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1. Introduction

It is the purpose of this paper to shed some light on the demand for labor and investment in regional labor markets. This contribution is to be seen in the larger framework of an interregional labor market study of Austria, undertaken at the Institute for Urban & Regional Studies (IIR), Vienna Economic University.

It was particularly during the 1975-76 recession that employment problems in regional labor markets have caught the public's and thereby also the politicians' eyes. The impact of the recession was quite distinct in different types of regions and regional unemployment rates exhibited wide variations.

The task of this paper is to try and establish a model which is statistically testable, an intention which due to data scarcities imposes heavy restrictions on the feasible degree of sophistication of such an attempt. The dependent variables are the demand for labor (of different qualification) and investment goods by industry, among the explanatory variables we expect to find factor prices, the demand for industrial goods, etc. Relevant and reliable regional data are difficult to be obtained. A special drawback in this respect is the lack of time series information, as problems of investment (and also of labor demand) are inherently dynamic in nature. All that can be offered statistically in those respects is therefore of a very preliminary nature and conclusions include many shadows on questions they are supposed to shed a light on.

The present paper deals only with the productive sector, i.e. large and small scale industry. An aggregated macro-model will be derived using information from a micro-economic approach. Although there will be no sectoral break down of industries, labor will be disaggregated by qualification according to different educational levels: In the preliminary statistical analyses 2 types of labor will be analyzed for which the necessary data were available, i.e. unskilled and skilled workers.

Standard non-spatial economic theory, both along neo-classical or Keynesian lines, relies basically on marginal productivity theory to explain the demand for labor and capital. In such a static approach no frictions exist to keep firms from hiring and firing labor at any point in time and to reach their optimal capital stock instantaneously. To derive a theory of investment - not of capital demand such frictions (Jorgenson, 1971) had to be introduced, either stemming from capacity bottlenecks in the investment goods' industry. (Lange, 1968) and for internal frictions. These are due to organisational changes and production losses during the installation time of the new equipment. (Treadway, 1969). Similar approaches were also utilized to derive the demand for labor (Scanlon et alii 1977). It is not the entire stock of labor that is up for decision at each period of time, but only a part of it ("Hiring and firing").

One of the most important driving forces behind necessary changes in the labor force and the capital stock are changes in demand for the goods produced ("accelerator models", eg. Samuelson, 1939). Others are changes in the factor prices and the availability of new technology.

In the framework of spatial models these factors have to be reinterpreted and new aspects appear. The most important among those is the existence of different market areas varying in size and the differentials in factor prices over space. Profit opportunities hence vary over space and as a consequence factor mobility can be observed. Contrasting opinions about the direction of these factors flows have led to the creation of different schools of thought - "Myrdalians vs. Neo-Classicists". Greatly simplified the thesis of the first can be summarized by saying: "Where there is a lot, more is due to come", and the analogous reverse (cumulative processes), the latter expects a tendency towards a spatial equilibrium (see e.g. Richardson, 1973). Although not explicitly treated in this paper, some observations on this question can be made.

Some attempts have been made to analyze the factors behind the claimed mobility of capital and labor over space (e.g. Peaker, 1971; Engle, 1975; La Bella, 1978; Fleck, 1975; Bade, 1977). Empirical studies, however have usually encountered data problems as observations over larger periods of time are often not available.

Another important problem frequently encountered in the literature (e.g. Stöhr & Tödtling, 1977; Bölting, 1976) is the impact of regional policies, especially in depressed areas. The effect of some regional investment incentives in Austria will be investigated in a very simplified manner in this study also, more detailed analyses are impeded again by the lack of data over longer periods of time.

2. The macro-economic setting

In the present study we try to analyze the demand for labor of educational level k in different types of regions, (LD^{kl}). (In the empirical analysis $k = 1, 2$ i.e. skilled and unskilled labor; and $l = 1, 2, 3$, i.e. urban; small urban and rural; peripheral areas) and the demand for investment goods in l (I^l) by the production sector. In statistical terms LD is defined as actual employment plus vacancies.

We will distinguish between existing firms the investment of which is made for the purpose of capital widening (extension of productive capacity), deepening (introduction of new technology) or replacement, and new firms which are creating new productive capacity in the region. This new capital can come either from within the region or can be transferred from other regions, usually because the investor thinks that the chosen regions will offer better profit opportunities. In theory there is also the case of actual, physical capital transfers to consider. Empirical studies (e.g. Fleck, 1975) show, however, that it is a negligible quantity, so we will not explicitly account for this gain in the regions of destination by booking a loss in the region of

origin.

$$(2i) I^l = I^{l_{old}} + \sum^n I^{ln}_{new}$$

To be found then is an explanation of the determination of $I^{l_{old}}$ and $\sum^n I^{ln}_{new}$ by entrepreneurs and investors.

A similar constraint holds for the demand for labor of qualification k:

$$(2ii) LD^{kl} = LD^{kl}_{old} + \sum^n LD^{kln}_{new}$$

Although some case studies (e.g. Stöhr & Tödtling, 1979; Pred, 1977) seem to warrant an approach that maintains the distinction between "regional" and "multiregional" firms because of their different behavior especially with regard to reactions in different stages of the business cycle, such distinctions can not be made here. Unfortunately the data situation makes such a procedure too costly at the moment.

A set of micro-economic models will be used in the following section to find the factors determining the levels of the investigated variables.

3. Micro economic models of labor and investment demand

3.1 Existing firms

3.1.1. The decision scenario

Profits of a firm (at all time periods t) are defined as turnover-costs. Let Y (all time and space-subscripts will be neglected at the moment) be the amount of an aggregate good the firm can sell at price p. Turnover is hence pY. The price level p of the good signals demand to the decision-maker. There are two groups of costs to be considered in our context, labor and capital costs. In a spatial model land prices would seem a logical cost factor. As our model will consider the individual regions as point economies, it is difficult to see what land price should be used as these prices vary continuously over space, this variable is hence omitted. (Information on land prices is scarce anyway, even an

"average" cannot be computed for all regional units used in the empirical analysis). Labor of qualification k (L^k) is paid a wage of w^k , the price of the investment good is q and the market interest rate (equivalent to capital cost in this connection) is r . Hiring (or firing) people costs more than just the wages (Scanlon & Holt, 1977). New labor often has to be trained to acquire the necessary skills to do the required job, there are extra filing fees and social security expenses, etc. Let these costs be $C^k(H^k)$ per newly hired worker, where H^k is the number of units of labor of qualification k newly hired. Let us also postulate to simplify, that when $H^k < 0$, savings will also accrue to the same extent (in reality this will often not be the case). Profits in period t then are:

$$\pi = pY - \left\{ \left(\sum_k w^k L^k \right) + \left(\sum_k (w^k + c^k(H^k)) H^k \right) + rK + q(1 - \text{sub}) I \right\}$$

Regional investment incentives usually offer subsidies to firms who decide to invest. There is, of course, a multitude of forms and methods to subsidize investment, often by means of cheaper credits, etc., we will assume that part of the investment cost will be covered by the government at a rate of (sub).

How much of good Y can be produced by employing L and K ? A production function $F(K, L)$ is usually postulated to exist to indicate the potential production volume. The usual neo-classical production function is a static construct, however. To change the scale, organisation, technology, etc., causes considerable friction in a firm. These changes take time, "production detours" are made which usually mean a loss of production today to increase tomorrow's output (Böhm - Bawerk, 1889 ; Hicks, 1973). Inputs and outputs hence have time profiles that do not allow us to expect current output to be only a function of existing stocks of production factors. We expect "frictions" then to increase with the levels of change in the production capacity and structure. To simplify

we let these frictions only last one period, the period of the change itself.

$$Y^k \leq F(L^1, \dots, L^k, \dots, K) - \left(\sum T^k(H^k) - \bar{T}(I) \right)$$

where $\partial F / \partial L^k = F_L^k, F_K > 0; T_H^k, F_I > 0$.

H and I being flows and L & K stocks, the firm also has to face dynamic constraints. To keep matters as simple as possible again let us hypothesize that replacement demand for capital is a constant proportion of existing capital stock, $\delta > 0$.

$$\frac{dK}{dt} = \dot{K} = I - \delta K, \text{ where } I \text{ is gross investment.}$$

Similarly there is a "replacement" demand for labor also, workers retire or drop out of the staff because of accidents, sickness, marriage, change of profession, etc. Let this "labor turnover rate" be a constant proportion of total labor employed, $\gamma^k > 0$.

$$\frac{dL}{dt} = \dot{L} = H^k - \gamma^k L^k$$

A few words about market structure should be added at this point. If we are talking about a small region the number of producers of industrial goods is most likely small, i.e. we often have a situation of monopoly or oligopoly. In its production decision the firm must hence take its influence on the total supply in its market area into consideration, which will influence the price level of the good. We hence have:

$$p = p(Y^{\text{own}}, \sum Y^{\text{others}}, \text{Income})$$

(For spatial markets this demand function will be specified in more detail below).

3.1.2. The decision problem

Let us postulate that the individual enterprise can decide about the levels of H^k , I and Y (production volume). As investment accumulates over time and total employment depends on the hiring and firing decisions at each period of time, L^k and K are state variables.

Our task is to derive demand functions for the production factors

L and K, i.e. H^k and I (as well as the optimal output level Y) at each period of time. To solve our problem we assume that the firm behaves as a "dynamic profit maximizer", i.e. it attempts to maximize the present value of its future earnings.

$$V = \int_0^T e^{-\rho t} \pi dt$$

where $\rho > 0$ is the rate of time preference, the discounting factor.

The following optimal control model can be set up ($T \rightarrow \infty$) (leaving out government subsidies for the moment):

$$\text{Max } V = \int_0^{\infty} e^{-\rho t} \pi dt$$

s.t.:

- (i) $\pi = pY - \left(\sum^k w^k L^k \right) + \left(\sum^k (w^k + c^k(H^k)) H^k \right) + rK + q I$
- (ii) $Y = F(L^1, \dots, L^k, K) - \sum^k T^k(H^k) - \bar{T}(I)$
- (iii) $\dot{K} = I - \delta K$
- (iv) $\dot{L}^k = H^k - \gamma L^k$
- (v) $p = p(Y, \dots)$

(For further restrictions on the partial derivatives see 3.1.1 above).

Control variables: H^k, I, Y

State variables: L^k, K

Co-state variables: λ^k, μ

Lagrange multiplier: ξ

We can now set up the following Hamiltonian (h) and Lagrangean functions

$$(l): \quad \text{Max } V = \int_0^{\infty} e^{-\rho t} \pi dt$$

s.t.: (i) - (iv)

$$h = e^{-\rho t} \left\{ pY - \left(\sum^k w^k L^k \right) + \left(\sum^k (w^k + c^k(H^k)) H^k \right) + rK \right. \\ \left. + q I + \sum^k \lambda^k (H^k - \gamma L^k) + \mu (I - \delta K) \right\}$$

$$z = h + \xi (F(L^1, \dots, L^k, K) - \sum^k T^k(H^k) - \bar{T}(I) - Y)$$

Let us further postulate that the second order conditions hold (which they do under the usual regularity conditions) we then obtain the optimal solutions to our problem by applying the P o n t r y a g i n Principle :

Pontryagin Principle:

$$(3.i)^k \quad \dot{\lambda}_{H^k} = e^{-\rho t} \{ - (w^k + c^k_{H^k} H^k + c^k(H^k)) + \lambda^k - \xi T^k_{H^k} = 0 \\ \rightarrow \lambda^k = \xi T^k_{H^k} + (w^k + c^k_{H^k} H^k + c^k(H^k))$$

$$(3.ii) \quad \dot{\lambda}_I = e^{-\rho t} \{ -q + \mu - \xi \bar{T}_I = 0 \Rightarrow \mu = q + \xi \bar{T}_I$$

$$(3.iii) \quad \dot{\lambda}_Y = e^{-\rho t} \{ p_Y Y + p - \xi \} = 0 \Rightarrow \xi = p_Y Y + p$$

If $p > 0$ & p_Y small, then $\xi > 0 \Rightarrow \mu = q + (p_Y Y + p) \bar{T}_I > 0$

$$\text{and } \lambda^k = (p_Y Y + p) T^k_{H^k} + (w^k + c^k_{H^k} H^k + c(H^k)) > 0$$

$$(p_Y Y + p) = \Delta p$$

$$(3.iv) \quad \dot{\lambda}^k = \rho \lambda^k - \frac{\partial L}{\partial L^k} = \rho \lambda^k + w^k + \lambda^k_Y Y - \xi F^k_L = (\rho + \gamma^k) \lambda^k + \\ w^k - \xi F^k_L = (\rho + \gamma^k) \lambda^k + w^k - \Delta p F^k_L$$

$$(3.v) \quad \dot{\mu} = \rho \mu - \frac{\partial L}{\partial K} = \rho \mu + r + \mu \delta - \xi F^k_K = (\delta + \rho) \mu + r - \Delta p F^k_K$$

Using (3i & iv, v) we obtain:

$$(3.vi) \quad \dot{\lambda}^k = (\rho + \gamma^k) \{ \xi T^k_{H^k} + (w + c^k_H H^k + c^k(H^k)) + w^k - \xi F^k_L \} \\ = w^k (\rho + \gamma^k + 1) + \Delta p \{ (\rho + \gamma^k) T^k_{H^k} - F^k_L \} + \\ \{ (c^k_{H^k} H^k + c^k(H^k)) \} (\rho + \gamma^k).$$

This rule says that marginal benefits (changes in the value of the stock and the value of the marginal products) have to be equal to marginal costs (wages, frictional losses of production and direct costs of changing the stock). (Arrow, 1968).

Furthermore - (3v) yields:

$$(3.vii) \dot{u} = (\rho + \delta) (q + \xi \bar{T}_I) + \bar{r} - \xi F_K$$

Capital gains (\dot{u}) and the value of the marginal product constitute marginal benefits, the price of investment goods and the frictional losses are marginal costs.

Postulating stationarity, i.e. $\dot{u} = \dot{\lambda} = 0$, so that there are no more revaluations of the stock variables will permit us to solve the system of simultaneous equations:

(3.iv) & 3.vii) for $\dot{\lambda} = \dot{u} = 0$, and (2i - iv) permits us to solve for H^{k+} and I^+ (including subsidies):

$$H^k = H(w^k, F_L^k, p, Y) ; I = I(q, sub, r, \bar{p}, Y, F_K)$$

(Note, however, that these control policies are only optimal for all initial conditions of the state variables K_0 & L_0^k if the system is globally stable. This cannot be shown in general. For a special case, local stability could be shown (see Brock & Scheinkmann, 1977)).

Making special assumptions about some functional forms, these demand functions will be derived below.

Using consistent aggregation procedures, we would now aggregate the individual functions to macro-functions for each region. This will not be done explicitly, as usually the functional forms and the sensitivities of the micro-functions are postulated to hold for the macro-functions as well.

3.2. Interregional capital - the establishment of new firms.

Let us suppose there is a "representative investor" in region 1, who

wants to know how to best allocate his investment fund over the regional system. He plans to establish new firms starting production of the aggregate good as soon as possible (to simplify again, we will assume that this will still be possible at the end of the period in which the decision is made). Profits from selling the product will differ over the possible locations. The value (V^l) of choosing a location will be equal to the profits possible there. As above these profits are defined as turnover minus costs. If a location different from his present one is chosen, however, capital transfers will be costly, their level depending, we hypothesize, on the distance costs between the region of origin and destination (d), and the amount transferred (I^{ln}).

$$\text{Transfer cost}^{ln} \dots TFC^{ln} = TFC(I^{ln}, d^{ln})$$

$$\text{where } TFC_I \text{ \& } TFC_d \geq 0.$$

The value of a transfer from region n to l is hence:

$$V^l = p^l Y^l - q I^{ln} + \sum_k (w^n + c^k (H^{kl})) H^{kl} + TFC(I^{ln}, d^{ln})$$

As above we assume that q , the price of the investment good is the same all over the nation.

The amount of Y that can be produced by labor and the new capital depends on the technology chosen. The total capital stock available in this first period is equal to investment (I) and labor is equal to (H^k)

$$Y^l = F(I^{ln}, H^{h1} \dots H^{kl} \dots) - \sum_k T^k(H^{kl}) - \bar{T}(I^{ln})$$

We further postulate that the transfer costs for capital staying in the region (I^{ll}) is zero, i.e. $TFC(I^{ll}, 0) = 0$. We do not pose the allocation problem as a binary choice, i.e. it may be optimal to distribute the available investment fund over many regions. The total profits from such a strategy would be:

$$V = \sum_n V^n.$$

This value, we suppose, will be maximized to derive the optimal capital flows to establish new firms.

We obtain the following optimization problem:

$$(3x) \text{ Max } V = \sum^n V^n$$

$$(3xi) \text{ s.t. } Y^n = F(I^{ln}, H^{n1}, \dots, H^{nk}, \dots) - \sum^k T^k(H^{kn}) - \bar{T}(I^k)$$

$$(3xii) \text{ and } TFC^{ln} = TFC(I^{kn}, d^{ln}),$$

$$(3xiii) \quad TFC^{ll} = 0$$

The control variables are I^{ln} and H^{nk} .

Substituting (3xi - 3xiii) into (3x) and setting the first partial derivatives equal to zero (again assuming second-order conditions to hold) we obtain:

$$(3xiv) \quad V_{I^{ln}} = p(F_{I^{ln}} - \bar{T}_I) - q - TFC_{I^{ln}} = 0$$

$$(3xv) \quad V_{I^{ll}} = p(F_{I^{ll}} - \bar{T}_I) - q = 0 \text{ (as } TFC(I^{ll}) = 0),$$

further:

$$(3xvi) \quad V_{H^{kl}} = p(F_{H^{kl}} - T_{H^{kl}}) - (w^l + c_{H^{kl}}^k H^{kl} + c^k(H^{kl})) = 0$$

Note again, that these first order conditions can in general be solved for I and L , yielding the corresponding demand functions.

To derive testable hypotheses some functional forms will have to be specified, which will be the task of the following section.

4. Functional forms and spatial models.

Which functions in our model have been left in implicit form?

In (2i) the total costs of hiring (or firing) labor $C^k(H^k)H^k$ need further specification:

Let $c(H)$ be linear, i.e.: Total costs are quadratic: cH^2

$$(4i) \quad c(H) = cH \implies \text{Marginal cost hence becomes: } 2cH$$

These costs may differ for different skill levels, i.e.

marginal cost is: $2c^k H^k$.

Similarly, let the difficulties in production arising from changes in the labor force and capital stock be also quadratic:

$$(4ii) T^k (H^k) = e^k (H^k)^2$$

$$\text{and (4iii) } \bar{T}(I) = fI^2$$

Marginal frictions are then: $2e^k H^k$ & $2fI$

Let the production function be of a (modified) Cobb-Douglas type:

$$Y = A \Pi^k (L^k)^{\alpha k} K^{\beta} - \varepsilon^k e^k (H^k)^2 - f I^2$$

The marginal products are then (e.g.)

$$(4iv) F_{L^1} = A \alpha^1 L^{(\alpha^1 - 1)} L^{\alpha^2} \dots K^{\beta} = \alpha^1 Y / L^1, \text{ etc.}$$

$$\text{and (4v) } F_K = A \beta \Pi^k (L^k)^{\alpha k} K^{\beta-1} = \beta Y / K.$$

Let us now look at our demand function $p = p$ (Production, Income) from a spatial point of view.

The market area considered stretches beyond the region 1 itself, particularly so for industrial goods. The probability, however, of the production of different regions to compete for customers in region 1 will fall with rising distance. Let us use the notion of a supply potential (YP), in which a distance discounting factor is used to take this falling supply probability mentioned into account. Such a potential is defined as (e.g. Paelinck & Nijkamp, 1976):

$$Y^n = \sum^n Y^n g^1(d^{ln}).$$

Similarly, not only the income in region 1 itself affects demand for the good Y, but also the income in other regions, from which customers will buy goods produced in 1. Distance friction will again cause a decline in significance of other regions' incomes. Let us then define an "income potential" RIP

$$RIP^n = \sum^n RI^n g^2(d^{ln}).$$

We further postulate a linear demand function for the good Y:

$$(4vi) p = \bar{a} - a (YP) + b (RiP), \text{ and}$$

$$p_{Y^1} = a Y_{Y^1} = - a Y^1 g(d^{11}),$$

now let $g(d^{11}) = 1$, then (4 vii) $p_{Y^1} = - a$.

In equation (3xii) capital transfer costs were defined.

$$\text{Let } TFC^{\ln} = v(I^{\ln})^2 g^3(d^{\ln})$$

Marginal transfer costs become: $2vI g^3(d^{\ln})$.

Using the specifications we can now proceed to solve the implicit demand equations derived in sections 3.1 & 3.2 ((3viii) - (3xvi)).

(3 vi) becomes:

$$w^k (\rho + \gamma^k + 1) + (p + p_Y Y) \{ (\rho + \gamma^k) 2e^{k_H k} - \alpha^k Y/L^k + (\rho + \gamma^k) \} (2c^k H^k) = 0$$

and by (4vi): $(p + p_Y Y) = \bar{a} - a(YP) + b(RiP) - aY = \bar{a} - a(YP + Y) + b(RiP)$

Let us now solve for H^k :

$$(4vii) H^k + = \frac{\alpha^k}{B} \frac{Y}{L^k} - \frac{(\rho + \gamma^k + 1)}{B} \frac{w^k}{(p + p_Y Y)}$$

$$= \frac{c^k (\rho + \gamma^k)}{B} \frac{1}{(p + p_Y Y)}$$



where $B = 2e (\rho + \gamma^k)$

$$\text{and (4viii) } I^{\dagger} = \frac{\beta}{D} \frac{Y}{K} \left[\frac{r + (\rho + \delta)q}{D} \frac{1}{(p + p_Y Y)} \right], D = (\rho + \delta)2f$$

To I and H^k we now have to add the investment and labor demand by new firms.

If we substitute $2vI g^3(d^{\ln})$ for the marginal transfer costs and in

(3xiv) $\bar{T}_T = 2fI$ we obtain after some transformations ($F_I = \frac{Y}{I}$):

$$\beta \frac{Y}{I} = 2(f + v g^3(d)) I + q$$

which yields the following quadratic equation:

$$(I^{\ln})^2 + \frac{q}{2(f + v g^3(d^{\ln}))} I^{\ln} - \beta p^{\dagger} = 0,$$

from which we get:

$$I^{\ln} = -\frac{q}{4(f + v g^3(d^{\ln}))} \pm \sqrt{\left(\frac{q}{4(f + v g^3(d^{\ln}))}\right)^2 - \beta p^{\dagger}}$$

We can approximate this solution by (as $\frac{q}{4(f + v g^3(d^{\ln}))}$ is small)

$$I_1^{ln} = - \frac{q}{4(f+vg^3(d^{ln}))} \left\{ 1 + 1 - 4p \frac{Y}{2(f+vg^3(d^{ln}))^2} \right\}$$

$$= - \frac{q}{2(f+vg^3(d^{ln}))} - 2pY \left\{ \frac{2(f+vg^3(d^{ln}))}{q} \right\}$$

or $I_2^{ln} = 2pY \frac{2(f+vg^3(d^{ln}))}{q}$

Total new investment in regional coming from other regions is then the sum over all these regions.

$$I_{new}^l = \frac{n \cdot I^{ln}}{\Sigma I} = \frac{n}{\Sigma} \frac{q}{4(f+vg^3(d^{ln}))} + \frac{n}{\Sigma} p^{n_Y n} \frac{4(f+vg^3(d^{ln}))}{q}$$

Let us now define an "investment cost potential" (ICP)

$$ICP^l = \frac{n}{\Sigma} \frac{q}{vg^3(d^{ln})}$$

We can now approximate I_{new}^l to become:

$$I_{new}^l = \epsilon_0 + \epsilon_1 (ICP^l) + \epsilon_2 (RIP^l) + \epsilon_3 (YP^l) \cdot \frac{1}{(ICP)^l}$$

by (4vi)

A similar procedure can be applied to solve for the labor demand created by the newly established firms. We use equation (3xvi) and the special assumptions used above for T_H and C_H as well as for F_H (analogous to F_L) and arrive at an analogous quadratic equation.

$$(H^{kln})^2 + \frac{w}{4(c^k+e^k)} H^{kln} - \frac{\alpha}{2(c^k+e^k)} pY = 0$$

Approximating the solution again and simplifying yields:

(4x):

$$H_1 = \frac{wK}{4(c^k+e^k)} \left(2 + \frac{4 wK\alpha}{2(c^k+e^k)} pY \right)$$

$$H_2 = \frac{\alpha wK^2}{2(c^k+e^k)} pY$$

Let us suppose the government uses subsidies to firms wanting to invest as a policy to attract industry to a region. Many such programs exist, most of them amount to a lowering of the total cost of investment. The amounts of such grants differ from region to region (see also 3.1.1. above).

Let total expenditure by government in a region be SUB. Usually these grants are tied to investments directly, suppose a rate of (sub) will be covered by the government, i.e.

$$\text{SUB} = (\text{sub}) q^I r$$

The investment costs to entrepreneurs are then: $q(1-\text{sub}) I$.

(sub will vary, q is the same over all regions by assumption).

Our investment demand functions now have to be modified - q will be replaced by $q(1-\text{sub})$ in all equations (4viii - 4ix).

5. Data availability and testable hypotheses.

In section 4 the equations for labor and investment demand were derived on a micro-economic basis. Individual demand curves can be aggregated, yielding macro demand functions by region. As there are no data available on H, the hiring and firing variable, directly, we have to make use of (2iv):

$$\dot{L}^k = H^k - \gamma L^k$$

Let us first approximate these differential equations by difference equations:

$$L_t^{k+} - L_{t-1}^k = H^{k+} - \gamma L_t^k$$

We can now solve for $L_t^{k+} = LD_t^k$:

$$LD_t^k = \frac{1}{1+\gamma^k} H^{k+} + \frac{1}{1+\gamma^k} L_{t-1}^k$$

Using 4 (viii) and (4x) yields:

$$(5i) LD_t^k = \frac{1}{1+\gamma^k} \left(\frac{\alpha^k}{B} \frac{Y}{L^k} - \frac{(\rho+\gamma^k+1)}{B} \frac{w^k}{(p+p_Y Y)} - \frac{c^k(\rho+\gamma^k)}{B} \frac{1}{(p+p_Y Y)} \right. \\ \left. + \frac{w^k}{2(e+c^k)} - \frac{2(e+c^k) \alpha A(pY)}{w^2} \right) + \frac{1}{1+\gamma^k} L_{t-1}^k$$

In case the underlying production function (2ii) is not of the Cobb Douglas type a different formulation would be necessary. The marginal product of L^k would in general be a function of the other variables appearing in the first part of the production function, i.e. K & L^k (this hypothesis is also partly tested with the given data).

In terms of regression analysis then the following approximation to (5i) can be tested:

$$(5ii) LD_t^k = A_0^k + A_1^k F L_t^k + A_2^k w_t^k + A_3^k (Y P_t + Y_t)^{-1} + A_4^k (RIP)^{-1}_t \\ + A_5^k (Y P) (w^k)^2 + A_6^k L_{t-1}^k$$

So far we have not distinguished between different types of regions.

It may very well be, that the parameters of the functions derived differ from region to region. This seems particularly reasonable for the production function. We used a shift parameter A in (4iv), indicating the scale of production. This scale parameter is influenced by two factors, i.e. technical progress and, in a spatial context, agglomeration economies. It is often claimed, that the information about new technologies diffuses from the urban centers of a nation down the urban hierarchy (see e.g. Törnqvist, 1968; Pred, 1977, Pedersen, 1970). At a given point in time then, different such scale parameters should be valid due to different states of technical progress and of variations in the size of the regional system implying agglomeration economies. As a test of these hypotheses is not directly feasible with the given data, only an indirect approach is possible. The total sample of observations based on counties in Austria, will be divided into 3 groups - i.e. large urban, small urban and rural and peripheral. (The classification is taken from Stöhr & Tödtling, 1979). The data used are cross-section data for 1975. For the lagged variables cross-sections were also available. Investment and production values are given in monetary terms only, the employment variables in terms of persons employed. Job vacancies are registered by the regional labor market administrative units and reported in number of persons. These two, although not strictly compatible as far as the definitions of qualification are concerned, were added to reach an approximation for labor demand. The marginal product of labor, which for the Cobb-Couglas case is proportional to the average product (see 4iv), was computed by using net production values and employment figures of 1975. In case no C.E.S or Cobb-Douglas function is used, F_L could be a function of the capital stock (the other labor variables were omitted because of severe multi-collinearity). The capital stock was estimated by using time series (of only 5 years, however) of regional

industrial investment data, discounted at 4.2% per year (following Prucha, 1979). In the production potential, computed for 1975, several distance functions were tried, the best results were obtained by using a formulation used by Kaniak (1976). Regional income data on the county level were only available for 1971, so these were used, applying the same distance function as for YP. Regional, hourly wage rates were available for 1975, disaggregated by qualification. (All the data used were obtained from the Austrian Central Statistical Office - most of them were collected by the "Austrian Federal Chamber of Commerce").

No regionalized data are available on interest rates (r), price levels (p) and the price level of investment goods (q). We claim that r and q do not vary systematically over the regional system. As the majority of Austrian banks is nationalised or under direct public control there is a fairly uniform capital market in Austria - unhappily there are no studies available to corroborate this thesis. When p appeared directly in an equation, formulation (4vi) was used. In equation (4vii) a "real wage rate" (modified by changes due to a change in the supply of Y) appears. As this real wage rate could not be computed (there are no regional price indexes available), the money wages were used.

In the investment equation the variable ICP (including sub!) was constructed by using data on the ERP credits and other regional policy programs (Kaniak, 1977). The "average accessibility" measure in (4iv) was omitted as this index was used in the formulation of the other potentials so it was left out of the empirical analysis.

(4viii & ix) combined and simplified yielded the following regression equation:

$$I_t = B_0 + B_1 F_{Kt} + B_2 (YP + Y)^{-1} + B_3 (RIP)^{-1} + B_4 ICP + B_5 YP$$

For F_K the average product Y/K was used (for the Cobb-Douglas case)

and just B_1 'K in another.

6. The empirical results

In the regressions performed simple OLS estimates were calculated. Spatial autoregression was tested for by means of the Moran (Hordijk, 1974) coefficient, but no serious problems were encountered. Several versions of the models outlined in 5. were tested. The main conclusions will now be briefly summarized.

To start with, there are significant differences in the behavior of different types of regions. Also the demand for labor is different by qualification.

As a general characteristic of the tests the insignificance of the marginal product terms (at least the way they were used here) had to be acknowledged.

Let us proceed more systematically now and look at the best regression results: We will start with the demand for unskilled labor across the regions, (LD^{11}) - the numbers in parantheses being the t-values:

$$\begin{aligned} \text{Urban areas: } LD^1 &= 468 + 1.28 L_{t-1}^1 - 20.9 w^1 + \\ &\quad (0.8) (8.4) \quad (-1.3) \\ &\quad 0.012(RIP)^{-1} - 0.75(YP)^{-1} \\ &\quad (0.93) \quad (-.56) \\ &\quad + 6554(YP+Y)^{-1} - 0.000013 K \\ &\quad (1.01) \quad (-0.26) \\ &\quad (R^2 = 0.92) \end{aligned}$$

Another version using the Y/L^1 as a variable to capture the influence of the marginal product fared a little better than K, the t-value being (-1).

To assess the demand effect only income of the region as such was used in one attempt, the t-value was better (1.0), but the sign was wrong. In the version given above the signs are plausible - the negative sign

for capital could indicate that it is mainly unskilled labor that is replaced by capital in urban areas.

Small urban and rural areas:

$$\begin{aligned}
 LD^1 = & -11.1 + 0.73 L_{t-1}^1 + 2.8 w_t^1 + 0.002 (RIP)^{-1} \\
 & (-0.045) (7.6) \quad (0.36) \quad (0.3) \\
 & + 0.007 (YP)^{-1} - 339.5 (YP + Y_t)^{-1} \\
 & \quad \quad \quad (-0.34) \\
 & + 0.9 K \\
 & (3.0) \quad (R^2 = 0.98)
 \end{aligned}$$

Wages were insignificant in all versions tried, the sign was only negative in one (otherwise bad) run. Using capital stock instead of F_L^1 yielded much better results in this regional classification than the marginal product term. The positive sign for the capital variable in these areas could imply that the substitution of capital for labor is less important, this could mean that capital widening is more common in these regions than capital deepening. As above, demand terms fared badly in general.

Peripheral areas:

$$\begin{aligned}
 LD^1 = & -255.74 + 1.1 L_{t-1}^1 + 3.8 w_t^1 + 0.0002 (RIP)^{-1}_t \\
 & (-0.4) \quad (9.3) \quad (0.47) \quad (0.023) \\
 & + 0.005 (YP)^{-1}_t - 8284 (YP + Y_t)^{-1}_t + 0.0000065 K_t \\
 & (0.12) \quad \quad \quad (0.52) \quad (0.12) \\
 & R^2 = 0.93
 \end{aligned}$$

The terms Y/L came out marginally better than K . The positive sign could again point in the direction of capital widening rather than deepening.

The results for LD^2 , i.e. the demand for skilled labor showed a slightly different pattern (see overview below).

region	const	L_{t-1}^2	w_t^2	$(RIP)_t^{-1}$	$(YP)_t^{-1}$	$(YP+Y)_t^{-1}$	K	R ²
urban	-587	0.83	32.7	-0.3	0.53	-16229	-0.000013	0.99
t	(-0.65)	(21.8)	(1.5)	(-1.22)	(-2.16)	(-1.42)	(-0.18)	
urban/ rural	-779	0.9	18.2	-0.031	-0.015	1302	0.00046	0.99
t	(-0.76)	(16.5)	(0.85)	(-1.16)	(-0.47)	(0.3)	(3.7)	
peri- pheral	-417	0.86	20.9	0.13	-0.84	2324	0.00053	0.98
t	(-0.41)	(12.1)	(0.7)	(1.0)	(-1.06)	(0.3)	(3.34)	

The marginal product variables K and Y/L turned out to be significant in the less urbanized areas, again. The sign of the coefficients show the same pattern as for unskilled labor, in the agglomerations capital tends to be substituted for labor, in the other areas the increased capacity has a positive employment effect.

The income terms fare much better in the urban regions, showing their larger market areas. They also do much better than in the case of the demand for unskilled labor. This could mean, that skilled labor tends to be used more in "export- (in the interregional sense applied here) - oriented industries. Wages seem to play little role (mostly insignificant) in this labor demand category.

Let us now turn to investment. It is a notorious fact, that good econometrically secured investment theories are hard to come by. It is not surprising therefore that the simple formulations used here do not yield very good results.

In general we can observe that the spatial version of the simple accelerator model does fairly well.

Marginal productivity variables in both versions tend to do better

region	const	RIP	YP	YP+Y	sub	K	R ²
urban	-94787	-3.4	1.9	-3681595	-183797	0.18	0.94
t	(-0.12)	(-0.6)	(0.3)	(1.8)	(0.3)	(10.0)	
urban/ rural	-71440	0.43	-5.6	-313440	-7144	0.21	0.99
t	(-0.8)	(0.15)	(1.8)	(-0.76)	(-0.84)	(17.9)	
peri- pheral	-26565	-1.28	6.33	-1614421	-265652	0.30	0.92
t	(-0.33)	(-0.34)	(1.5)	(-1.0)	(-0.33)	(14.8)	

The marginal product terms in both versions show a decreasing importance as the industrial development level increases. In the urban areas, where innovation plays a more important role, the dependence on past capital could be less essential. This conclusion is very tentative, however, because of the influence of the different scales of capital stocks and the replacement demand parameters. The Y/K coefficients in general exhibit a t-value around 1 only, but do demonstrate the same effect as the K variable. This could also point in the direction of agglomeration economies. Neither the simple accelerator model using only regional demand, nor the spatial version do very well, although the potentials used yield better results. It seems, however, that in small regions industrial production is much more oriented towards demand coming from other regions, as domestic demand is too small to justify larger investments.

The subsidies used in the analysis do not seem to play a very important role in the determination of investment, the t-value of 0.8 suggests that there may have been an impact in the small urban/rural regions of Austria.

(It was interesting to note, that if wages of both labor categories are used-which do not appear in the simple theoretical model developed-both come out as being significant in all types of regions. A rise in the wages of unskilled labor has a uniformly positive influence on capital investment, the highest effect occurring in the agglomerations. The effects of wage increases for skilled laborers are less pronounced, the t-values are much lower, the negative signs and small absolute values of these coefficients could be interpreted as implying a more rigid elasticity of substitution between capital and skilled labor.

Concluding one could say, that the approach taken could be potentially useful. As the analysis stands now, considerable improvements seem possible. A broadening of the data base, especially in the direction of time series could improve estimates and permit to take expectations (in the term of lagged variables) better into consideration.

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