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Real estate taxation and other fiscal policies as regulators of growth in ageing regions

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Abstract: Because of ageing, the availability of human resources is decreasing and only an increase in taxes can assure new public facilities for residents with declining functional capacities. Urban shrinkage is a remarkable phenomenon which cannot be convincingly explained by existing theories of urban growth, but it is strongly linked with the market in human resources in production economics. Within the human resource market, commuting or migration costs are compensated, thus influencing wage rates and/or land rent, capitalized on the value of residential properties. Therefore, those institutions that are planning the location and intensity of activities in the nodes of a supply chain should consider the influence of the required level of all kind of taxation, also the real estate, as well as the net wages, which depends on the spatial dispersion of the workers' dwellings. Therefore, owners and managers of a supply chain also have to consider the fiscal policy in the region and the central location where they intend to invest in production or distribution unit. So, the intensity of the flow of items (in-process inventories) and intensity of the inflow of human resources interact in the area in which the activity cell is located and, together with tax policy and subventions, if such exist, influence the net expected profit of the business. Therefore, the paper presents an approach to the integration of the gravity model of spatially dispersed human resources with the supply systems described by extended MRP Theory, explicitly focused on the fiscal policy of the local authorities of a city and its functional region. The numerical examples show how the demographic projections which we calculated for 2019-2070, giving the ratio between active population and population 65+ in Slovenian regions influence the availability of human resources in the region, influencing the managerial decision of where to look for a workforce, and how these policies influence growth or decline of urban areas and their functional regions in the case of Slovenia.

Keywords: human resources, ageing, gravity model, taxation, supply chain, central places, urban housing rent

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1. INTRODUCTION

Regarding the ongoing shrinkage processes that are affecting a number of European and US cities, the literature suggests a new planning paradigm and strategies. Although in developed countries like Germany or USA urban populations began to shrink in large numbers more than half a century ago, the shrinking city discourse did not emerge until the very late 1990s (Mallach, 2017), and the number of articles has started to grow substantially only in the last decade. For example, in ScienceDirect, we can find the first articles on the shrinking city indexed in 1994, and until 2005 the yearly number was always much less than 400, while in the last four years the number of articles published increased by over 1,000 per year. As Mallach writes: *'The discourse became the starting point for local actions, spearheaded by an informal alliance of local officials and both local and national sources of expertise, largely outside academia'*.

We are studying urban growth or decline through the perspective of human resources and the ability of cities and global supply chains with nodes located in such cities to attract them, either as commuters to a workplace in a city or as residents working in activity cells of a production or distribution chain. In planning activities focused to attract new human resources in the area, fiscal policy could be one of the main regulators of city dynamics and attractiveness for a production activity. Therefore, our paper is focused on these regulators of supply chain activity location and intensity, combining the gravity and MRP models. In both, the fiscal policy is embedded.

The results of daily commuting and migration forecasting models give us important indicators for planning activities in the central places of regions. These parameters can be calculated on the basis of the spatial interaction modelling (SIM). SIM is the generic name of various models used to explain and forecast different movements of human resources over space, like migrations or intraregional and interregional commuting flows of human resources. While SIM approaches range from the basic symmetric gravity model (Cesario, 1974) to Wilson's entropy and discrete choice models (Wilson, 2010), we shall here develop the extended asymmetric gravity approach with the acronym NE_SIM, linked to the activity cells as nodes in a global supply chain, as was presented in Bogataj et al. (2017). In such a combined model, taxation policies can be introduced, such as is suggested here. Also, the impact of increased local tax revenues is modelled and presented for the special case study. Based on an analogy to the Newtonian model of the force of attractions, the flows will be modelled as an upgrade of the general spatial interaction model, or SIM, developed by Cesario (1974). In our research, Cesario's model was further developed as an asymmetric function with many new, normalized factors (Bogataj et al., 2019). It is now extended by parameters which enable us to analyse the impact of property taxation on the attractiveness of a municipality and jobs located there, as are presented by equations 1-4. The commuting flows $C_{.j}$ and migration flow $M_{.j}$ to a central place of the chosen functional region j from all other areas could be formalised as:

$$C_{.j} = c(C)\sum_i K(\tau_{ij})^{\varepsilon(C)} \prod_{\kappa \epsilon S} K(\kappa)_i^{\gamma(\kappa)} K(\kappa)_j^{\delta(\kappa)} \quad (1)$$

$$M_{.j} = c(M)\sum_i K(\tau_{ij})^{\varepsilon(M)} \prod_{\kappa \epsilon S} K(\kappa)_i^{\alpha(\kappa)} K(\kappa)_j^{\beta(\kappa)} \quad (2)$$

Here $C_{.j}$ means the sum of all daily commuting inflows to the central place j, where the activity cell of a supply chain is located, and $M_{.j}$ presents the sum of all immigration to j per year. $K(\kappa)_i$ and $K(\kappa)_j$ are the relative measures of the size of factors κ relative to the average of a state in the origin and destination respectively, τ_{ij} is the time distance between them, $\varepsilon(C)$ and $\varepsilon(M)$ are negative parameters characterizing the distance friction, while $c(C)$ and $c(M)$ are calibration parameters. The variables and their coefficients $K(\kappa)$ as a relative measure of the average in the total analysed space, are proxies for the abilities of the origin to generate a flow (also describing a stickiness) and to attract a flow (describing an attractiveness). In the same way, we can describe and forecast the flows out of i :

$$C_{i.} = c(C)\sum_j K(\tau_{ij})^{\varepsilon(C)} \prod_{\kappa \in S} K(\kappa)_i^{\gamma(\kappa)} K(\kappa)_j^{\delta(\kappa)} \quad (3)$$

$$M_{i.} = c(M)\sum_j K(\tau_{ij})^{\varepsilon(M)} \prod_{\kappa \in S} K(\kappa)_i^{\alpha(\kappa)} K(\kappa)_j^{\beta(\kappa)} \quad (4)$$

Several variables $\kappa(i)$ and $\kappa(j)$ are used to characterise the flows. In our study the variables included in the model are the following:

Table 1: The variables in the NE_SIM model which characterise the spatial units and flows

$\kappa = POP$	Population size of the spatial unit	τ_{ij}	The distance between the origin of human resources and their destination (node of a supply chain).
$\kappa = UEM$	Unemployment	$1+q_{\chi,i}$	The factor of changes in relative property taxes.
$\kappa = w$	Gross personal income	κ =*REV*	Municipality revenues per capita.
$\kappa = DWE$	Number of dwellings per thousand inhabitants	$\kappa = V$	The average net market price per square meter of housing units.

2. TAXATION AS A REGULATOR OF HR FLOWS

We assume that the relative taxation in the spatial unit i changes for the factor $1+q_{\chi,i}$ so that the coefficient of housing values increases, as presented by (5) and (6):

$$C'_{ij} = C_{ij} \cdot (1+q_{\chi,i})^{\gamma(\chi)} \cdot (1+q_{\chi,j})^{\delta(\chi)} \quad (5)$$

$$M'_{ij} = M_{ij} \cdot (1+q_{\chi,i})^{\alpha(\chi)} \cdot (1+q_{\chi,j})^{\beta(\chi)} \quad (6)$$

Here the notation of the multipliers $(1+q_{\chi,i})$ and $(1+q_{\chi,j})$ means the relative increase in the market value of housing units because of changed real estate taxation in the regions i and j, respectively. C'_{ij} and M'_{ij} are the intensities of new flows resulting from changed taxation for the coefficients $(1+q_{\chi,i})$ and $(1+q_{\chi,i})$, respectively. Here, κ references one of the factors included in our study. We can write $\kappa \in \{POP, UEM, w, DWE, \chi, REV, V\}$, belonging to the municipality of origin *i* (emissivity indicator or stickiness), or the destination *j* (factor of attractiveness); the analyzed factors and/or their coefficients are explained in Table 1. The impacts of emissivity in the municipalities of origin, the attractiveness to flows in the municipalities of destination, and the impact of distances between the origin and the destination were estimated by a regression analysis, giving the values of α, β, γ, and δ, as well as their significance level. Human resources will move to the central place where the activity cell of a supply chain with increasing production activities is located if the costs of housing units are low enough and the differences in salaries acceptable. We are considering the economic effects of local property taxes, as a percentage of the market value of the housing units, being the present discounted value of the stream of urban rents generated by the housing units. If the rent is denoted by *R* per year, and if the yearly real estate tax as a proportion of the market value is denoted by χ, then the market value of property *V* can be calculated as:

$$V(R,\chi,r) = \sum_t (R - \chi V)/(1+r)^t \quad (7)$$

In equation (7), *r* is the interest rate and t gives a summation over the number of years into the future. If the life of a housing unit goes to infinity, the relationship between the market value and the rent can be written as:

$$V(R,\chi,r) = (R - \chi V)/r \Rightarrow V = R/(r+\chi) \quad (8)$$

In (8), $r+\chi$ is the capitalization rate. Our assumption is that if the tax rate is different in different regions, the flow of daily commuters will change because the proportions between real estate values will change. If the tax rate changes equally in all regions, then the proportions between real estate values will not change. Therefore it will not influence commuting flows. This means that the changes in forecasting dynamics of trips to work or migration appear only when taxation policies depend on individual spatial areas (municipalities) and these areas have implemented different tax rates. Let us assume that, in the beginning, all areas have the same tax rate χ_o, but later only *j-th* municipality introduces higher taxation χ_j. In this case, *V* increases to $V_j^* = V_j \cdot (r+\chi_o)/(r+\chi_j)$ and the multiplier $K_j(V)$ decreases approximately (if the population in this area is sufficiently small compared to the total population) to $K_j(V^*) = K_j(V) \cdot (r+\chi_o)/(r+\chi_j)$. It influences the changes in intensity of commuting and migration inflows

$$C^{*}_{.j} = C_{.j} \cdot \left[(r+\chi_o)/(r+\chi_j) \right]^{\delta(V)} = C_{.j} \cdot \left[1+q_{\chi,j} \right]^{\delta(V)} \quad (9)$$

$$M^{*}_{.j} = M_{.j} \cdot \left[(r+\chi_o)/(r+\chi_j) \right]^{\beta(V)} = M_{.j} \cdot \left[1+q_{\chi,j} \right]^{\beta(V)} \quad (10)$$

and outflows:

$$C^{*}_{j.} = C_{j.} \cdot \left[(r+\chi_o)/(r+\chi_j) \right]^{\gamma(V)} = C_{j.} \cdot \left[1+q_{\chi,j} \right]^{\gamma(V)} \quad (11)$$

$$M^{*}_{j.} = M_{j.} \cdot \left[(r+\chi_o)/(r+\chi_j) \right]^{\alpha(V)} = M_{j.} \cdot \left[1+q_{\chi,j} \right]^{\alpha(V)} \quad (12)$$

If the available net commuting workforce in the municipality j was previously $C_{.j} - C_{j.}$, now, it will change to:

$$\Delta_{Cj} = C_{.j} \cdot \left[1+q_{\chi,j} \right]^{\delta(V)} - C_{j.} \cdot \left[1+q_{\chi,j} \right]^{\gamma(V)}, \quad (13)$$

and cause a change to the yearly net migration

$$\Delta_{Mj} = M_{.j} \cdot \left[1+q_{\chi,j} \right]^{\beta(V)} - M_{j.} \cdot \left[1+q_{\chi,j} \right]^{\alpha(V)} \quad (14)$$

The question appears how the wage policy of producers can be counterbalanced by the tax policy in the municipality j. Real estate taxes are the largest component of local taxes, which in turn are the main source of investments in public facilities, influencing the attractiveness and stickiness of municipalities for human resources. Let us assume that a share of the collected housing taxes is invested in transport and other infrastructure, including amenities which influence an increase in the attractiveness of a municipality j for the factor of its attractiveness $(1+\lambda\chi_j+\lambda_o)/(1+\lambda\chi_o+\lambda_o)$ for commuters and $(1+\eta\chi_j+\eta_o)/(1+\eta\chi_o+\eta_o)$ for workers' migration flows, where λ_o, η_o are the attractors for commuters and migrants respectively, dependent on other taxes invested in the area. In such a case when municipality j increases the property taxes from χ_o to χ_j and those other factors do not change, the net intensity of commuting workforce flows will change:

$$\Delta_{Cj} = C_{.j} \cdot \left[1+q_{\chi,j} \right]^{\delta(V)} \left[\frac{(1+\lambda\chi_j+\lambda_o)}{(1+\lambda\chi_o+\lambda_o)} \right]^{\delta(REV)} - C_{j.} \cdot \left[1+q_{\chi,j} \right]^{\gamma(V)} \left[\frac{(1+\lambda\chi_j+\lambda_o)}{(1+\lambda\chi_o+\lambda_o)} \right]^{\gamma(REV)} \quad (15)$$

$$\Delta_{Mj} = M_{.j} \cdot \left[1+q_{\chi,j} \right]^{\beta(V)} \cdot \left[\frac{(1+\eta\chi_j+\eta_o)}{(1+\eta\chi_o+\eta_o)} \right]^{\beta(REV)} - M_{j.} \cdot \left[1+q_{\chi,j} \right]^{\alpha(V)} \cdot \left[\frac{(1+\eta\chi_j+\eta_o)}{(1+\eta\chi_o+\eta_o)} \right]^{\alpha(REV)} \quad (16)$$

In the case where there are no real estate taxes and no investments in municipality facilities and amenities, Δ_{Cj} and Δ_{Mj} can also be achieved by changes to gross personal income. Let us take the case of employment in the production activities located in the municipality j. The impact of this increase in wages on the availability of human resources and on the NPV of a supply chain is described in Bogataj et al. (2017). When the production at a node j is increasing and needs an additional flow of workforce to the node, the required increase: $\Delta_{Cj} + \Delta_{Mj}$ could be achieved by increasing wages for factor $1+q_{w,j}$, or could be partly or fully replaced by the proper tax policy:

$$\Delta_{Cj} + \Delta_{Mj} = C_{.j} \cdot \left[1+q_{\chi,j} \right]^{\delta(V)} \left[\frac{(1+\lambda\chi_j+\lambda_o)}{(1+\lambda\chi_o+\lambda_o)} \right]^{\delta(REV)} \cdot \left[1+q_{w,j} \right]^{\delta(w)} - C_{j.} \cdot \left[1+q_{\chi,j} \right]^{\gamma(V)} \left[\frac{(1+\lambda\chi_j+\lambda_o)}{(1+\lambda\chi_o+\lambda_o)} \right]^{\gamma(REV)} \cdot \left[1+q_{w,j} \right]^{\gamma(w)} + M_{.j} \cdot \left[1+q_{\chi,j} \right]^{\beta(V)} \cdot \left[\frac{(1+\eta\chi_j+\eta_o)}{(1+\eta\chi_o+\eta_o)} \right]^{\beta(REV)} \cdot \left[1+q_{w,j} \right]^{\beta(w)} - M_{j.} \cdot \left[1+q_{\chi,j} \right]^{\alpha(V)} \cdot \left[\frac{(1+\eta\chi_j+\eta_o)}{(1+\eta\chi_o+\eta_o)} \right]^{\alpha(REV)} \cdot \left[1+q_{w,j} \right]^{\alpha(w)} \quad (17)$$

3. THE FLOW OF ITEMS

The planned flows in time and space can be transparently and illustratively presented when constructing an extended Material Requirements Planning (MRP) system, which enables the operator to observe and control the flows in a global supply chain (Bogataj et al., 2011; based on Grubbström, 2007). Its extension to the global supply chains and consideration of the impact of locations was made possible when a transportation matrix was introduced in the model, as presented by Bogataj et al. (2017), using the notation presented in Table 2.

Table 2: Notation

n ... The number of activity cells in a supply chain.
s … The frequency in the Laplace transformed space.
h_{ij} … The number of items i from location i needed to produce one unit of the item j at location j.
Δ_{kj} … Distribution lead time to transport the item from k to j.
$\tilde{\mathbf{\Delta}}^{pr}(s-\omega)$ … Distribution lead time matrix in ω dynamics.
$\tilde{\mathbf{P}}(s)$ … The vector of manipulation intensity expressed in the Laplace transformed space of the complex variables.
$\tilde{\mathbf{H}}^{tr}$ … The generalised delayed transportation-input matrix which describes only transportation delays in input matrix $\mathbf{H}$.
t_j … The time when in jth activity cell cycle starts.
$\tilde{\mathbf{H}}^{pt}$ … The generalized delayed input matrix in the space of complex variables.
d_{ij} … Transportation costs per item per time unit, i to j.
ω … The growth/decline of intensity $\mathbf{P}$.
g_{kj} … Output flow between activity cells k and j.
τ^{tr}_{ij} … Transportation lead time from i to j.
$\tilde{\boldsymbol{\tau}}^{pr}$ … Production lead time matrix in a frequency domain.
P_j … The intensity of production or warehousing in j.
$\tilde{\mathbf{G}}^{tr}$ …The generalised, delayed transportation-output matrix.
Γ_j … The length of the cycle in the process of activity j.
$\tilde{\mathbf{G}}^{pt}$ … The output matrix retarded also by transportation.
$\mathbf{p}$ … The price vector.
$\tilde{\mathbf{G}}^{pt}(s-\omega) - \tilde{\mathbf{H}}^{pt}(s-\omega)$ the generalised delayed and dynamic technology matrix.

The fix nodes (activity cells) could be: (a) manufacturing sites, (b) warehouses, (c) offices, or (d) control centers. The supply chain nodes can also be characterized by attractiveness for existing and potential flows of daily commuters and migrants to the municipality where the activity cell is located (see Bogataj et al., 2019), considering also growing or declining intensity of supply chain flows described by $e^{\omega t}$. Here we shall also assume that the dynamics of supply chain flows can change on the planning horizon. These changes influence human resource needs from a broader area of a functional region. In the paper Bogataj et al. (2019), we studied only the case when these needs influence changes in labour costs, but here we can add the knowledge of how changes in real estate taxes and revenues, which are used for investments in urban facilities, including investment in public amenities, influence the availability of human resources, as developed by (1) – (17). The price vector (18) for total production depends on the allocation of activity cells in different areas (functional regions), and the net production is given in (19):

$$\mathbf{p}(l)=\left[p_1(l),p_2(l),...,p_n(l)\right]=\mathbf{p}=\left[p_1^{l_1},p_2^{l_2},...,p_n^{l_n}\right] \quad (18)$$

$$\left[\tilde{\mathbf{G}}^{pt}(s-\omega)-\tilde{\mathbf{H}}^{pt}(s-\omega)\right]\cdot\tilde{\mathbf{P}}(s-\omega) \quad (19)$$

According to the Net Present Value Theorem, by exchanging the Laplace frequency s in the transformation of a cash flow for the continuous interest rate ρ, the Net Present Value (NPV) of the cash flow is obtained. We introduced also the ω dynamics of production intensity, which leads to the expression of NPV ($\varphi = s-\omega$), which has not yet been considered: $\mathrm{NPV}_{\mathrm{prod}}=\mathbf{p}(l)\left(\tilde{\mathbf{G}}(\varphi)-\tilde{\mathbf{H}}(\varphi)\right)\tilde{\mathbf{P}}(\varphi)$ (20)

In our standard treatment, ordering costs are collected into the row vector $\mathbf{Q}=\left[Q_1,Q_2,...,Q_m\right]$. Therefore: (21)

$$NPV_{ord}=-\mathbf{Q}\tilde{\mathbf{v}}(\varphi)=-\mathbf{Q}\left[\tilde{v}_1(\varphi)... \quad \tilde{v}_n(\varphi)\right]^T=-\sum_{j=1}^{n}Q_j\tilde{v}_j(\varphi)$$

$$NPV_{tr}=-\mathbf{E}^T\left[\mathbf{\Pi}_G(\rho-\omega)+\mathbf{\Pi}_H(\rho-\omega)\right]\tilde{\mathbf{P}}(\rho-\omega) \quad (22)$$

$\mathbf{E}^T$ is the row vector of units which enables us to summarise costs of transportation between a pair of nodes. If ω is changing on the time horizon, in the sequence of time intervals with limits $0,t_1,t_2,..t_k,\infty$ so that it is piecewise constant, of values $\omega_0,\omega_1,\omega_2,...,\omega_k$ in general, we write:

$$\begin{aligned}&NPV(\omega_h)=\mathbf{p}\left(\tilde{\mathbf{G}}^{pt}(\rho-\omega_h)-\tilde{\mathbf{H}}^{pt}(\rho-\omega_h)\right)\tilde{\mathbf{P}}(\rho-\omega_h)-\\&-\mathbf{E}^T\left(\tilde{\mathbf{\Pi}}_G(\rho-\omega_h)+\tilde{\mathbf{\Pi}}_H(\rho-\omega_h)\right)\tilde{\mathbf{P}}(\rho-\omega_h)-\\&-\mathbf{Q}\tilde{\mathbf{v}}(\rho-\omega_h)\mathbf{E}-NPV_{HR}(\rho-\omega_h)-Inv\end{aligned} \quad (23)$$

$$NPV=NPV(\omega_0)-Inv+\sum_{h=1}^{k}e^{-\rho\cdot t_h}\left\{NPV(\omega_h)-NPV(\omega_{h-1})\right\}$$

Changing the location of activity j from l to l' could influence NPV_{tr} and NPV_{HR} significantly. Therefore, we shall assume $NPV_{tr}(j)\neq NPV_{tr}(j')$. The final evaluation of *NPV* of all activities at constant growth or decline is:

$$\begin{aligned}&NPV = NPV_{prod}+NPV_{tr}+NPV_{ord}-NPV_{HR}-Inv=\\&=\mathbf{p}\left(\tilde{\mathbf{G}}^{pt}(\rho-\omega)-\tilde{\mathbf{H}}^{pt}(\rho-\omega)\right)\tilde{\mathbf{P}}(\rho-\omega)-NPV_{HR}(\rho-\omega)-Inv-\\&-\mathbf{E}^T\left(\tilde{\mathbf{\Pi}}_G(\rho-\omega)+\tilde{\mathbf{\Pi}}_H(\rho-\omega)\right)\tilde{\mathbf{P}}(\rho-\omega)-\mathbf{Q}\tilde{\mathbf{v}}(\rho-\omega)\end{aligned} \quad (24)$$

or in the case of changing dynamics:

$$\begin{aligned}&NPV=-Inv+NPV_{prod}(\omega_0)+NPV_{tr}(\omega_0)+NPV_{ord}(\omega_0)+\\&+\sum_{h=1}^{k}e^{-\rho\cdot t_h}\left\{NPV_{prod}(\omega_h)+NPV_{tr}(\omega_h)+NPV_{ord}(\omega_h)-NPV_{HR}(\omega_h)\right.\\&\left.-NPV_{prod}(\omega_{h-1})-NPV_{tr}(\omega_{h-1})-NPV_{ord}(\omega_{h-1})+NPV_{HR}(\omega_{h-1})\right\}\end{aligned} \quad (25)$$

Also, we shall denote different taxes and fees accrued by work, which belong to the functional region FR in which the activity cell is activated, by NPV_{tax}, which depends on the fiscal policy of that spatial unit. For future analysis of such a system, we should be aware that the income of FR can be invested in the region to attract more human resources to the region, or (if it is too high) this policy can repel the activity cells from the territory. Therefore:

$$NPV_{profit}=NPV_{prod}-NPV_{tr}-NPV_{ord}-NPV_{HR}-NPV_{tax}-Inv$$

$$\Delta NPV_{profit}=NPV_{profit}(j')-NPV_{profit}(j); \qquad j=j(l);j'=j(l')$$

Activities j will move from l to l' if $\Delta NPV_{profit}>0$. (26)

4. AVAILABLITY OF HUMAN RESOURCES AT A GIVEN PROPERTY TAX AND INVESTMENT POLICY

Let us now assume that production growth is proportional to the growing needs for human resources (constant productivity). The additional human resources required per time unit, if production increases from an initial volume $P_j(t=0)=P_j$ to $P_j(t=1)=P_j\,e^{\omega}$ items per time unit, is $\Delta\Lambda_j(t=1)=L_jP_j(e^{\omega}-1)$. This additional volume will be captured from the flow of commuters (in the activity cell j, initially equal to $\Lambda_{C,j}$ from where $r_{C,j}.\Delta\Lambda_{C,j}$ workers are appropriate for this activities), and migrants (initially yearly equal to $\Lambda_{M,j}$), from where $r_{M,j}\cdot\Delta\Lambda_{M,j}$ is the number of those who have abilities suitable to be employed for activity j. For assuring the production growth ω, it follows that the following conditions should be achieved if also real estate taxes and municipal revenues influence the attractiveness and stickiness of a studied municipality:

$$\begin{aligned}&L_jP_j(e^{\omega}-1)=r_{C,j}\cdot C_{.j}\left[1+q_{\chi,j}\right]^{\delta(V)}\left[\frac{(1+\lambda\chi_j+\lambda_o)}{(1+\lambda\chi_o+\lambda_o)}\right]^{\delta(REV)}\cdot\left[1+q_{w,j}\right]^{\delta(w)}-\\&-r_{C,j}\cdot C_{j.}\cdot\left[1+q_{\chi,j}\right]^{\gamma(V)}\cdot\left[\frac{(1+\lambda\chi_j+\lambda_o)}{(1+\lambda\chi_o+\lambda_o)}\right]^{\gamma(REV)}\cdot\left[1+q_{w,j}\right]^{\gamma(w)}+\\&+r_{M,j}\left\{M_{.j}\cdot\left[1+q_{\chi,j}\right]^{\beta(V)}\cdot\left[\frac{(1+\eta\chi_j+\eta_o)}{(1+\eta\chi_o+\eta_o)}\right]^{\beta(REV)}\cdot\left[1+q_{w,j}\right]^{\beta(w)}-\right.\\&\left.-M_{j.}\cdot\left[1+q_{\chi,j}\right]^{\alpha(V)}\cdot\left[\frac{(1+\eta\chi_j+\eta_o)}{(1+\eta\chi_o+\eta_o)}\right]^{\alpha(REV)}\cdot\left[1+q_{w,j}\right]^{\alpha(w)}\right\}\end{aligned} \quad (27)$$

In (27), $r_{C,j}$ and $r_{M,j}$ are the shares of the net flow of commuters and migrants respectively having the skills needed for employment in the activity cell j. It is easy to estimate these initial values from the data of employed workers in the activity cell and national statistics about migrations and commuters. For the general approach when the natural growth also contributes to the number of available workers, we can find $\Lambda_{O,j}$ in local or national statistics. From (31), using data from national statistics, the only unknown value is the needed growth of wages $q_{w,j}(t)$ at a given property tax policy and level of municipal revenues, for planned dynamics of production intensity $P_j(t) = P_j\, e^{\omega t}$. In our prior paper (Bogataj et al., 2019) we derived the optimal $q_{w,j}(t)$ at given increase of production. In the case study of Slovenia, we shall now study the difference in required changes of wages, when the new law on real estate tax will enter into force, if also investments in the municipality are considered.

5. THE CASE STUDY

In the case study, we consider how different real estate tax policies and investments in public facilities (in the social infrastructure, in given age structure in Slovenia as result of municipality's revenues) influence the availability of human resources. The projection of ratio between active population and population 65+ is falling by the years (2020; 2030; 2040) to the (11.2, 7.8, 4.7) respectively. Those, working on physically demanded jobs retire even earlier (Rogelj and Kavšek, 2017). The VAT and taxation of company's profits are assumed to be the same in all municipalities; therefore, the difference between them is zero. The data about migration to workplaces and labour commuting among 212 municipalities was acquired from the Statistical Office of the Republic Slovenia (SURS) for the year 2015. SURS also provided the following data: (a) about the inhabitants in the municipality from where the relative value $K(POP_\circ)$ to the average of Slovenia was calculated; (b) the number of unemployed persons, from where the coefficient to the average of Slovenia $K(UEM_\circ)$ was calculated; (c) gross personal income, from where $K(w_\circ)$ as the coefficient to the average of Slovenia was calculated; and (d) data on number of dwellings per thousand inhabitants in each municipality, giving the coefficient to the average of Slovenia $K(DWE_\circ)$. The data on municipal revenue was acquired from the Ministry of Finance of the Republic of Slovenia, and the data on the average price per square meter of residential units in each municipality was acquired from the Database of the Surveying and Mapping Authority of the Republic. The data on time-spending distance as the fastest travel time by car between the municipality centres of Slovenia was calculated in GIS. We analysed the impact of factors in the origin (stickiness) and destination (attractiveness) on migration (M) and labour commuting (C), following equations (1)-(4). The gravity models give values of parameters, presented in Table 3. Let us now assume that in the region l, activity j is running by the intensity $P_j = 3{,}000$ and the managers decided to be intensified with dynamics $P_j e^{\omega t}$, where ω = 0.7, $r_{C,j} = 5\%$ and commuters and $r_{M,j}$ =2 % migrants. Initially, from the migration and commuting: $\left[M_{.j},\, M_{j.},\, C_{.j},\, C_{j.}\right]$ = [1000, 800, 800, 750]. The managers have to calculate how the wages should rise ($q_{w,j}$) to assure the planned growth of production $\mathbf{P}(t) = \mathbf{P}\exp(\omega t)$ if property taxes are 10% higher than the taxes at the other municipality, and if these taxes increase the municipality revenue per capita by 15%, as in other municipalities, which is used for investments.

For the case of increased taxes, the results are obtained from (31):

$$\Delta\Lambda_j = (0.05\cdot(1000-800)+0.02\cdot(800-750))\cdot(\mathrm{e}^{0.7}-1) = 15.206$$

$$\begin{aligned}\Delta\Lambda_j &= 0.05\cdot\left\{1000\cdot\left[1.1^{0.622}\cdot 1.15^{0.896}\cdot(1+q_{w,j})^{2.199}-1\right]\right\}- \\ &-0.05\cdot\left\{800\cdot\left[1.1^{0.169}\cdot 1.15^{0.69}(1+q_{w,j})^{-0.336}-1\right]\right\}+ \\ &+0.02\cdot\left\{800\cdot\left[1.1^{1.063}\cdot 1.15^{0.731}(1+q_{w,j})^{1.063}\right]\right\}- \\ &-0.02\cdot\left\{750\cdot 1.1^{0.321}\cdot 1.15^{0.624}\left[(1+q_{w,j})^{0.774}\right]\right\}\end{aligned} \tag{28}$$

From (28) it follows that an increase in wages of 4.49% will enable attracting enough net migrants and net commuters, if this municipality increases investments in urban facilities and amenities by 15% per capita, on the basis of a relative increase in the real estate taxation rate of 10%.

Table 3. The results of Slovenian case study

Notation	Description	Statistics			
M_{ij}	Estimated intensity of labour migration flow from i to the municipality j.	Multiple R=0.611 Adjusted R^2=0.373 Constant: c(M)=0.007 Time spending power: ε(M)= -2.619			
C_{ij}	Estimated intensity of labour commuter flow from i to j.	Multiple R=0.717 Adjusted R^2=0.514 $constant$: $c(C) =$ 0.011 $time\ spending\ power$: $\varepsilon(C) =$ -4.369			
Regression coefficients (potency) p-values<0.0001					
	Coefficients	α	**β**	γ	δ
$K(POP_\circ)$	Population	0.794	0.723	0.558	1.183
$K(UEM_\circ)$	Unemployment	0.569	0.625	0.575	0.477
$K(w_\circ)$	Average gross personal income	0.774	1.063	-0.336*	2.199
$K(DWE_\circ)$	Number of dwellings per 1000 inhabitants	-0.249	-0.249	-0.191	-0.314
$K(REV_\circ)$	Municipal revenue per capita	0.624	0.731	0.690	0.896
$K(V_\circ)$	Market price of housing	0.321	0.429	0.169	0.622

The willingness to commute strongly depends on distance. If the distance from home to the location of the production unit increases by 10%, the intensity of flow decreases by 65.94% ($=1.1^{-4.369}$). If the gross and net salary in destination j increases by 10% (the percentage of income taxes and social contributions being equal in all spatial units), the intensity of flow of human resources could increase by 23.3% ($=1.1^{2.199}$), while a 10% growth in salaries in the origin i could result in it retaining 3.15% of workers who have been commuting. It is interesting to see that the increase in the price of real estate (including taxes), which can also be the result of taxation in origin ($\gamma(V) = 0.169$), is less important to the flows of commuters to the destination than is the ability of the destination to attract them ($\delta(V) = 0.622$).

Let us now consider how investments in urban facilities of origin and destination influence commuting flows! In Table 3, we can find: (REV)=0.690 and $\delta(REV) = 0.896$. This means that the per capita increase in municipal revenue which is used for investments in public facilities and amenities in the same municipality increases the flow from origin and to destination. If revenues increase relative to others by 20%, the inflow increases by $1.2^{0.896}$=17.75%, while outflow increases only by $1.2^{0.69}$=13.4% until the revenues in the other communities do not change. It is interesting to see that the increase in the prices of real estate (including taxes), which can also be the result of taxation in origin ($\gamma(V) = 0.169$), pushes the flows of commuters to the destination less than destination is able to attract them ($\delta(V) = 0.622$). Let us now consider how investments in urban facilities of origin and destination influence commuting flows! In the Table 3, we can find: γ (REV)=0.690 and $\delta(REV) = 0.896$. It means that increase of the municipal revenue per capita which are used for investments in public facilities and amenities in the same municipality increase flow from origin and flow of destination. If the revenues increase relatively to others for 20% above the average the inflow increase for $1.2^{0.896}$=17.75% while outflow increase only for $1.2^{0.69}$=13.4% until the revenues in the other communities do not change. Also, we are able to conclude that the increase of prices of real estate which can also be results of taxation ($\alpha(V)=0.321$) in origin, push the flows of migrants to the destination less than destination is able to attract them ($\beta(V)=0.429$), while the revenues per capita, invested in the facilities of municipality also push the flows from origin ($\alpha(REV)=0.624$) less than the destination can attract them for the same reason ($\beta(REV)=0.731$).

6. CONCLUSIONS

In this paper, we introduced a novel approach to study the interactions between supply chain flows (flow of items, information, and financial flows) and human resources as commuting or migration flows in an FR at growing or volatile production intensity according to the managers' decission, when the number of needed workers is changing, also dependent on tax policy in the economic area, and the present value of the stream of profit is evaluated. Here we suggest an approach that can support strategic managerial decisions concerning where to locate an activity cell and what intensity could be reached for a higher profit regarding the market of human resources, when residences are dispersed in the region and not just in the city under consideration. The main result of this paper is the formulation of the optimal choice of location for a certain activity cell in a supply chain (32), where the growth of production and the growth of commuting and migration in dependence of the growth of the wage rate appear. The optimal increase of wages in a given plan of production growth is also given in the case study. In cooperation with local authorities, some other factors influencing the flow of human resources could also be improved, leading to more sustainable economic growth in the broader area. The study is especially pertinent in the case of shrinking cities in aging Europe, where human resources are emigrating from the FR of these cities, or they are aging out of the workforce.

Mayock (2016) has stated that little is known about the magnitude of the compensating differentials for commuting to work when production is increasing at the same level of productivity. We succeeded to derive the interaction between the increased flow of items in a supply chain and available human resources commuting in the FR of the activity cell, which belongs to a supply chain with a volatile flow of items, by introducing asymmetric SIM (Lowry-like) expression to the extended, dynamic version of the MRP model. Using the presented approach, we can evaluate the possible influences of increasing production intensity on labour costs and properly calculate the added value of a supply chain, which influences the present value of the stream of profits. Further development of this model would enable global supply chain managers and regional authorities to study the optimal allocation of activity cells. Therefore, for individual supply chains, the optimal solution of the allocation problem must be solved, having considered the labour costs in the broader environment as presented here.

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