlon and Holt, 1977). To keep the model as simple as possible, these costs are the same for hiring and for firing (with a negative sign).

(12) Sum of wages $= \sum^{k} w^{k} L^{jk}$

(13) Friction cost: $\sum^{k} C(H^{jk}), \; C_H \geq 0$

The cost to be borne for the provision of the production factor "knowledge" (T) consists of the purchasing cost for patents and/or R & D in the form of wages for scientific personel (S) and equipment (E):

(14) $q_P P^{jk} + (w_S S^{jk} + q_E E^{jk})$

The already existing stock (T) causes per unit running costs of (r_T) · R&D investment expenditures which are not made in the control region cause transaction costs, supposed to rise with the volume of the expenditures and with the distance from the control region:

(15) Spatial friction cost of R & D = $\phi\,(R^{jk}, d^{jk})$

Costs of technological know-how:

$$(16) \qquad q_P P^{jk} + (w_S S^{jk} + q_E E^{jk}) + \phi(R^{jk}, d^{jk}) + r_T T^{jk}$$

Collecting terms, we can now compute the total profit of a multi-regional firm at time t.

$$(17)\ \pi^j = \sum^k (p^k Y^{jk}) - q_I \sum^k I^{jk} - r q_I \sum^k K^{jk} - \sum^k TI\,(I^{jk}, d^{jk})$$

$$- \sum^k (w^k L^{jk}) - \sum^k C^k (H^{jk}) - \sum^k (q_P P^{jk} + w_S S^{jk} + q_E E^{jk} +$$

$$\phi\,(R^{jk}, d^{jk}) + r_T T^{jk})$$

3.2.The demand for investment goods, labor and R & D investment

The demand for production factors is derived by maximization of the present value of the hypothetical multiregional firm.

Let be the rate of discount of future earnings, so that the present value (V) of the expected profits is:

$$(18) \qquad V_t = \int_0^{\infty} e^{-\rho t} \pi dt$$

The variables the decision maker can control in each period of time, are investment (I), hiring and firing (H), R&D-personel (S) and equipment (E), patents (P), and the volume of production (Y). The stock variables K, L and T are the consequences of past decisions, thus representing the state variables.

The question then is, what levels of the control variables have to be realized in a given period to maximize the present value of the expected future profits arising from these controls.

To solve this kind of cost-benefit analysis we will make use of optimal control theory and the Pontryagin Principle (Pontryagin et al, 1962).

The relevant control problem is:

Maximize V (see Equation (17) & (18))

given: (2), (4), (5), (6), (7)

(The stock variables K, L & T cannot become negative).

The Pontryagin Principle (see e.g. Arrow, 1968) applied to this problem, postulates (assuming the non-negativity constraints on K, L and T to hold):

(a) The sum of the marginal effects of a change in the control variables has to be equal to the scarcity prices (λ) of the relevant stock variable at each period (control conditions), where the scarcity price measures the marginal contribution of the relevant stock variable to the present value.

$$(19) \qquad -q_I - TI_I jk + p^k f_I jk + \lambda_1^{jk} = 0$$

where λ_1^{jk} is the "shadow price" of capital in region k

(20) $$-w^k - C_H^k jk + P^k f_H{}^{jk} + \lambda_2^{jk} = 0$$

where λ_2^{jk} is the "shadow price" of labor, and

(21) $$p^k f_P - q_P + \lambda_3^{jk} = 0$$

(22) $$p^k f_S jk - w_S + \phi_R jk \; R_S jk + g_S jk \;\; \lambda_3^{jk} = 0$$

(23) $$pf_E jk - q_E jk + \phi_R jk R_E jk + g_E \lambda_3^{jk} = 0$$

(b) As stocks accumulate (or diminish), their scarcities change, so do, hence, their shadow prices. One part of this change is caused by discounting the future, the second part consists of the gap between marginal cost and revenue caused by a change in the stocks.

(24) $$\dot{\lambda}_1^{jk} = (\delta+\rho)\lambda_1{}^{rk} + rq_I - p^k f_K jk$$

(25) $$\dot{\lambda}_2^{jk} = (\gamma+\rho)\;\lambda_2{}^{jk} + w^k - p^k f_L{}^{jk}$$

(26) $$\dot{\lambda}_3^{jk} = \lambda_3^{jk}(\varepsilon+\rho) - p^k f_T{}^{jk} + \phi_R R_T^{jk} + r_T + \mu\, g_T$$

(Note that the assumption of a very slowly changing transportation and communication network was made implying constant d^{jk}).

Given "well-behaved" problems, (for a discussion of second order conditions and stability see: Brock and Scheinkman, 1977), following these rules will lead to optimal production, location, investment, R&D, etc. plans. The indicated rules represent a system of simultaneous equations which can be solved to yield the optimal levels of I, H, S, E, P for all locations, i.e. the dynamic demand equations for production factors.

Computing the time derivatives of the control conditions yields equations for the dynamic of the co-state variables λ. Simultaneously the shadow price relations have to hold. Rearranging terms yields solutions of these sets of equations, which, given specific functional forms could be solved for the optimal levels of the control variables as a function of prices, parameters etc.

The solution with implicit functional forms are of the following nature:

$$(27) \quad (\dot{TI}_I jk) - (\dot{p}^k f_I jk + p^k \dot{f}_I jk) - (\delta+\rho)(TI_I jk - p^k f_I jk)$$

$$= (\delta+\rho)\, q_I jk - \dot{q} + r q_I jk + p^k f_K jk, \text{ etc.}$$

4. Towards an operational model and some empirical results.

4.1 From theory to testable hypotheses.

In order to be able to attempt an empirical test of the claims just made, further, more specific assumptions have to be made.

The production function

$$(28) \quad Y^{jk} = A\, (K^{jk})^{\alpha}\, (L^{jk})^{\beta}\, (T^{jk})^{\gamma} - (aI^{jk} + bH^{jk} + cP^{jk} + \bar{c}R^{jk}).$$

In this special case the marginal frictions are constant, the change over time equals zero.

Let the transaction cost of changing the capital stock be the square of the volume of investment and multiplicatively related to the distance between the region of origin and destination of a capital transfer. To facilitate the analysis we also postulate that these costs are always equally high, independent of whether it's the first investment in a new region or a subsequent one.

$$(29) \qquad TI\ (I^{jk},\ d^{jk}) = m(I^{jk})^2\ .\ \psi\ (d^{jk})$$

The cost of changing the labor force changes with the square of the level of change.

$$(30) \qquad C(H^{jk}) = h\ (H^{jk})^2$$

The allocation of R&D investment to a region (k) can be assumed to follow a similar rule.

$$(31) \qquad \phi(R^{jk},\ d^{jk}) = n\ (R^{jk})^2\ \ \psi(d^{jk})$$

To simplify matters further and to make the problem tractable from an econometric point of view we approximate marginal products by average products.

Making use of all these special assumtions yields demand equations of the following forms for investment and labor demand.

$$(32) \qquad I^{jk} = \frac{1}{2m\,\psi(d^{jk})} \{ (\delta + \rho)\, q_I - \dot{q}_I + p^k m - \dot{p}^k a + r q_I - p^k\, (Y^{jk}/K^{jk})\, \alpha - 2mI\, \psi(d^{jk}) \}, \text{ etc.}$$

Making use of the "representative firm" concept we assume that the aggregate demand function of investment and labor demand follow the same pattern as they do for the individual decision-maker.

Theoretically, the interregional investment flow matrix could now be filled row by row. Making use of the accounting identity developed in section (2) we could derive the total investment actually undertaken in a region by summing over the rows in figure 3. By the same token the right hand side of the demand equations have to be summed now, yielding a macro formulation of the relevant equations.

Some further, rather ad hoc assumptions were made to cope with the fact, that at present the fuller version of the model including R&D expenditures cannot be tested due to the lack of appropriate data. Technological progress, if not explicitly modeled, expresses itself via capital & labor productivity. The theory of innovation diffusion postulates, applied to the question of the spatial distribution of productivity, that these are related over space and time. Again Austrian data at present do not permit a specification of this process explicitly. To salvage some of this idea we simply computed "productivity potentials", i.e. distance factor discounted sums of productivities. Note that in the aggregation procedure to derive regional investment all variables on the right hand side are weighted by the distance related spatial friction cost variable, the sum over which yields some aggregate measure of the region's "accessibility". This measure, if not computed explicitly, influences the coefficients of all variables, this was taken into account by the specification of separate models for different types of regions, for which this measure is hypothesized to be fairly homogeneous. The explicit calculation of these accessibility weights raises the problem of the proper cut-off point -- which has not been solved satisfactorily, yet.

Another type of problem is raised by the specification of the appropriate factor costs. In the case of the capital goods the, probably not very heroic, assumption of uniform relative capital costs over space were made. For average industrial wages this assumption notoriously does not hold, as our data set clearly revealed. In the absence of a good econometric grip on the question of wage determination over time and space to be modeled explicitly, a very simple approach was tested. No separate simultaneous wage determination model was formulated, but the spatial connectivity of regional labor markets was expressed by a simple distance discount weighted sum of regional wages. This specification fared better empirically than the assumption of spatial independence of wages, i.e. the use of region of destination wages only.

The next specification problem arose out of the fact that no regional output price indicators are available. An inverse demand function approach was tried in which the price level depends on the quantity of output and income as well as on the national rate of inflation. As the demand for goods in a region arises in the form of domestic plus export demand, incomes in the other regions exert only a "cost" (distance) corrected influence, a construct leading to the specification of income potentials -- which were calculated for exports to foreign countries separately. As income data on the county level are not available in Austria, net production values were used as proxies.

Summarizing, the following equations were the bases of estimations:

$$INV = A_0 + A_1\ QR + A_2\ DNPW + A_3\ DIDEFL + A_4\ KPPO + A_5\ NPW + A_6\ PNPWPO + A_7\ DGBNPDEF + A_8\ DPNPWPO + A_9\ DBIPRW + A_{10}\ DINV$$

$$DB = B_0 + B_1\ WPO + B_2\ DNPW + B_3\ DWPO + B_4\ APPO + B_5\ NPW + B_6\ PNPWPO + B_7\ DPNPWPO + B_8\ DBIPRW + B_9\ DDB$$

with

INV	Investment demand
DB	(Change of) employment demand
QR	Product of investment goods deflator and interest rate
DNPW	Change of net production value
DIDEFL	Change of investment goods deflator
KPPO, APPO	Potential of capital (labor) productivities
NPW	Net production value
PNPWPO	Product of GNP deflator and net production value potential
DPNPWPO	Change of PNPWPO
DBIPRW	Change of sum of GNP's of the major Austrian foreign trade partners
DINV	Change of investment demand
WPO	Wage potential
DWPO	Change of WPO
DDB	Second derivate of labor demand
DBNPDEF	Change of GNP deflator

4.2 Some empirical results.

As mentioned above the parameters of the equations for different types of regions containing the same set of independent variables. The hypothesis to be tested was that investment demand reacts in a different qualitative (i.e. a different set of significant coefficients is to be expected) as well as quantitative (the elasticities of the variables differ) manner.

Although different estimation techniques were used, the following discussion is based predominantly on the 3 SLS parameter estimates. In general it can be observed that in terms of the goodness of fit statistics (R^2, etc.) the investment model proved to be fairly successful (see detailed tables of results in the appendix), while the labor demand equations came out rather badly on these terms. One has to add, however, that labor demand is actually estimated in the form of the rate of change of demand, a fact which usually implies worse goodness of fit characteristics.

In both submodels the dominance of the "accelerator hypothesis", i.e. the strong reactions of the decision-makers to changes in the demands for the respective outputs, is clearly established.

Furthermore productivity changes seem to play an important role. The specification in terms of potentials to signal the spatial interdependence of thechnological progress fares better than the inclusion of the productivity of the region of destination only. This result suggests, however, that a more theory based approach towards R&D investment seems to be warranted.

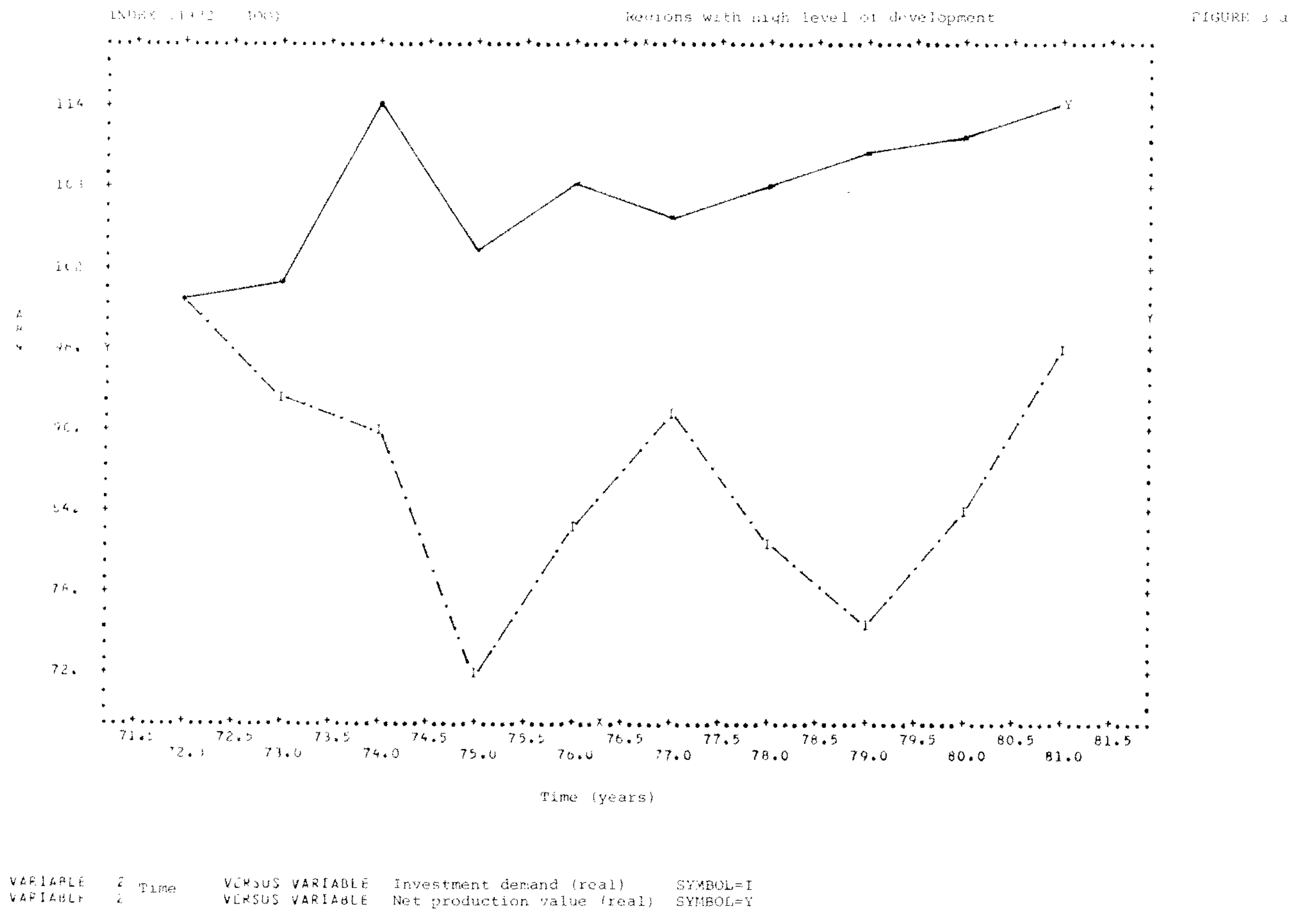
A similar argument holds for the wage potential, as a specification for the wage determination process.

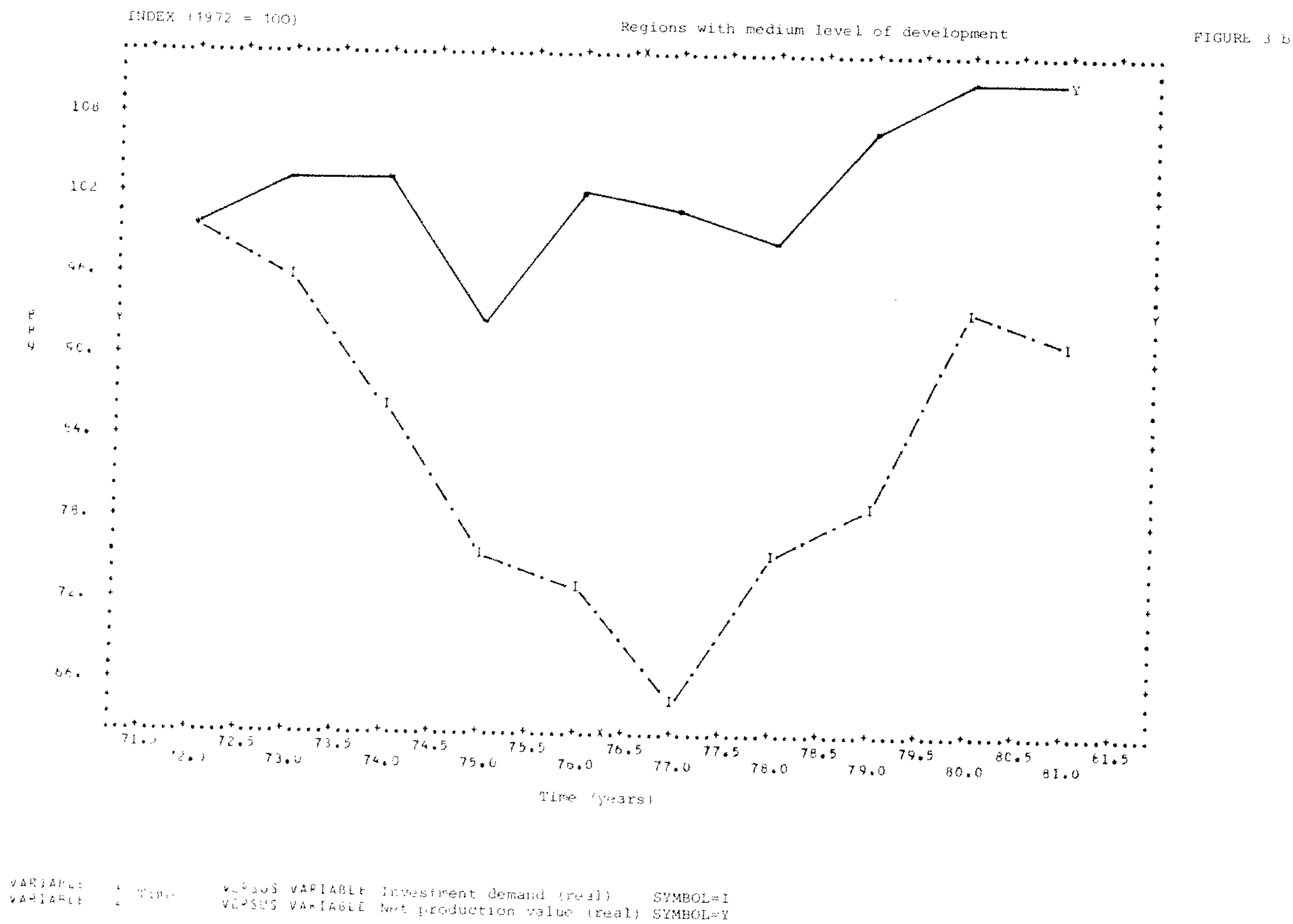
Turning to the investment demand model in more detail now, the results reveal that the significance of the variables varies greatly over the different types of regions (see table A 1 in the appendix). For the most developed, the urban regions,the list of significant variables (t values 1.9) is the longest, as the development level falls, fewer variables seem to matter. A closer look at these variables reveals that in the regions with a lower development level it is predominantly demand change and the cost of capital that count. While the full set of variables applies only to the highest development level. Interpreting this result in the light of the product cycle hypothesis, firms in the economic periphery of a country tend to produce either industrial routine products where substitution processes can no longer be set in motion, or very small firms produce for local everyday needs, for which a more or less fixed technology leads to the same results. Expanding the production capacity becomes predominantly a question of the volume of demand for the goods produced. High interest rates make life for these firms difficult, so they tend to wait for better times. In the high development regions the firms generally tend to have a certain range of substitution possibilities at their disposal which implies that all the cost information necessary to make decisions about substitution processes are taken into account. This is particularly true in the rings of the agglomerations, which in the period 1972 - 1981 represented the industrial heartland of Austria. In the core regions, where many innovations tend to see the light of the industrial day, demand for the products tends to matter more again than the cost variables. (In the present contribution however, cores and rings are not distinguished explicitly).

A similar picture emerges regarding the elasticities. Demand variables (such as NPW, PNPWPO,...) again take the lion's share of importance, followed by productivity (KPPO), while cost variables (DIDEFL and QR) seem to matter less in terms of the elasticities (computed on the basis of the average level of the respective variables). This is particularly true in the agglomerations, in the less developed regions the demand variables (NPW and DBNPWPO) which are also significant, are the most important movers of regional investment activities. In the intermediate group of regions productivity becomes a significant influence on top of the demand variables.

The following graphs (3a-c) illustrate these results by showing the development of investment (I) and the demand for goods (NPW) over time, to exemplify. Another illustration (graphs 4a-c) shows the time paths of investment (I) and the productivity variable (KPPO).

Secondary sector (without construction)





Secondary sector (without construction)

FIGURE 3 c

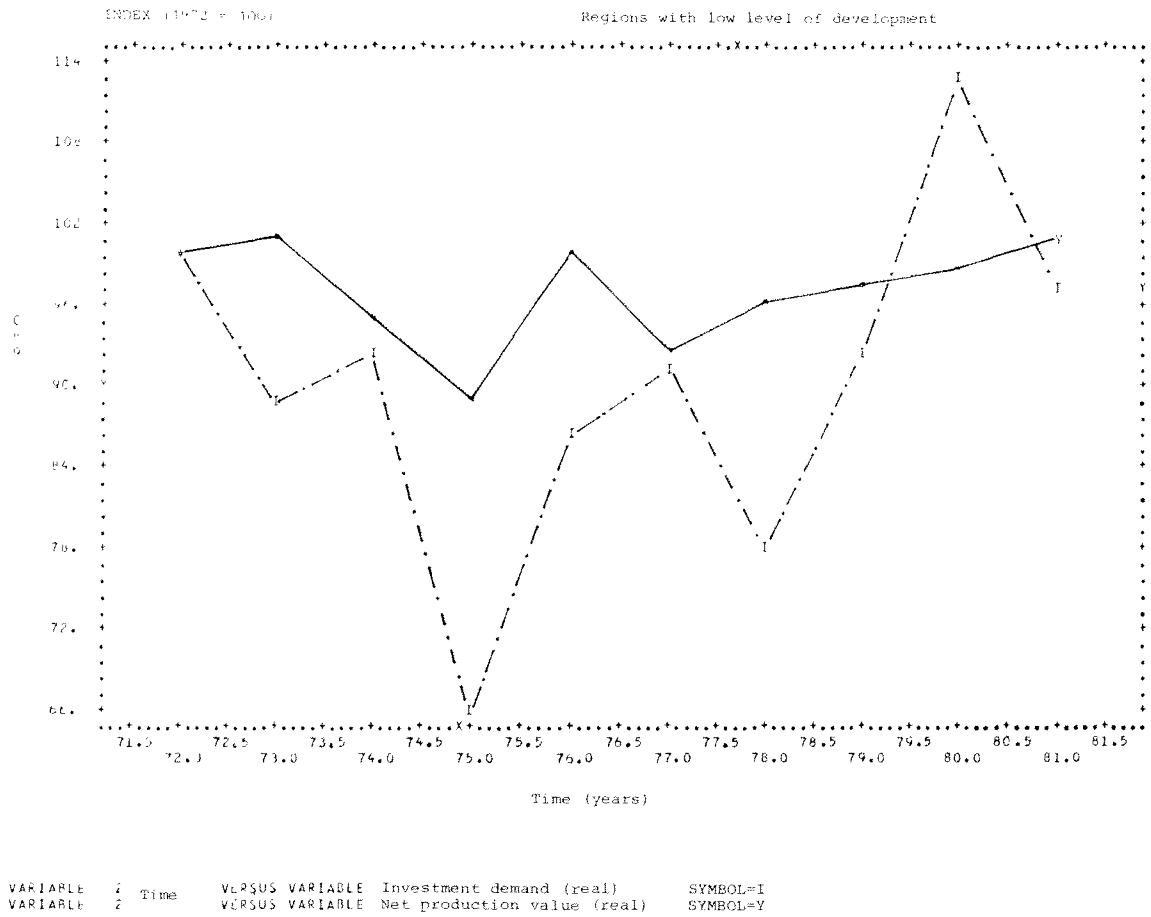
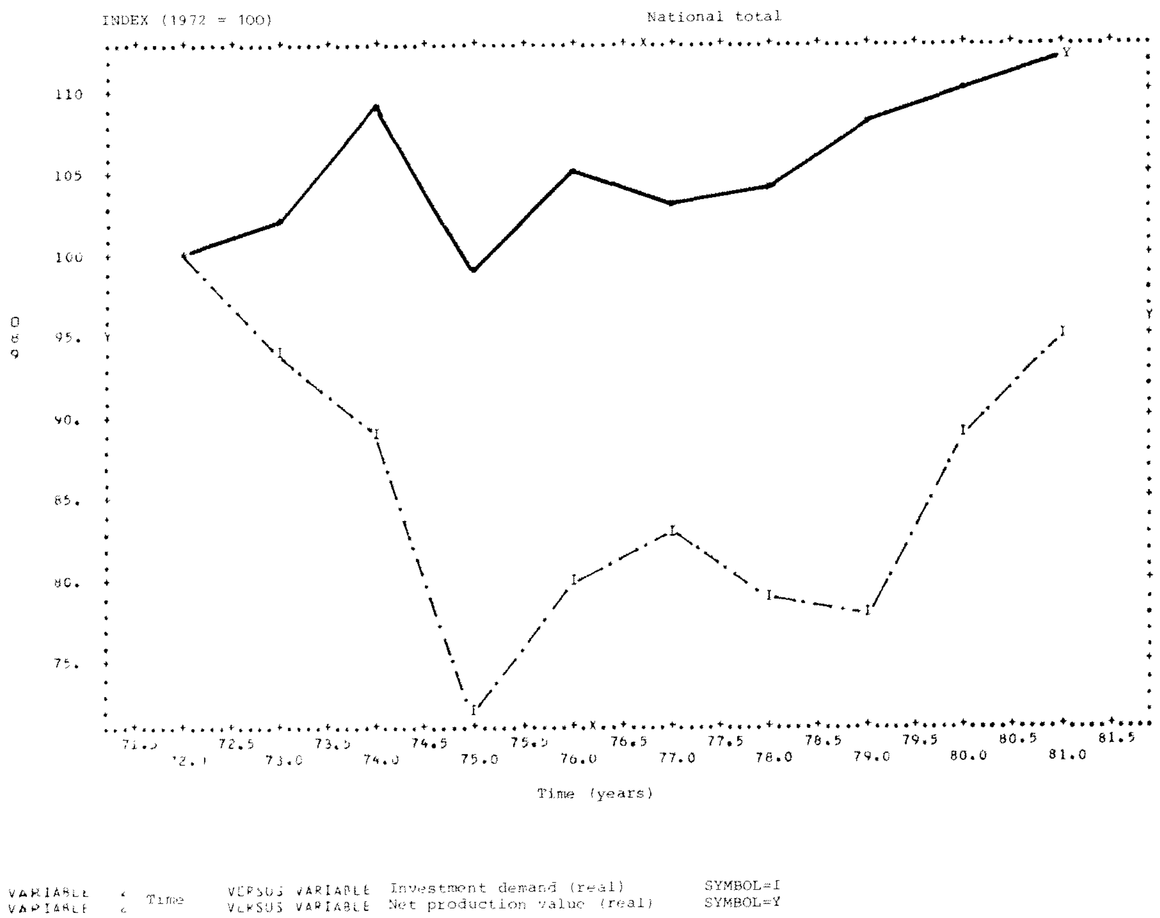
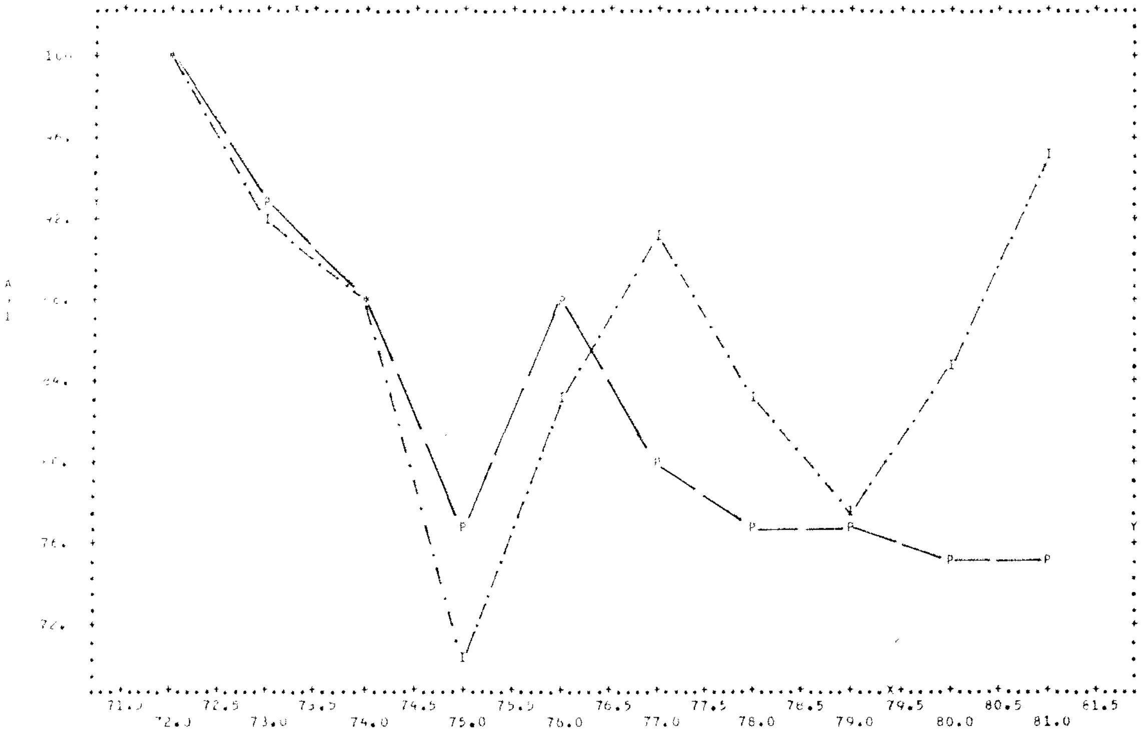


FIGURE 3 d



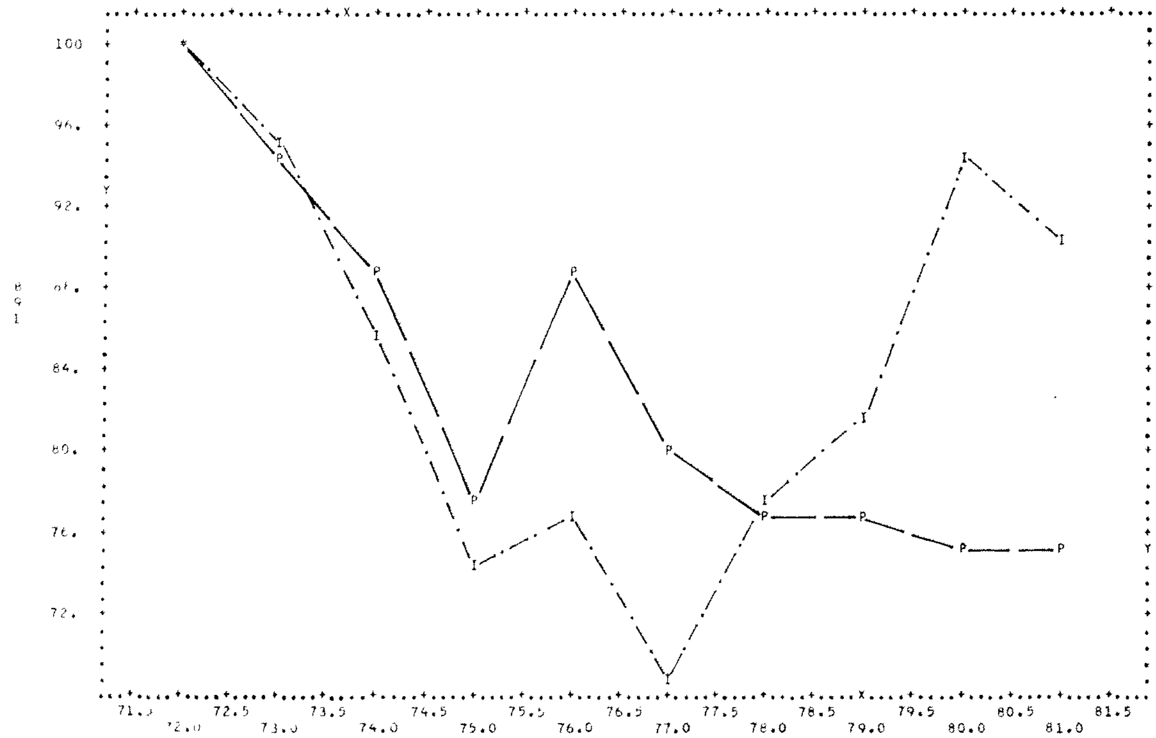
Secondary sector (without construction)

INDEX (1972 = 100) Regions with high level of development FIGURE 4 a



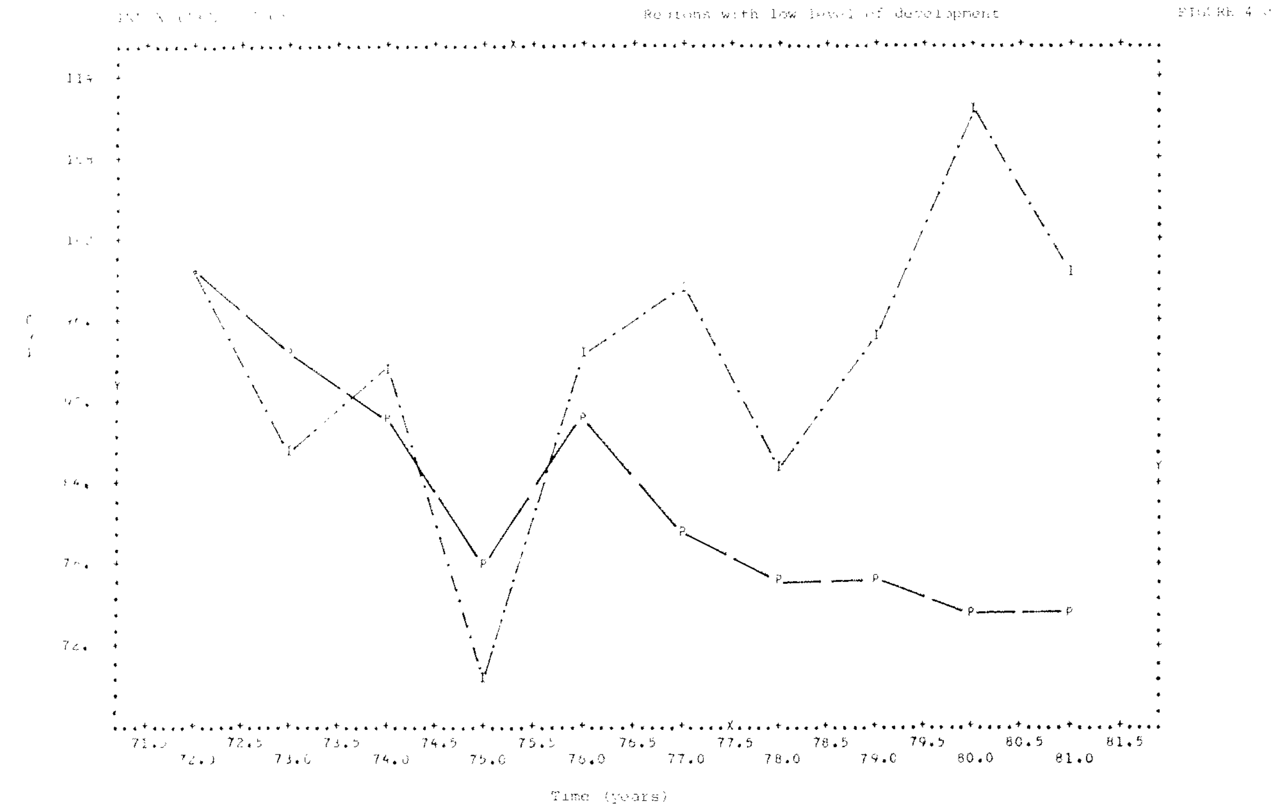
VARIABLE 2 VERSUS VARIABLE INV (real) SYMBOL=I
VARIABLE 2 VERSUS VARIABLE KPPO(real) SYMBOL=P KPPO = Potential of capital productivities

INDEX (1972 = 100) Regions with medium level of development FIGURE 4 b

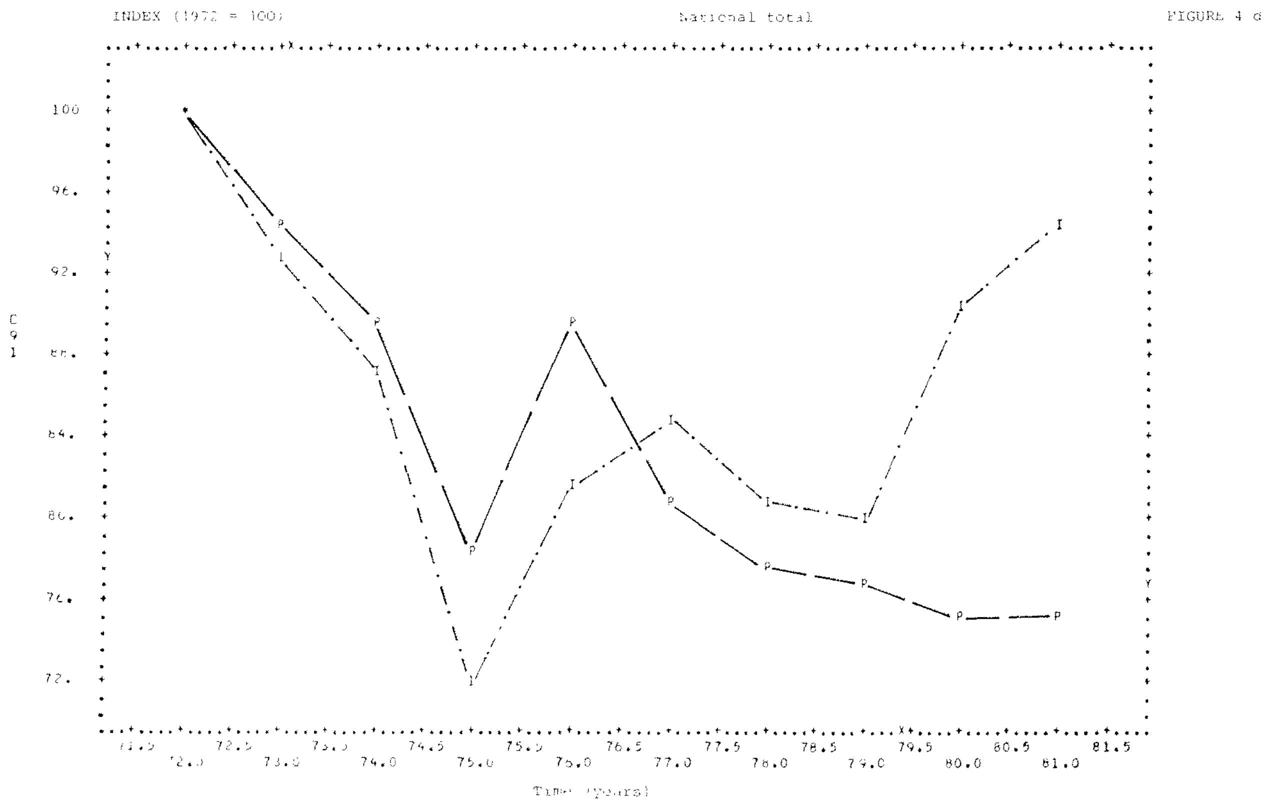


VARIABLE 2 Time VERSUS VARIABLE INV (real) SYMBOL=I
VARIABLE 2 VERSUS VARIABLE KPPO (real) SYMBOL=P KPPO = Potential of capital productivities

Secondary sector (without construction)



VARIABLE 2 Time VERSUS VARIABLE INV (real) SYMBOL=I
VARIABLE 2 VERSUS VARIABLE KPPO (real) SYMBOL=P KPPO = Potential of capital productivities



VARIABLE . Time VERSUS VARIABLE INV (real) SYMBOL=I
VARIABLE . VERSUS VARIABLE KPPO (real) SYMBOL=P KPPO = Potential of capital productivities

Again the graphs reveal that in the less developed regions the time paths of the dependent variable follow the path of the most important variable (NPW) very closely, which is less the case in the highly developed regions. It is also demonstrated that the ups and downs in the less developed regions are more pronounced while investment activities in the agglomerations tend to be buffered by other considerations than pure changes in the demand for goods.

Turning to labor demand now, as already mentioned, results in terms of the overall goodness of fit weren't satisfactory (see table A 2 in the appendix). Additional work seems to be necessary to improve the specification to be tested.

Looking at the respective "t" values first, the labor demand equation responds to the demand as well as to the cost variables. The most significant influence, as in the case of the investment submodel, turns out to be the demand for goods. The highest elasticity may be found in response to changes in the labor productivity, followed by wages. The sign of the productivity coefficient is positive, contrary to the theoretical specification outlined. There could be several reasons for this phenomenon. The use of a productivity potential to capture at least some of the innovation diffusion concept could be misleading, or the separability assumption incorporated into the theoretical model does not hold. It may well be that regions of high labor productivity attract more investment in a lead and lag fashion, which should be explicitly modeled.

In the other types of regions the picture becomes even more blurred and no clear answer is provided as to which influences could be called dominant or even significant. It seems that changes in wages could be a meanigful explantory variables, as well as the demand for goods. Productivity of labor appears to exert no significant influence.

5. Concluding remarks

Regarding the problem of technological progress the present contribution seems to indicate that an explicit formulation of R&D activities and innovation could improve the model. Although an approach was outlined, which could in principle be empirically pursued with Austrian data, this is clearly not the case at the moment. For a simple cross-section approach there aren't enough observations (Austria has 9 federal states), and pooling techniques fail as there is only one point in time available at present. Efforts will be made in the future by the statistical office to go down to the county level and to conduct an R&D activities survey of Austria every 3 years.

But it isn't only data problems which need to be solved, also the theory and particularly the operationalization leaves much to be desired. Given the model as it stands now, no reasonable assumption about the functional forms of the production function for the increase in know-how by R&D investment allow a tractable model formulation for the demand for R&D personel and equipment.

Furthermore the riskiness of undertaking R&D activities needs to be considered in more detail. How the portfolio choice problem between the less risky purchase of patents and the risky R&D choice should be incorporated in the optimal control model is not yet clear.

By the same token the various diffusion processes (innovation, wage determination) should be formulated in a much less ad hoc way. The data base for a direct empirical approach to the problem does not exist in Austria, so other avenues will have to be detected.

The strong separability assumptions made in the production functions should be reconsidered as well to be able to allow for more direct interaction between the various submodels.

The smaller version of the model, containing only investment and demand produces fairly plausible results. The temporal lag structure should be investigated in more detail, especially as the length of the time series information increases (at the moment only 10 obeservation points over time are available). As the impacts of the national variables can only be estimated on the basis of the time series information, this strategy does not seem warranted at the moment.

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APPENDIX

Table 2. The determinants of regional investment demand; regression results (variables in nominal terms)

REGIONS WITH HIGH LEVEL OF DEVELOPMENT

ENDOGENOUS VARIABLE = INV (INVESTMENT DEMAND)

R SQUARE = .92545

VARIABLE		EXP. SIGN	3-STAGE B	T	ELASTICITY
QR	PRODUCT OF INVESTMENT-GOODS DEFLATOR AND INTEREST RATE	−	-.2843E+03	-.6851E+00	-.23624
DNPW	CHANGE OF NET PRODUCTION VALUE	+	.4519E+00	.3259E+01	.07140
DIDEFL	CHANGE OF INVESTMENT GOODS DEFLATOR	?	-.2975E+05	-.1912E+01	-.21796
KPPO	POTENTIAL OF CAPITAL PRODUCTIVITY	−	-.4650E-01	-.2504E+01	-.62694
NPW	NET PRODUCTION VALUE	+	.1342E+00	.3057E+02	.81209
PNPWPO	PRODUCT OF GNP DEFLATOR AND NET PRODUCTION VALUE POTENTIAL	+	.7277E-04	.3336E+01	.78792
DBNPDEF	CHANGE OF GNP DEFLATOR	?	.5884E+05	.1154E+01	.49449
DPNPWPO	CHANGE OF 'PNPWPO'	?	-.3036E-10	-.3143E+01	-.09091
DBIPRW	CHANGE OF SUM OF GNP'S OF THE MAJOR AUSTRIAN FOREIGN TRADE PARTNERS	?	-.1036E+00	-.1893E+01	-.25059
DINV	CHANGE OF INV. DEMAND		.6331E+00	.9119E+01	.03591
C			.2297E+06	.8212E+00	0.00000

REGIONS WITH MEDIUM LEVEL OF DEVELOPMENT

ENDOGENOUS VARIABLE = INV

R SQUARE = .69355

VARIABLE	3-STAGE B	T	ELASTICITY
QP	.1009E+03	.5115E+00	-.02004
DNPW	.3774E+01	.4312E+01	-.07075
DIDEFL	-.6734E+04	-.8290E+00	-.19893
KPPO	-.2453E-01	-.1933E+01	-.09878
NPW	.2275E+00	.1306E+02	1.06356
PNPWPO	.2719E-04	.2314E+01	.01707
DBNPDEF	-.3093E+04	-.1264E+00	.60437
DPNPWPO	-.2341E-09	-.4200E+01	.06150
DBIPPW	-.1051E-01	-.3700E+00	-.04988
DINV	.5605E+00	.1124E+02	.02931
C	.1866E+05	.1003E+00	0.00000

REGIONS WITH LOW LEVEL OF DEVELOPMENT

ENDOGENOUS VARIABLE = INV

R SQUARE = .62636

VARIABLE	3-STAGE B	T	ELASTICITY
QP	.1445E+03	.3460E+01	.47810
DNPW	.7940E+00	.1970E+01	-.02716
DIDEFL	.9911E+03	.5663E+00	.06347
KPPO	.2391E-02	.7083E+00	.75422
NPW	.2058E+00	.7420E+02	1.06288
PNPWPO	-.2500E-05	-.9980E+00	-.56115
DBNPDEF	-.3457E+04	-.6406E+00	-.19670
DPNPWPO	-.6415E-10	-.1925E+01	-.00413
DBIPPW	.1349E-02	.2218E+00	.12425
DINV	.5008E+00	.8899E+01	.03019
C	-.9256E+05	-.1806E+01	0.00000

Table 3. The determinants of regional labor demand; regression results (variables in nominal terms, employment in heads)

REGIONS WITH HIGH LEVEL OF DEVELOPMENT

ENDOGENOUS VARIABLE = DB (LABOR DEMAND)

R SQUARE = .44158

VARIABLE		EXP. SIGN	3-STAGE B	T	ELASTICITY
WPO	WAGE POTENTIAL	−	-.5085E+00	-.2244E+01	38.18788
DNPW	CHANGE OF NET PRODUCTION VALUE	+	-.2465E-03	-.1147E+01	.56303
DWPO	CHANGE OF 'WPO'	?	-.2220E+01	-.5591E+01	14.42806
APPO	POTENTIAL OF LABOR PRODUCTIVITY	−	.4458E+00	.3252E+01	-53.72373
NPW	NET PRODUCTION VALUE	+	-.6044E-04	-.8303E+01	3.96963
PNPWPO	PRODUCT OF GNP DEFLATOR AND NET PRODUCTION VALUE POTENTIAL	+	-.3989E-08	-.7922E-01	.21275
DPNPWPO	CHANGE OF 'PNPWPO'	?	.4027E-13	.2689E+01	-1.51285
DBIPPW	CHANGE OF SUM OF GNP'S OF THE MAJOR AUSTRIAN FOREIGN TRADE PARTNERS	+	-.2035E-04	-.2991E+00	.16150
DDB	SECOND DERIVATE OF LABOR DEMAND	?	-.3286E-02	-.1002E+01	-.07027
C			.2542E+03	.9858E+00	0.00000

REGIONS WITH MEDIUM LEVEL OF DEVELOPMENT

ENDOGENOUS VARIABLE = DB

R SQUARE = .21850

VARIABLE	3-STAGE B	T	ELASTICITY
WPO	.2075E-01	.4495E+00	-38.93738
DNPW	-.1717E-03	-.2285E+00	.80609
DWPO	-.3646E+00	-.3638E+01	-35.21759
APPO	-.5033E-02	-.1386E+00	108.32916
NPW	-.2189E-04	-.1331E+01	-5.09917
PNPWPO	-.4756E-09	-.3273E-01	-28.66904
DPNPWPO	.2606E-13	.5487E+00	1.50456
DBIPRW	-.1666E-04	-.7450E+00	.15329
DDB	.6896E-02	.1879E+01	.18311
C	.2420E+03	.1877E+01	0.00000

REGIONS WITH LOW LEVEL OF DEVELOPMENT

ENDOGENOUS VARIABLE = DB

R SQUARE = .36504

VARIABLE	3-STAGE B	T	ELASTICITY
WPO	-.9459E-01	-.8640E+00	-41.75710
DNPW	.1508E-02	.3272E+00	3.25483
DWPO	-.2624E+00	-.1261E+01	-37.78120
APPO	.3647E-01	.3457E+00	90.15558
NPW	-.9248E-04	-.1075E+01	-3.04363
PNPWPO	.1757E-07	.4019E+00	-12.20666
DPNPWPO	.7656E-13	.2007E+00	-.40490
DBIPRW	.1633E-04	.3065E+00	-.76560
DDB	-.1126E-01	-.4056E+00	.42654
C	.2447E+03	.5379E+00	0.00000