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Different roles of municipalities in an urban agglomeration: a regional agent-based economic model

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0. Abstract

Historically Switzerland is characterized by numerous small towns. During the twentieth century, the image of Swiss cities has changed: the expansion of the city reached the limits of administrative urban borders, penetrating in peripheral locations. The main reasons concern not only the territorial or cultural environment, but also (and always more) the possibility to support public services, public investments and public accounts.

Currently, urban agglomerations include dozens of municipalities and this is seen as a virtuous strategy to provide basic public services and utilities in peripheral areas.

Swiss federalism has fostered the development of a large number of small and medium-sized cities. This creates the conditions for polycentric and decentralized settlements. However, each cantonal entity is asked to provide solid results, without a real empirical example.

At this stage of the territorial and institutional transformation, the understanding of different municipalities' roles is essential: the "work" and "live" functions are spread irregularly throughout the territory. Some core cities are traditionally business locations hub but the progressive urbanization has enhanced the attractiveness of the belt municipalities, for both residential and business purposes.

We try to identify the different functions and relations between 45 agglomerated municipalities in southern Switzerland (Ticino), using a territorial agent based model. The analysis focus on four analytical dimensions: economic competitiveness, attractiveness, openness and social equality.

Our research adopts a bottom-up approach to urban systems, considering the agglomeration mechanism and effects of different regional and urban policies. Urban residential dynamics are the result of simultaneous household's choices; thus, no program can be planned, without the ability to understand and predict the individual decisions in the short and long term.

Recently, agent-based models (ABMs) have been proposed in order to support urban policy makers. Simulating the individual actions of diverse agents on a real city and measuring the resulting system behaviour and outcomes over time, they provide a good test bed for evaluating the impact of different policies

Our analysis starts from the micro level at the smallest territorial unit (municipalities). The database is created merging the Swiss official secondary data for one reference year (2011) with Eurostat and OECD-Regpat.

The model, linking territorial characteristics and agents, simulates the single location choices and formation of urban development patterns, which are influenced by residential and industrial agglomeration forces and policy interventions.

The results highlight that the understanding of municipalities' functions on the territory appears to be essential for designing a solid institutional agglomeration (or city). From a methodological point of view, we contribute to improve the application of territorial ABM.

Finally, our results provide a robust base to evaluate in a dynamic way various political interventions, in order to ensure a sustainable development of the agglomeration and the surrounding territories.

JEL codes: C63, R12, R14

Keywords: urban agglomeration, urban policy evaluation, Agent Based Models

1. Introduction

The structure of firms used to be different from nowadays. Traditionally important factors for entrepreneurs were to be close to natural resources, close to workforce and to customers and, if possible, to be as far as possible from competitors, which offered technically and qualitatively similar products. Factories in this economic environment used to be rather static. The remaining of a firm in the precise position in the space, even with slightly changing factors of attractiveness, seemed more reasonable than that the same would incur the complex procedure of disinvestment and reinvestment in the cost intensive infrastructure and hardware. On the contrary, over the recent years, the degree of firms' mobility, as well as the mobility of residents and workers increased rapidly. For entrepreneurs the weight of the capital requirements for machinery to workforce and know-how changed to the favor of the second. Globalization of markets connected with increased mobility opened new ways and simplified access to markets abroad for firms and facilitated the recruitment of able workforce within a much wider range than before. On the other hand, competition increased in the same way. Firms' challenges shifted in consequence from the need to be "locally" competitive to the ability of remaining steady also in the global dimension. Not insignificant in this trend were also the firms' abilities to offer a more specialized and differentiated product than competitors' ones.

The importance of being close to local resources and markets lost in significance to the favor of being present at a strategically important access point in the global context. Not only the factors of connectedness to the world and to markets are today guiding firms in the localization decision, but a vast set of factors influences their choice and the by them perceived degree of attractiveness of a specific area or location for these firms' branch.

For this reason, the aim of this paper is to analyse the actual localization of determined branches in the different subareas of the Lugano conurbation, the main city in southern Switzerland. Key points are the comprehension of the actual situation and to understand the dynamics that guide enterprises in their localization decision. The main part of this scientific paper consists in understanding the movements of defined branches within the geographical space over time. [Kröll 2014]

A set of attractiveness defining indicators and their relative importance for the included groups of firms are the main input for the construction of an Agent-based model. Connecting this to the dynamic characteristics of the geographical subunits, an inter-temporal observation of firms' movements within the conurbation is enabled. In the second main part

the effect of introducing a new policy, that influences directly on the characteristics, more precisely on a determined part of indicators of a sub region, will be analysed. This second part helps, additionally to the findings of the first part: the theoretically best possible allocation of a branch, with given attractiveness indicators in the geographical space; to test the effects of newly created policies with the goal to improve local attractiveness and to analyse the efficiency and relevance of these by policymakers created actions.

The remainder of the paper is structured as follows. The second section reviews development of urban agglomerations in Switzerland in existing literature. The third section describes functional specializations of communities. The third part reviews Agent Based Model theory and illustrates the empirical model for the analysis. Empirical results are presented in the fifth section. The sixth section presents concluding remarks.

2. Development of urban agglomerations in Switzerland

In the last 25 years, the configuration of many cities in Switzerland changed profoundly. Many considered single cities started to make part of a conurbation-area. [Bundesamt für Raumentwicklung ARE, 2009: 11] This means that many of the surrounding municipalities have become stronger interconnected with the core city. For this reason, the extension of conurbations in the entire country started to grow. A first effect is the inclusion of an increasing number of rural towns into the conurbation area, which adds additional residential population to the agglomeration. Increasing interest is assigned to the role of the, through mergers absorbed communities of the region. An important point is the function of those municipalities within the conurbation. Furthermore, a second tendency, a constant migration stream from rural towns into conurbation municipalities makes conurbation's population grow.

The term that aggregates the two previously mentioned effects is called "urbanization". In the following graph, quotas of residential population living in rural and urban areas are contrasted and illustrated in percent quotas.

[Insert Figure 1 about here]

When considering the growing extension of Switzerland's conurbations over twenty years, starting with 1980, one particularity to notice is that cross-border agglomerations are perceived only starting with 1990. The scale of all Swiss conurbations in the three years of

reference, 1980, 1990 and 2000 are exposed in the following map. The systematic growth of agglomerations is best illustrated in the Basel area. Towards north, a gradually growing extension of this cross-border agglomeration can be observed. In the area surrounding the Zürich agglomeration, more and more conurbations start to be interconnected with each other. They are increasingly integrated in the actual conurbation of Zürich. Within year 2000, conurbation of Winterthur was almost absorbed, but also the agglomerations of Zug and Lucerne are always stronger connected with the Zürich conurbation.

[Insert Figure 2 about here]

With the increasing number of conurbation municipalities, the average number of inhabitants of urban municipalities is decreasing, as the newly included communities mainly are of rural character and therefore have a lower density than existing conurbations. [Bundesamt für Raumentwicklung ARE, 2009: 12].

Analysing this tendency more in detail, two main directions can be pointed out. First, in the period between 1983 and 1995, an increasing consumption of residential space by workers and residents caused a lower intensity of space utilization. Secondly, the internal urbanization, so a less than proportionally increasing residential space, compared to total living space responds in opposite way to the decreasing intensity of space utilization and slightly moderates the impact. [Bundesamt für Raumentwicklung ARE, 2009: 22]

The following graph portrays the growth of residential space, compared to the increase of workplaces and residents for entire Switzerland, or the partial spaces of rural and urban areas.

[Insert Figure 3 about here]

3. Functional specializations of communities

Within a conurbation, functions and roles are distributed heterogeneously. A determined area can be specialized in a “living” or “working” function. In order to analyse the specialization, a computation of the number of workplaces per 100 residents is made. The following graph shows the average degree of specialization for Switzerland and its sub regions.

[Insert Figure 4 about here]

A better insight can be gained analysing a specific conurbation on municipality basis. For this, the agglomeration of Lugano (Ticino) in southern Switzerland was examined. The considered conurbation is made of 45 municipalities. One of them is classified as core-city and the core-zone is completed with four other communities. The remaining surrounding area counts 40 political communities. In the map below, all 45 municipalities have been categorized in four quartiles, according to their relative presence of workplaces per residents. To compute the functional specialization, the number of workplaces offered in a certain municipality for every 100 residents are counted. The so in dark blue coloured area is characterized by a high functional specialization in “working”, the fair coloured zones instead are prevalently “living” areas.

[Insert Figure 5 about here]

Regions with a high quota of workplaces, are unsurprisingly within the core zone. Most of the surrounding area communities are residential areas for employees of the city of Lugano.

A more detailed idea about the specialization within the working function can be gained through a comparison of importance of every economic sector for the respective municipality. As primary sector has a very low importance for the region of Lugano, the following map compares the relative importance of the secondary and the third sector activities for the analysed communities. In the graph below, the quota of tertiary sector workplaces above the secondary sector workplaces is illustrated. The map categorizes the conurbation’s communities in four quartiles, in the dark blue ones, the tertiary sector assumes highest importance, while in the white coloured ones, secondary sector is of relevance.

[Insert Figure 6 about here]

In tertiary sector specialized are the core-city and mainly communities in the Capriasca region, which are located between the centre of the map and the upper right edge. Furthermore, the tertiary sector is important for the municipalities located in the most south regions of the Lugano area. A higher importance to secondary sector is assigned mainly to

municipalities in the Vedeggio region (northwestern part) and parts of the Malcantone area, located in the western part of the map.

A similar analysis can be conducted for all conurbations in Switzerland. The so gained insights help to identify the existing dynamics within a specific geographic space and to understand the interaction of the included municipalities with each other. Not at least, a classification in “working” and “living” functional specialization helps to understand commuters-streams of the area. Much more again, the analysis provides a preliminary understanding of which areas offer relatively the most workplaces and therefore attract a higher quota of firms than other municipalities do. Further, through the classification of every community and its sectorial specialization, an idea about the prevailing corporate structure of a defined area can be gained.

4. The model

Increasing popularity of Agent-based models in social science is underlined by the ability of this tool to create a representation in which individuals and their actions can be directly included. It offers the possibility to design agents’ decision rules and to situate agents in a space of geographical or alternative character; it is so possible to represent multiple scales of analysis in one model. As Agent-based modeling involves models on a computer program basis, it is a form of computational social science. It represents in a simplified way the social reality, creating as much as possible variables’ characteristics so to simulate reality. In essence, a set of independent variables defines the input of the model; a set of dependent variables consequently defines the output of the simulation. In the model, a set of agents with different properties can be designed. Their behavior can be further influenced by the bearings of the other agents. [Gilbert 2008: 1-2]

Once the simplified reality has been designed, the effect of determined experiments can be tested. In this case, some treatment is applied on the isolated system and the effect of the changed behavior of agents, compared to precedent run, without treatment (control). In social sciences, the isolation of a system often is not possible or ethically problematic and therefore the advantages of Agent-based modeling are helpful in experiments. Further, also the costs of a conducted experiment are much lower than testing a treatment in the real world. [Gilbert 2008: 3]

4.1 Agent-Based model theory

Agent-based models can be of different characters:

1) *Scale models*: They are smaller versions of the reality, can be also reduced in complexity, and be of a less detailed level. It can happen that in this kind of model validity of conclusion can be reduced, as some of the features are not included.

2) *Ideal-type models*: With idealization, one or more complicating factors are removed so that the model is based on some characteristics that might also in exaggerated way design the target.

3) *Analogical models*: Analogy between some better understood phenomenon and the question to clear is drawn.

4) *Equation based models*: In this typology, relationships between variables are set up through a mathematical connection of inputs and outputs. The most interest is in the question of how well data fits the equation and less on the real consequence of the equation. Often these mathematical models are not very helpful in clarifying why one variable is related to the other. [Gilbert 2008: 4-5]

The created Agent-based model for the attractiveness of Lugano area has an equation-based character, as the behavior of integrated agents is guided by a core equation. The model also has scale model character, as it reduces in size and details the reality of the Lugano area. Then, for the removal of some, not quantifiable and complicating factors it is also an ideal type model in a certain sense. Less it is to consider an analogical model.

Further, in the simulation environment agents are programmed so to react to the computational environment where they are located in. The Agent-based model provides further the possibility of interaction between different agents and enables them to share information. [Gilbert 2008: 5]

The environment instead is defined as a virtual world, in which agents move and act. In the Lugano area attractiveness model, the environment is designed as geographic space and several indicators characterize each of the different places. The model has not a spatially explicit character, as municipalities of the different zones do not have a fixed location in the space, but are distributed randomly. Another feature is to connect agents with network links. [Gilbert 2008: 6]

The time dimension in this configuration is modeled in discrete time steps. In this way, each of these time steps has the same duration. However, three considerations have to be kept in mind for designing Agent-based models with discrete time steps:

1) Synchronicity: Normal computers are not able to elaborate more things at the same time. Therefore, some attention is required when programming the sequence of actions. There are three possible ideas how to work around this weakness of the system: first is to invoke each agent in a sequential order and so define a sequential asynchronous execution that puts in a predefined order the actions of every agent. Second alternative is to define a random asynchronous execution and so agents interact in a randomly chosen order with each other. Advantage of this method is that by running several times a model, the problem of time order can be solved. Third option is to simulate in a synchronous execution in which agents are ordered in a convenient way and all interactions are calibrated so that all inputs to agents are completed before all outputs are. For the Lugano area model, synchronicity does not have such a high importance as the interaction of firms with the municipalities happens in the order depending on the actual physical distance of a firm to a certain town. The concept of first come, first serve is applied and for the rest the random order of how the system is setup and the multiple repetitions resolve the remaining problematic through random asynchronous execution.

2) Event-Driven Simulation: Instead of moving from one time step to the next, the model moves from one event to the next event. This does not have importance for the Lugano area model, as it is completely time based.

3) Calibrating Time: The problematic of translating the time steps of a model into the time steps of real world. Often in real world, actions happen less quickly and the starting point of a determined problem is later than in simulation. According to theory, no exact solution to overcome this problem is provided. For the attractiveness of the Lugano area Agent-based model, this effect appears for the fact that firms move much quicker and more sensible in the geographic space than in reality. It is therefore important to interpret the trend of localized firms over time, from multiple simulations to figure out results. [Gilbert 2008: 28-29]

Agent-based models can also be applied in urban space planning. As an example, it is possible to integrate a simulation model with the Geographical Information System (GIS), to explore urban dynamics. In this context, the advantages of an Agent-based model are that the individual's actions and the behaviors over time were used to provide a test for developing models of cities. [Crooks 2006: 1]

More specifically, in this model, objects, for example houses and persons, are coupled through spatial-specific objects with their functions and situations. So for example, firms and people can be assumed as non-fixed objects, while parks are fixed objects for example. Non-fixed objects are assigned to have transition rules, which guide their behavior of moving in the space. [Crooks 2006: 2]

4.2 The model in detail

The inputs gained from theory are helpful and to be kept in mind for the actual design of the Agent-based model that describes the attractiveness of the Lugano conurbation's participant municipalities for firms of different branches. In the following part, the ideas and theory are connected to each other and an Agent-based model to simulate the movement of firms in the geographic space is designed.

The model is programmed into NetLogo, a program specifically designed to accommodate agent-based modelling. Following Dahlem ABM documentation guidelines (Wolf et al., 2010), the features of the model are structured as follows.

The model is structured so that the constructed space has geographic character, representing the total 45 municipalities of the Lugano conurbation. This virtual conurbation contains a number of municipalities, called *NumPatches*, and each of this makes part of one of the five defined regions. Each of these municipalities has assigned an initial value for the variables of:

- “Ground Prices”, defining the prices in CHF for a m² of construction ground;
- “Energy Prices”, defining the prices of a kWh of electricity for firms;
- “GDP pro capita”, the average income per contributor to direct federal taxes;
- “Tax Multiplier”, municipality's multiplier for communal taxes on the cantonal taxes-basis;
- “Infrastructure”, difference to the mean of percentage of space used for infrastructure;
- “International Population”, percentage of residential population having foreign nationality;

- “International Tourists”, number of international tourists visiting the community;
- “Accessibility”, required minutes to reach Lugano from the community using public transportations;
- “Economic Independence”, the number of prevalently inactive population (≤ 15 years and > 65 years) divided by the number of prevalently active population with age between 15 and 65 years;
- “Poverty rate”, percentage of population that is maintained by social aid;
- “Cost of public transportations”, number of Arcobaleno zones required for a ticket to reach Lugano.

Values of these variables are kept constant for the entire simulated first year, so to give the initially randomly distributed firms the chance to find an attractive location. From day 366 on these variables change every year, continuing the trend of the past five years.

The number of municipalities making part of each region is defined, by the reality and the categorization made in the first part of this work.

Further, a number of firms, “*NumFirms*” are created on the interface to setup the model. Each of these firms can make part of one of the ten defined branches. Distribution is based on the relative number of firms in each branch that existed in 2011 in the Lugano conurbation. All created firms, depending on the branch they work in, assign different importance to each of the variables. Weights are constant over time.

Two sliders: “*strict 1*” and “*strict 2*”, help to calibrate the model. Further, they expose the variability of the model. They include also, how much risk taking the firms are when deciding to leave a location in order to find a more preferable location for them. For the normal run and simulation “*strict 1*” is imposed at the value of 96 and “*strict 2*” at the value of 0,97.

Concerning the functional specification of the model, the following listed variables (Communities’ state variables) characterize the geographic component and so the communities. In NetLogo these are called patches and each of them is defined by these, either set up or computed variables.

[Insert Table 1 about here]

Firms' state variable characterize each of the created firms in the model. The firms are called turtles in NetLogo. All firms find their perfect location combining their preferences with the variables of the actual location and maximizing then the location value.

[Insert Table 2 about here]

Some additional variables are created in the model to help surveying the behavior of agents and to calibrate the model. Others are created for systematical reason and to help solve problems within the model's run.

[Insert Table 3 about here]

The model interface is so constructed that on the top left side the number of patches and so the number of municipalities to create can be chosen as well as the desired number of firms to participate in the model. Also with a switcher button, it is possible to give tax advantage to one of the five defined regions. Further a counter, called "count turtles" gives an idea how many of the created firms really appear in the model and how many were deleted because of rounding problems.

Two plots on the left bottom side, help to figure out the absolute and relative quota of located firms, and are used to calibrate the model.

In the middle part, the view illustrates the geographic area of the Lugano conurbation, in which the agents will act according to their characteristics. On the right side, five plots, one for each of the regions count the number of the totally located firms in the region, divided by colors in the analyzed ten branches.

By clicking on the setup button the chosen quantity of municipalities and firms are created, maintaining the relative distribution of the firms and municipalities that exists in the real Lugano conurbation. To run the more similar model to the real world, the following data should be used as input:

- NumPatches = 45, as there are 45 communities in the Lugano conurbation.
- NumFirms = 510, too many firms make it impossible to observe movements in the view; whereas too few are problematic, as their location would be influenced highly by the initial, random distribution.
- strict1 = 96

- strict2 = 0.97

In the plot on the left side can be observed, that approximately after one year, a healthy quota of nearly 90 percent of firms have found a satisfying location. More or less ten percent of firms are moving around and are continuously looking if some of the other locations have changed their attractiveness so that it would be more attractive to settle in a new community, rather than turning back in the previous location.

On the right hand side, the five plots count the number of firms by branches that are present over time in the municipalities of a determined zone. Not all branches have the same number of firms; some branches are stronger and represented with a higher number of firms in the conurbation as others. This fact comes from the real world firms' distribution. In these plots, especially the variability of the number of settled firms of a determined branch are interesting to observe, as well as the trend towards more firms of a certain branch or less firms of an observed branch locating in a municipality.

5. Main Results

To gain an idea about the localization behavior of the firms and their relative importance in the considered area the model needs to run more times. A function in NetLogo called "Behavior Space" is applied. Using the previous set up with 510 firms, the model executes 300 runs, each stopping after one (365 ticks), three (1095 ticks) or ten years (3650 ticks). This Monte-Carlo simulation helps to figure out an average value of in the region located firms of a certain branch after the chosen years of simulation (one year with fixed variables and remaining years with dynamic variables).

Running the model for the first year and giving the firms so enough time to find their best starting location the following average data from 300 runs can be gained:

[Insert Table 4 about here]

In this starting point, the most important branches for the core city are social and administrative services and high value creation industry. Lugano has a quota of nearly ten percent of all firms that settle in town. The core zone instead is attractive for company-oriented services and low value creation industry. These important communities for the entire conurbation host more than a third of all firms in this starting point. Leaving the core zone

and analysing the first of the three surrounding areas, the Malcantone region, more than proportional represented are retail and catering firms as well as the low value creation industry. In the Veduggio / Capriasca area, supply firms and logistics, traffic and wholesale branch seem to find slightly better conditions than other branches. This is valid also for the Lake Lugano region in this starting phase. In the Malcantone and Lake Lugano area, slightly more than ten percent of all firms are located in each of the areas. The Veduggio / Capriasca region has a slightly higher quota of firms, reaching around fifteen percent in all branches.

Summing up all percentages for every branch, less than 100 percent will be obtained, this for the missing firms that have not found a satisfying location yet or left a location again in order to find a more attractive place. Target of this model is to have a percentage of around 90 percent of firms located in the entire space. The 90 percent mark will be achieved only after about three years. In this first year, about 85 percent of firms are located considering all branches.

Starting with year two, the variables that define a location start to change, following the trend of the past five years (before 2011). Therefore, after totally 1095 ticks, three years or more precisely, after one static year and two dynamic years the results of location change slightly.

The quota of located firms grew further. Attractiveness of the core city has improved and made an additional three percent of firms settle in Lugano. A slightly less growing quota of firms settled in the core zone. Development of the surrounding area is less promising than of the before mentioned regions. Despite a continuous increasing quota of located firms, the Malcantone region was able only to maintain its quota. This region was not able to attract any of the newly located firms. Even worse is the situation for the remaining regions, namely the Veduggio / Capriasca and the Lake Lugano region. Both of them could not gain advantage of the dynamicity in time and their quota of located firms decreased.

Not only the quantity of located firms per region changed, but also the most important branches present in each of these subareas. In the core city, construction and low value creation industry became the most important sectors. Low value creation is still one of the most important branches for the core zone. Moreover, logistics, traffic and wholesales increased their relative importance in the core zone.

Reinforcing the trend and the dynamicity, by moving forward in time, a better vision of actual attractiveness of every region for determined branches can be identified.

6. Conclusions

This paper has presented the actual localization of determined branches in the different subareas of the Lugano conurbation, the main city in southern Switzerland, aiming at understanding the actual situation and the dynamics that guide enterprises in their localization decision. The main part of this scientific paper has consisted in understanding the movements of defined branches within the geographical space over time.

The two analyses conducted in this work try to answer the research question from two distinct points of departure. At first location factors analysis is obtained through the methodology of a graphical matching. On the other hand, each of five geographical sub-regions is defined by its attractiveness in the partial dimensions of the attractiveness analysis. This analysis was conducted remedying on the 2011 data and therefore provides a static solution to the problem.

A second approach, a simulation with an Agent-based model, provides an alternative way to analyze the attractiveness of a region for a determined branch. This solution is based on eleven indicators that define a location and the relative importance that each branch assigns to these indicators. This second analysis is dynamic and includes the possibility that preferences of determined branches change in time.

Results show that every branch has a clear defined “core zone” and that the actual localization depends on an extended and precise set of indicators.

Actually, a region within the Lugano conurbation might not be more attractive than another region in absolute terms, but can meet more specifically the requirements of a specific economic institution than the other areas.

The present work is a basic research on the attractiveness of the municipalities in the Lugano conurbation for firms, considering different branches and gives a contribution in understanding the reason why a firm chooses a region to settle rather than another zone. The comprehension of these motives is important and indispensable when creating new policies with objective to increase attractiveness of a defined area for firms. A policy can be real only if decision makers influence variables that change attractiveness in the most effective and sustainable way, and obviously if the economic gains exceed the costs of the undertaken measures.

This research can be further developed in various directions as design a more detailed model that includes municipalities’ characteristics not only in an aggregated way (with

zones). In this case, singular communities' characteristics would be integrated. Linearly to this, also branches could be split up in more, distinguished sub branches.

Moreover, it could be possible to create additional agents, which are mobile within the region, as, an example, residential population, families, retirees or foreigners looking for a tax-advantageous location.

Further, applying the analyses and the model on a larger scale, including further regions and conurbations, including more indicators and variables, to obtain a more detailed and characteristic model and analysis and identify effects of different possible projects and policies on included variables will constitute a further step of the research.

In this way, it will be possible to figure out the effects of these measures on the localization decision of agents.

Figure 1 - Quota of urban residential population on the total population of Switzerland 1980-2000

Source: Bundesamt für Raumentwicklung (ARE), 2009

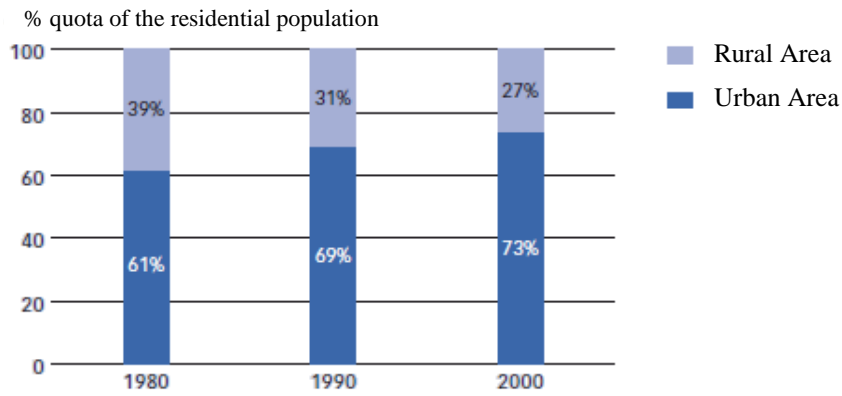


Figure 2 - Extension of Swiss conurbations 1980-2000

Source: Bundesamt für Raumentwicklung (ARE), 2009

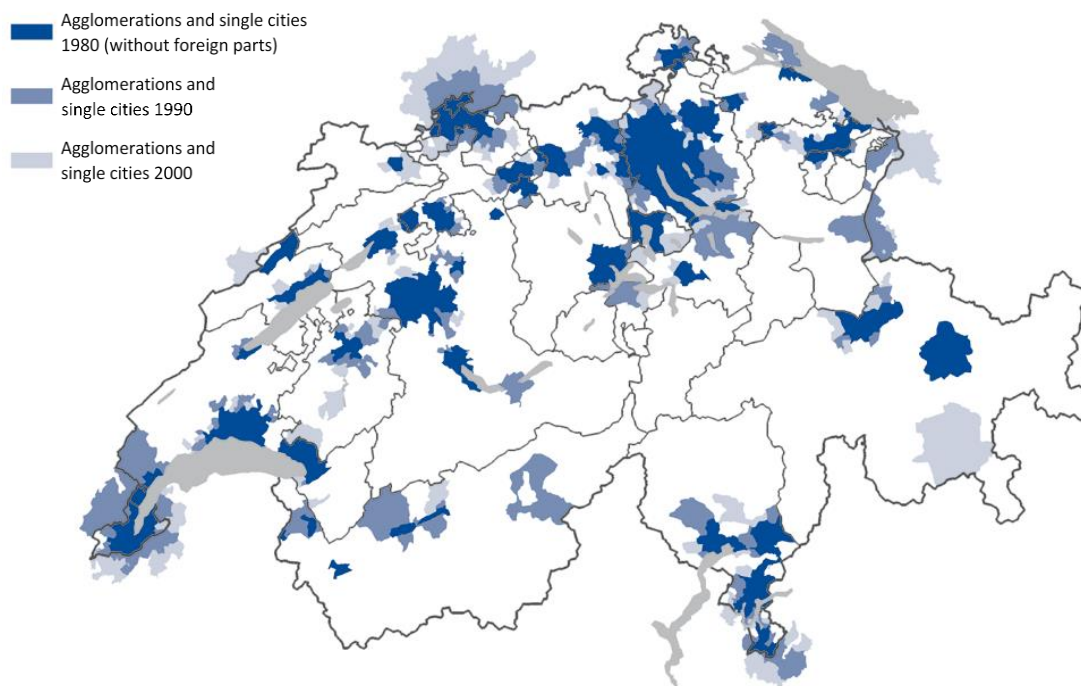


Figure 3 - Growth rates of residential space, residents and workplaces in partial spaces 1983-1995

Source: Bundesamt für Raumentwicklung (ARE), 2009

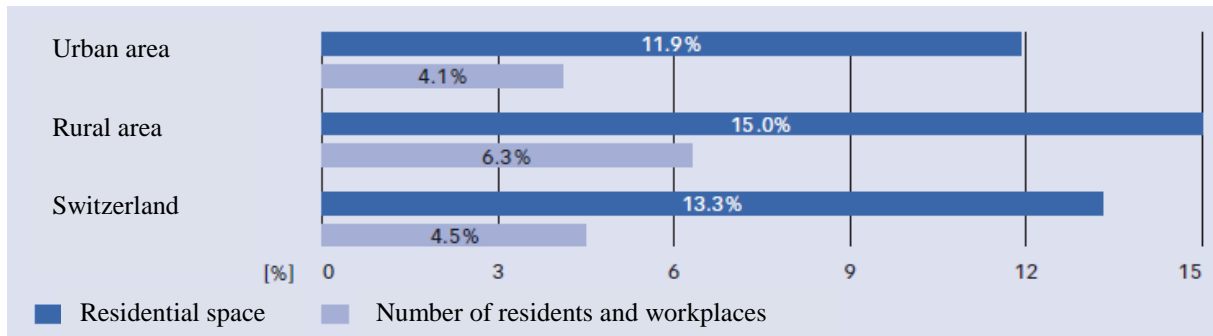


Figure 4 - Workplaces per 100 residents in the respective areas

Source: Bundesamt für Raumentwicklung (ARE), 2009

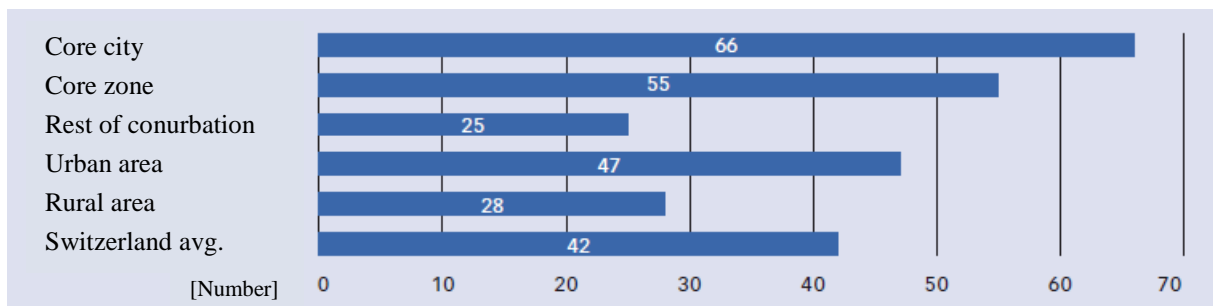


Figure 5 - Number of workplaces per 100 residents

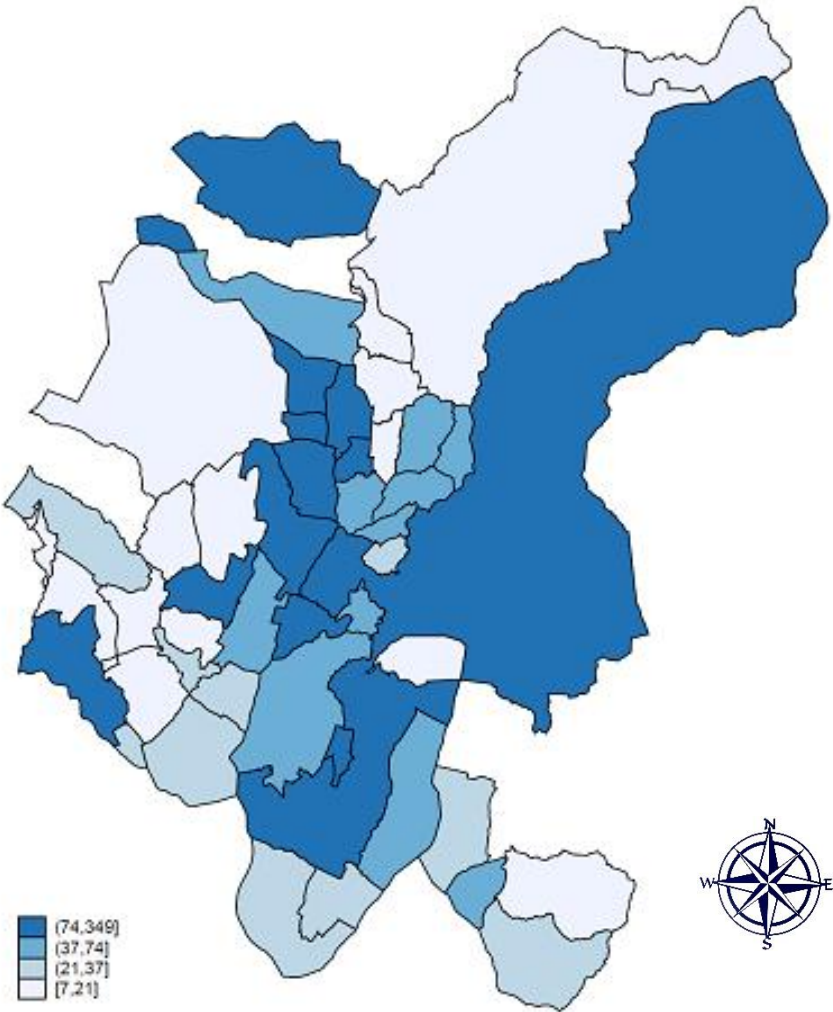


Figure 6 - Quota of service sector workplaces above secondary sector workplaces

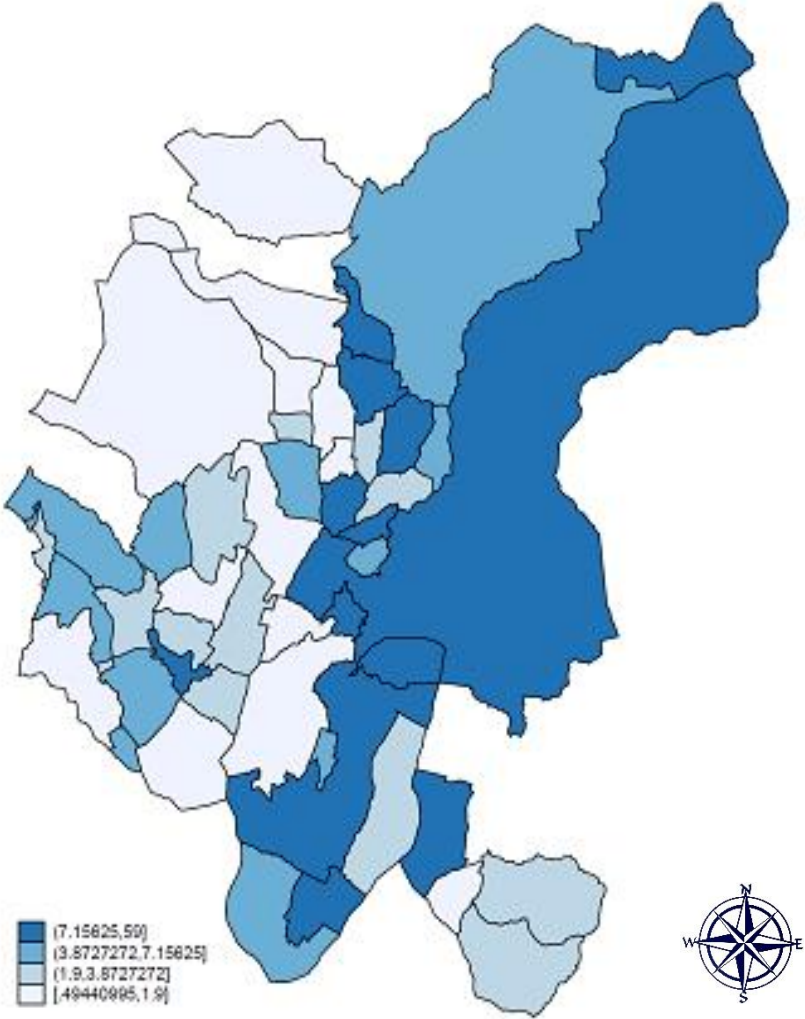


Table 1 - Variables of communities

Name	Type	Description	Updating	Initialization
MaxNumFirms	$N = \text{NumFirms} * \text{quota}$	Maximum number of firms that can locate in this community.	Fixed	Computed
Zone	$N = [1,2,3,4,5]$	Number of the zone of location.	Fixed	Computed
GroundPrices	$0 < R$	Prices for m ² of construction ground.	Fixed for the first year, after volatile	Set up
EnergyPrices	$0 < R$	Prices of kWh of energy for firms.	Fixed for the first year, after volatile	Set up
GDPcapita	$0 < R$	GDP per capita in the community.	Fixed for the first year, after volatile	Set up
TaxMultiplier	$0 < R$	Tax multiplier on the cantonal basis.	Fixed for the first year, after volatile	Set up
Infrastructure	$0 < R < 1$	Quota of space that is used for infrastructure.	Fixed	Set up
IntPopulation	$0 < R < 1$	Quota of foreign residents on the population.	Fixed for the first year, after volatile	Set up
IntTourists	$0 \leq N$	Number of tourists visiting the community	Fixed for the first year, after volatile	Set up
Accessibility	$0 < N$	Minutes to reach London with public transports.	Fixed	Set up
EconIndipendence	$0 < R$	Quota of persons with less than 15 or more than 65 years divided by persons that have between 15 and 65 years.	Fixed for the first year, after volatile	Set up
PovertyRate	$0 < R < 1$	Quota of residential population receiving social aid.	Fixed for the first year, after volatile	Set up
CostPublicTrans	$0 < N$	Number of Arcobaleno zones to buy for reaching Lugano.	Fixed	Set up

Table 2 - Variables of firms

Name	Type	Description	Updating	Initialization
TypeBranch	N = [1,2,3,4,5,6,7,8,9,10]	Description of which branch the firm makes part.	Fixed	Computed
weight_GroundPrices	$0 < R < 1$	Relative importance of ground-prices.	Fixed	Set up
weight_EnergyPrices	$0 < R < 1$	Relative importance of energy-prices.	Fixed	Set up
weight_GDPcapita	$0 < R < 1$	Relative importance of GDP pro capita.	Fixed	Set up
weight_TaxMultiplier	$0 < R < 1$	Relative importance of tax multiplier.	Fixed	Set up
weight_Infrastructure	$0 < R < 1$	Relative importance of available infrastructure.	Fixed	Set up
weight_IntPopulation	$0 < R < 1$	Relative importance of presence of international population.	Fixed	Set up
weight_IntTourists	$0 < R < 1$	Relative importance of visiting international tourists.	Fixed	Set up
weight_Accessibility	$0 < R < 1$	Relative importance of accessibility.	Fixed	Set up
weight_EconIndipendence	$0 < R < 1$	Relative importance of economic independence of population.	Fixed	Set up
weight_PovertyRate	$0 < R < 1$	Relative importance of poverty rate.	Fixed	Set up
weight_CostPublicTrans	$0 < R < 1$	Relative importance of cost of public transportations to reach Lugano from the location.	Fixed	Set up

Table 3 - Variables of the model

Name	Type	Description	Updating	Initialization
strict1	$0 \leq N \leq 100$	Level of risk taking to find a better location if settled.	Fixed	User input
strict2	$0 \leq R \leq 1$	Sensibility to leave a chosen location again.	Fixed	User input
NumFirms	$0 \leq N$	Number of real created firms in the space.	Fixed	User input
Experiment	String = ["0", "zone 1", "zone 2", "zone 3", "zone 4", "zone 5"]	Assign tax advantage to communities of a certain region, or turn the experiment off.	Fixed	User input
% of located firms	$0 \leq R \leq 1$	Quota of generated firms that find a location.	Volatile	Computed
Number of located firms	$0 \leq N$	Number of firms that are located.	Volatile	Computed
Firms in Core – city	$0 \leq N$	Number of firms by branches located in the region.	Volatile	Computed
Firms in Core – zone	$0 \leq N$	Number of firms by branches located in the region.	Volatile	Computed
Firms in Malcantone region	$0 \leq N$	Number of firms by branches located in the region.	Volatile	Computed
Firms in Vedeggio / Capriasca region	$0 \leq N$	Number of firms by branches located in the region.	Volatile	Computed
Firms in Lake Lugano region	$0 \leq N$	Number of firms by branches located in the region.	Volatile	Computed
ValueLoc	$0 \leq R$	Value of actual location.	Volatile	Computed
MaxValueLoc	$0 \leq R$	Maximum value achieved of the firm in any location in the space.	Volatile	Computed
Located	$N = [0,1]$	If a firm is located in a community it assumes one.	Volatile	Computed
NumFirmsLocated	$0 \leq N$	Number of branches.	Fixed	Set up
Concentration	$0 \leq R \leq 1$	Quota of located firms.	Volatile	Computed
Number	$0 \leq N$	Number of firms that are not assigned to a branch.	Volatile	Computed
Number	$0 \leq N$	Number of patches that have been assigned to a zone.	Volatile	Computed

Table 4 – First results

Branch Type	Core city		Core zone		Malcantone		Vedeggio / Capriasca		Lake Lugano		Total
	Firms	%	Firms	%	Firms	%	Firms	%	Firms	%	
1 year											
1	3,15	9	12,43	35,51	4,08	11,66	4,96	14,17	3,9	11,14	35
2	9,38	9,47	35,15	35,51	11,76	11,88	13,82	13,96	11,78	11,9	99
3	2,04	9,27	7,66	34,82	2,61	11,86	3,11	14,14	2,52	11,45	22
4	9,95	8,72	40,98	35,95	14	12,28	16,37	14,36	12,99	11,39	114
5	13,14	9,19	51,17	35,78	17,74	12,41	20,63	14,43	16,7	11,68	143
6	0,19	9,5	0,69	34,5	0,26	13	0,33	16,5	0,27	13,5	2
7	4,16	9,24	16,09	35,76	5,55	12,33	6,57	14,6	5,14	11,42	45
8	1,68	8,84	6,62	34,84	2,29	12,05	2,97	15,63	2,34	12,31	19
9	2,82	9,72	10,25	35,34	3,37	11,62	4,08	14,07	3,31	11,41	29
10	0,16	8	0,73	36,5	0,26	13	0,29	14,5	0,22	11	2

1 = Banks and insurances

2 = Social and administrative services

3 = Information and communication

4 = Company-oriented services

5 = Retail and catering

6 = Supply firms

7 = Construction

8 = Logistics, traffic and wholesales

9 = High value creation industry

10=Low value creation industry

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