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# SPATIAL PLANNING AND POLICY EVALUATION IN AN URBAN CONURBATION: A REGIONAL AGENT-BASED ECONOMIC MODEL [1]

*This paper studies different functions and relations between 45 agglomerated municipalities in southern Switzerland (Ticino), using a territorial agent-based model. Our research adopts a bottom-up approach to urban systems, considering the agglomeration mechanism and effects of different regional and urban policies, and simulates the individual actions of diverse agents on a real city using an Agent-based model (ABM). Simulating the individual actions of diverse agents on a real city and measuring the resulting system behaviour and outcomes over time, they effectively provide a good test bed for evaluating the impact of different policies. The database is created merging the Swiss official secondary data for one reference year (2011) with Eurostat and OECD-Regpat. 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. Applying the analyses and the model on a larger scale, including further regions and conurbations, and including more indicators and variables, to obtain a more detailed and characteristic model, will constitute a further step of the research.*

**Keywords:** firm localization, urban agglomeration, territorial indicators, spatial planning, municipal economy, urban roles, municipalities' characteristics, urban policy evaluation, Agent-Based Models, simulation

## Introduction

The structure of firms used to be different from nowadays: 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. Therefore, 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. [1; 2]

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 the 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. [1]

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 aims at, in addition to the findings of the first part, understanding the theoretically best possible allocation of a branch, with given attractiveness indicators in the geographical space; at testing the effects of newly created policies with the goal to improve local attractiveness and at analysing the efficiency and relevance of these by policymakers. [2; 3]

The remainder of the paper is structured as follows. The second section reviews development of urban agglomerations in Switzerland in existing literature and 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 fourth section. The last section presents concluding remarks.

## Theoretical basis

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. This means that many of the surrounding municipalities have become strongly 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 city, 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.[1]

The term that aggregates the two previously mentioned effects is called "urbanization". In the following graph (Figure 1), quotas of residential population living in rural and urban areas are contrasted and illustrated in percent quotas.

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 (Figure 2). The systematic growth of agglomerations is best illustrated in the Basel area. Towards the 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 the year 2000, a conurbation of Winterthur was almost absorbed, but also the agglomerations of Zug and Lucerne are always stronger connected with the Zürich conurbation.

With the increasing number of conurbation municipalities, the average number of the inhabitants of urban municipalities is decreasing, as the newly included communities are mainly of rural character and therefore have a lower density than existing conurbations.

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.[2]

[1] Bundesamt für Raumentwicklung ARE (2008). Monitoring urbaner Raum, Themenkreis B2: Funktionale Spezialisierung im schweizerischen Städtesystem. Retrieved from: http://www.are.admin.ch/themen/agglomeration/00641/03369/index.html?lang=de (date of access: 05.05.2015).

[2] Bundesamt für Raumentwicklung ARE (2009). Monitoring urbaner Raum Schweiz — Analysen zu Städten und

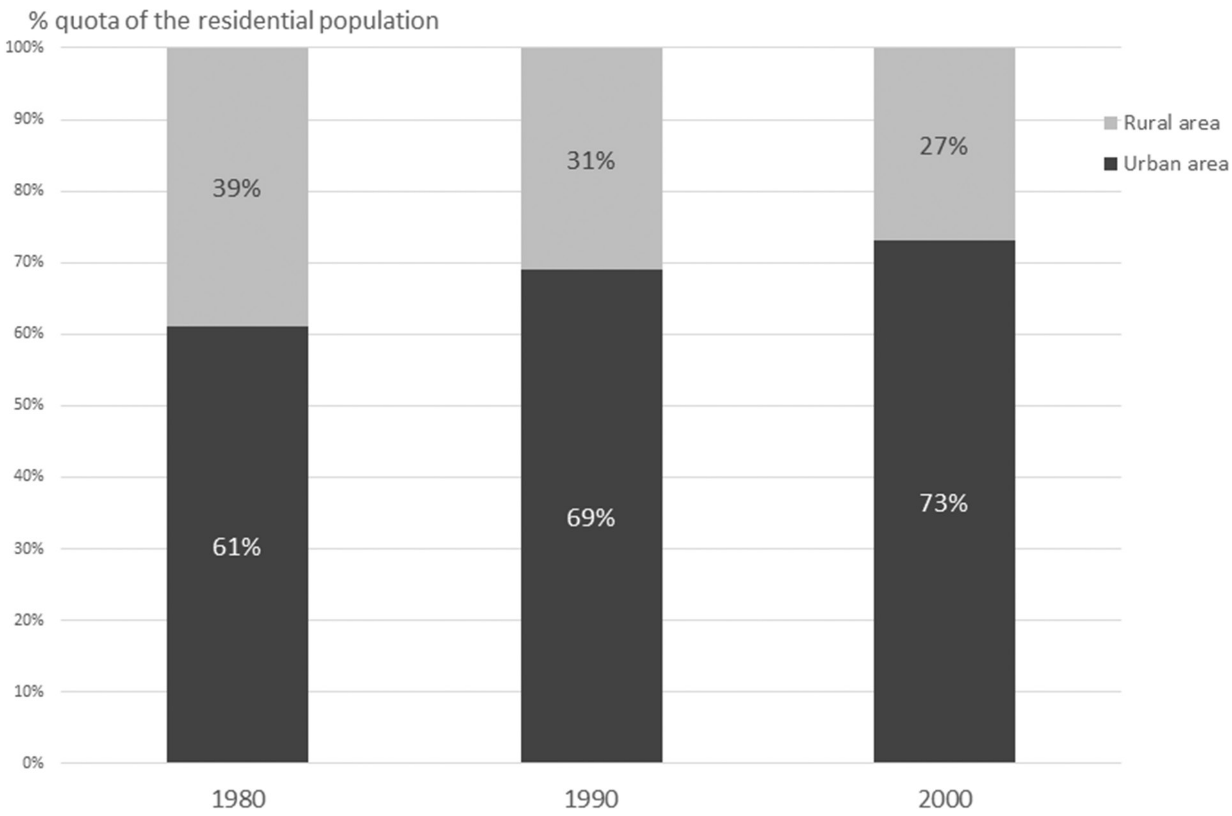


**Fig. 1.** *Quota of urban residential population on the total population of Switzerland 1980–2000.*
*Source: Bundesamt für Raumentwicklung (ARE), 2009*

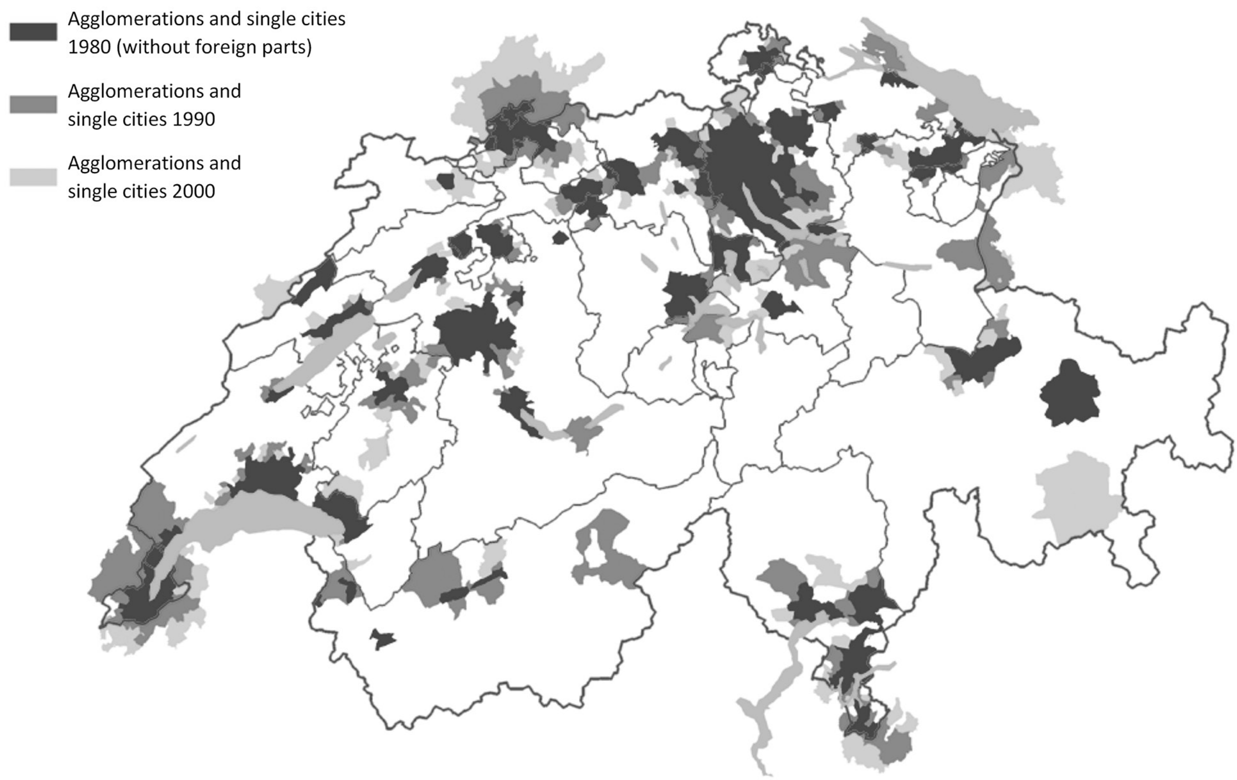


**Fig. 2.** *Extension of Swiss conurbations 1980–2000.*
*Source: Bundesamt für Raumentwicklung (ARE), 2009*

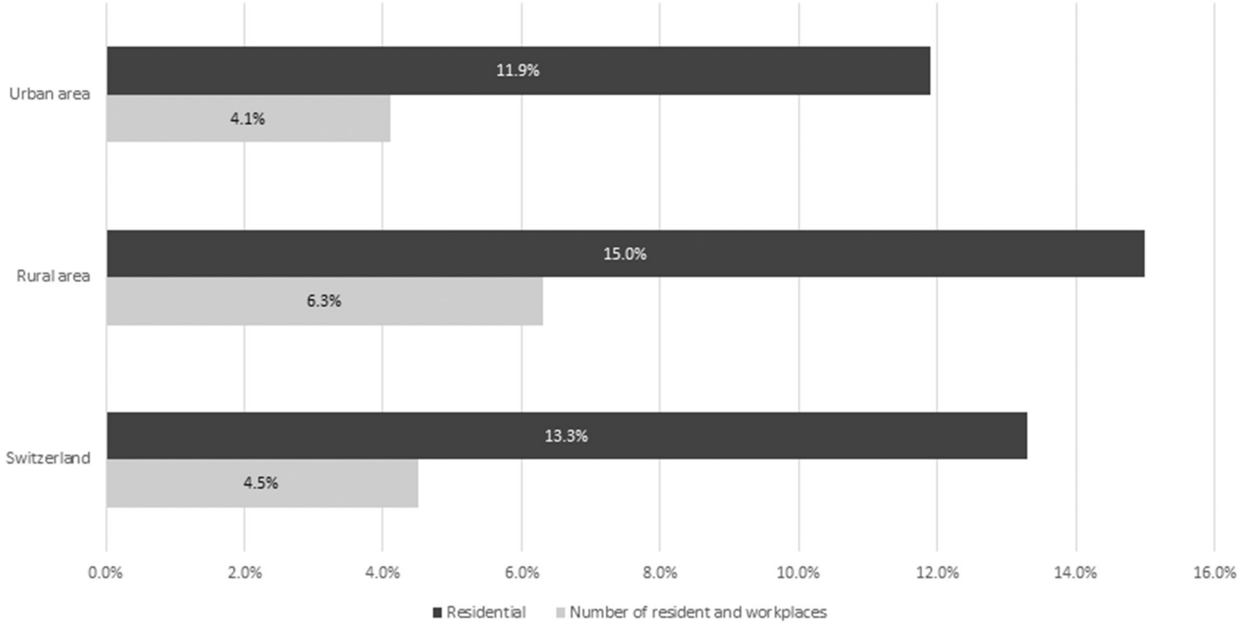


**Fig. 3.** *Growth rates of residential space, residents and workplaces in partial spaces 1983–1995.*
*Source: Bundesamt für Raumentwicklung (ARE), 2009*

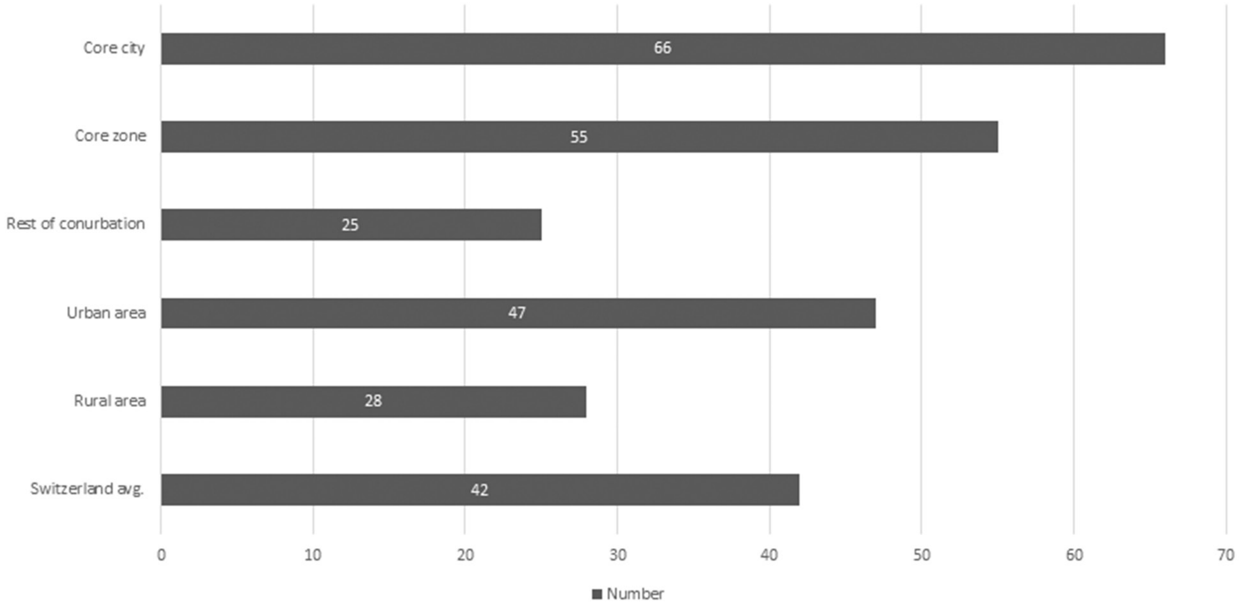


**Fig. 4.** *Workplaces per 100 residents in the respective areas.*
*Source: Bundesamt für Raumentwicklung (ARE), 2009*

The following graph (Figure 3) 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.

Within a conurbation, functions and roles are distributed heterogeneously. A determined area can be specialized in a "living" or "working" function. [4] In order to analyse the specialization, a computation of the number of workplaces per 100 residents is made. The following graph (Figure 4) shows the average degree of specialization for Switzerland and its sub-regions.

A better insight can be gained analysing a specific conurbation on a 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, while the remaining surrounding area counts 40 politi-

Agglomerationen. Retrieved from: http://www.are.admin.ch/dokumentation/publikationen/00015/00295/index.html?lang=de (date of access: 05.05.2015).

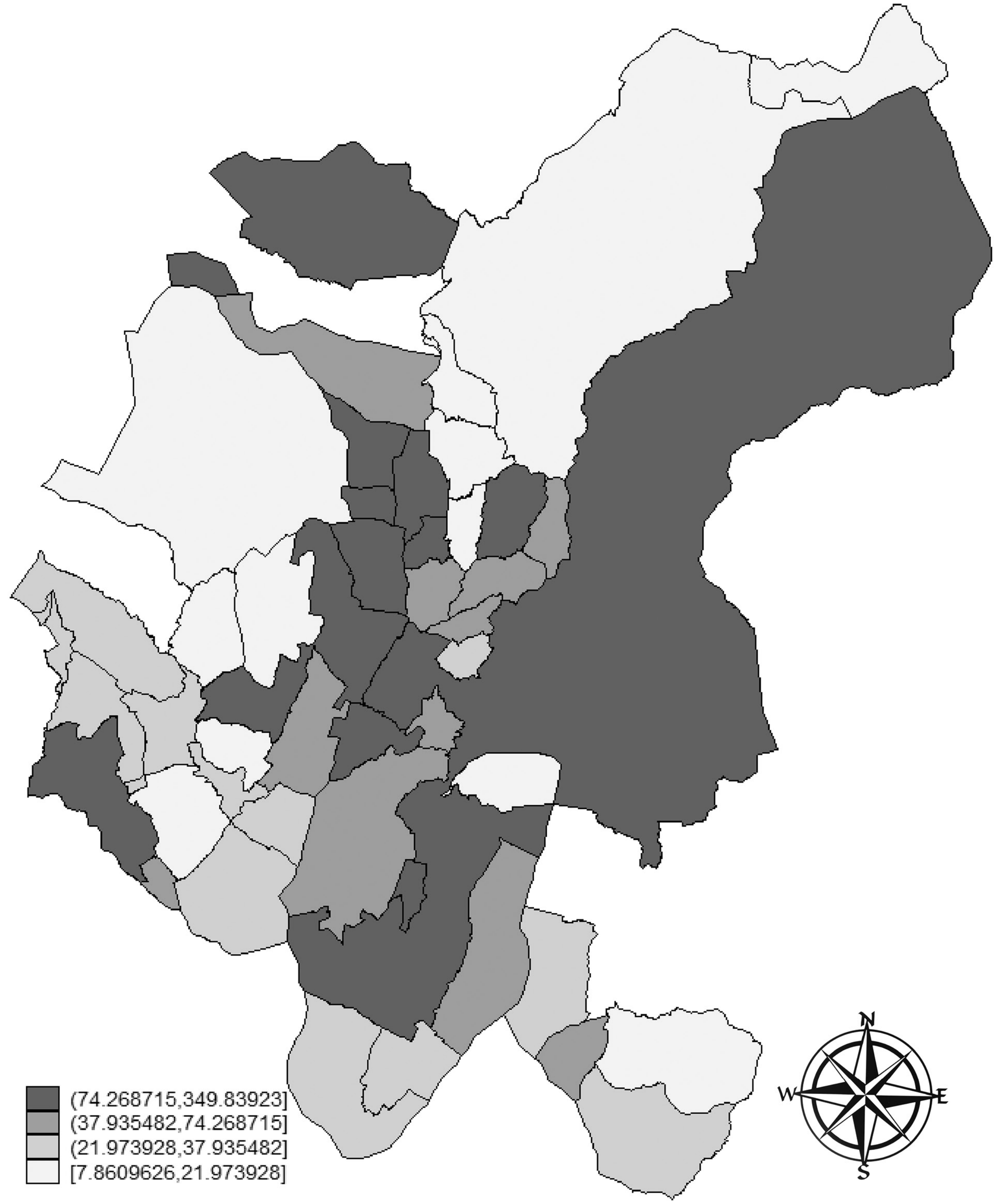


**Fig. 5.** *Number of workplaces per 100 residents*

cal 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 is registered (Figure 5). The area coloured in dark grey is characterized by a high functional specialization in "working", the fairly coloured zones instead are prevalently "living" areas. [2]

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

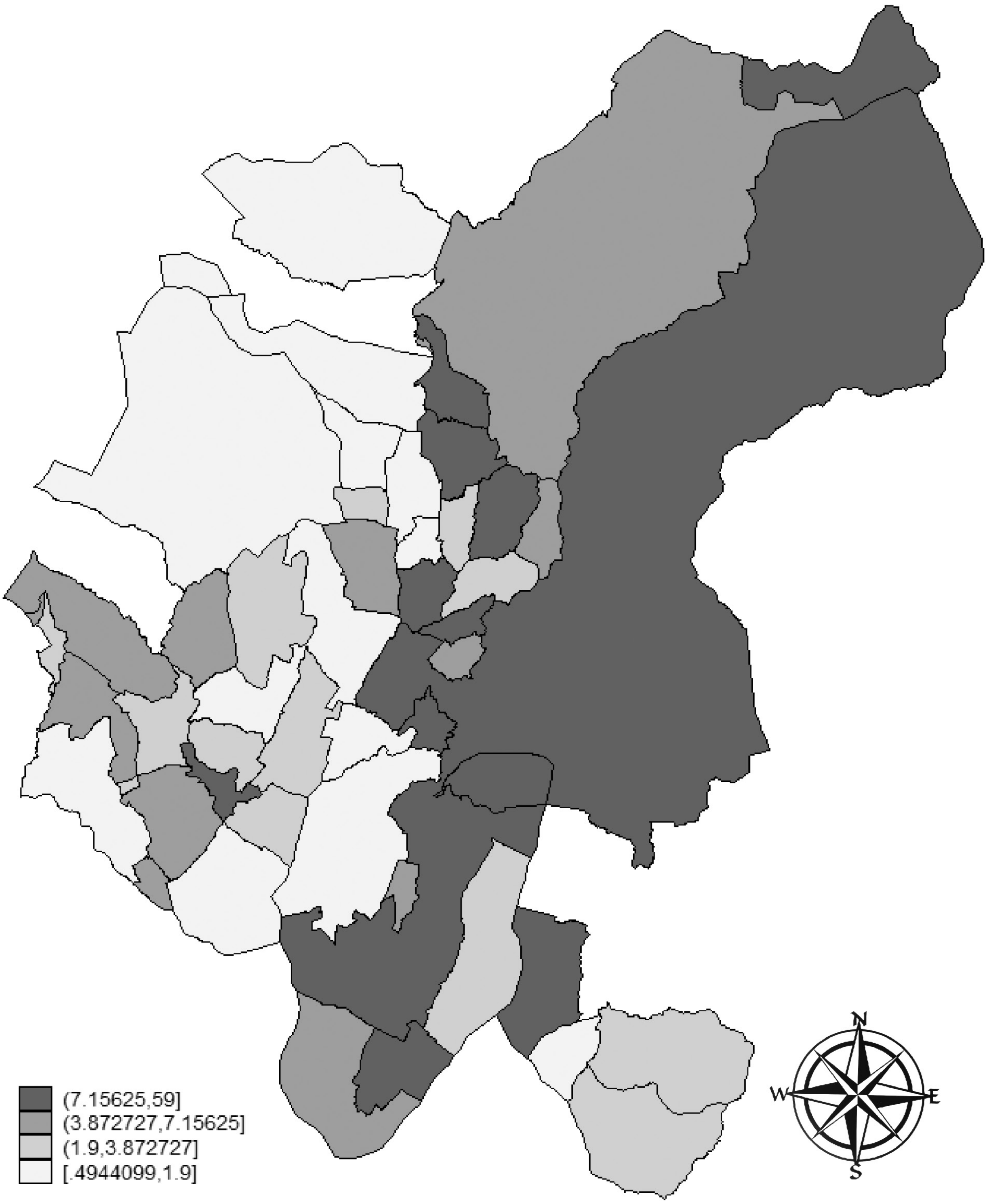


**Fig. 6.** *Quota of service sector workplaces above secondary sector workplaces*

through a comparison of the importance of every economic sector for the respective municipality. [5; 6] As the 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 (Figure 6), 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 grey ones, the tertiary sector assumes the highest importance, while in the white coloured ones, secondary sector is of relevance.

Specialized in tertiary sector 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 southern 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. [7; 8; 9]

## Methods and Data

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. [10] 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 model involves models on a computer program basis as 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. [11, p. 1–2; 12]

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 is not often 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. [11, p. 3; 13]

### *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. [11, p. 4–5]

The implemented 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 be consider as 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 in addition the possibility of interaction between different agents and enables them to share information. [11, p. 5; 14]

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. [11, p. 6; 15]

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. A second alternative is to define a random asynchronous execution and so agents interact in a randomly chosen order with each other. The advantage of this method is that by running several times a model, the problem of time order can be solved. The 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 depends on the actual physical distance of a firm to a certain town. The concept of "first come, first serve" is, therefore, 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 problem of translating the time steps of a model into the time steps of the real world. Often in the 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 in a more sensible way 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. [11, p. 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. [16; 17, p. 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. [17, p. 2]

*Earlier applications*

This paper develops an ABM of localization decisions taken by firms within an urban agglomeration. It is not, however, the first to do so. Tsekeris and Vogiatzoglou (2010) for example were establishing a multi-regional model in order to simulate the behavior of workforce as well as the decision making of relocating firms. Their model also accounts for characteristics that drive industries in their location decision, taking into account agglomeration forces. [4]

In another model, Xie et al. (2007) include growth linked to the development of the entire Wuxian City area in China. The units of analysis define the development of the land in the region. The created model is based on a first scale analysis, which includes the growth of different spatial aggregates, remedying on different spatial aggregates. The agent-based model then is created in a way that allows matching new patterns of urbanization against behavior of households. [14]

A third agent-based model that provides useful background information is the one published by Baruffini (2015). It generates an artificial labour market which describes the dynamic matching between labour supply and demand and how it is affected by specific changes in policy and social parameters. His model is effective in testing different scenarios useful in the evaluation of different policy setting, allowing to define model parameters on worker's nationality, agent's wealth, agent's strategy, worker's "learning constraint", the flexibility of the labour market and differences between sectors. [15]

*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. [18]

The model is programmed into NetLogo, a program specifically designed to implement agent-based modelling. Following Dahlem ABM documentation guidelines [19], 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 London 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", the 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.

In order to test the universality and functionality of the model, in a first step, the distribution of firms among the municipalities during the fixed period of the first 365 days in the model was compared with the real relative specialization of each region. The specialization value was calculated for every single municipality on the basis of the 2011 data of the distribution of firms in the Lugano conurbation.

Results are exposed in Table 1 below.

Table 1

**Distribution of firms**

| | **Total** | **Banks and Insurances** | | **Social and administrative services** | | **Information, Communication** | | **Company-oriented services** | | **Retail, Catering industry** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Core City | 7971 | 650 | 8.2 % | 1227 | 15.4 % | 275 | 3.5 % | 1820 | 22.8 % | 1781 | 22.3 % |
| Core Zone | 1174 | 32 | 2.7 % | 154 | 13.1 % | 62 | 5.3 % | 154 | 13.1 % | 346 | 29.5 % |
| Surrounding Area | 5110 | 140 | 2.7 % | 976 | 19.1 % | 181 | 3.5 % | 733 | 14.3 % | 1286 | 25.2 % |
| Malcantone | 920 | 18 | 2.0 % | 198 | 21.5 % | 24 | 2.6 % | 90 | 9.8 % | 211 | 22.9 % |
| Vedeggio / Capriasca | 2624 | 62 | 2.4 % | 517 | 19.7 % | 105 | 4.0 % | 374 | 14.3 % | 606 | 23.1 % |
| Lake Lugano | 1566 | 60 | 3.8 % | 261 | 16.7 % | 52 | 3.3 % | 269 | 17.2 % | 469 | 29.9 % |
| Total | 14255 | 822 | 5.8 % | 2357 | 16.5 % | 518 | 3.6 % | 2707 | 19.0 % | 3413 | 23.9 % |
| | **Total** | **Supply (Energy, waste, etc.)** | | **Construction** | | **Logistics, Traffic, Wholesale** | | **High value creation industry** | | **Low value creating industry** | |
| Core City | 7971 | 23 | 0.3 % | 455 | 5.7 % | 239 | 3.0 % | 276 | 3.5 % | 18 | 0.2 % |
| Core Zone | 1174 | 6 | 0.5 % | 119 | 10.1 % | 47 | 4.0 % | 118 | 10.1 % | 4 | 0.3 % |
| Surrounding Area | 5110 | 20 | 0.4 % | 507 | 9.9 % | 160 | 3.1 % | 286 | 5.6 % | 16 | 0.3 % |
| Malcantone | 920 | 6 | 0.7 % | 107 | 11.6 % | 35 | 3.8 % | 54 | 5.9 % | 5 | 0.5 % |
| Vedeggio / Capriasca | 2624 | 5 | 0.2 % | 292 | 11.1 % | 79 | 3.0 % | 163 | 6.2 % | 4 | 0.2 % |
| Lake Lugano | 1566 | 9 | 0.6 % | 108 | 6.9 % | 46 | 2.9 % | 69 | 4.4 % | 7 | 0.4 % |
| Total | 14255 | 49 | 0.3 % | 1081 | 7.6 % | 446 | 3.1 % | 680 | 4.8 % | 38 | 0.3 % |

Source: Bundesamt für Statistik. Statistik der Unternehmensstruktur (STATENT) 2011. Retrieved from: http://www.bfs.admin.ch/bfs/portal/de/index/infothek/erhebungen__quellen/blank/blank/statent/02.html (date of access: 26.03.2015).

Table 2

**Variables of communities**

| Name | Type | Description | Updating | Initialization |
|---|---|---|---|---|
| MaxNumFirms | $N$ = NumFirms × 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 m2 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 |
| GDPcaptia | 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 ≤ 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 |

A high concentration of a branch in a municipality can be both, a factor of increasing attractiveness that makes further enterprises of this branch move towards this municipality or have the opposite effect and reject firms from locating there, because with the growing number of firms also the competition increased. Which of this effect is more important depends on again in the critical factors that conduct a branch to success. On one hand, a location near competitors can be attractive, so that talented persons are available in the area and the company can gain profits from the presence of know-how. In addition, the presence of important partners can be a favorable factor to attract further firms. Factors as the before mentioned, prevail mainly for firms that operate internationally and whose output markets are abroad. An example could be watch-and-clock industry or even biochemistry firms. Industries operating and selling mainly on the local market are more likely to choose locations further from competitors' ones. Especially when the business is location-bound and not mobile, so that direct competition is created. Examples could be hotels (if a too high concentration in the location is reached) or small food shops. Others, even being location bound choose to settle in a commune only so to not leave the field without a battle to competitors. Examples here can be found in the retail segment, banks and insurances but also in company-oriented services. More important than avoiding competition situation to them is to appear as strong as possible in all locations. [2, p. 39]

The relative importance of certain branches in the Lugano conurbation is the defining factor that provided the model verification concerning the decision of localization for a firm.

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" is 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

Table 3

**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_GDPcaptia | $0 < R < 1$ | 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 |

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, Table 2) 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.

Firms' state variable (Table 3) 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.

Some additional variables (Table 4) 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.

The model interface is therefore constructed in order to view on the top left side the number of patches and so to let choose the number of municipalities as well as the desired number of firms to participate in the model. In addition, using a switcher button, it is possible to give a tax advantage to one of the five defined regions. Further, a counter, called "count turtles" gives an idea on 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 exist 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

Table 4

**Variables of the model**

| Name | Type | Description | Updating | Initialization |
|---|---|---|---|---|
| strict1 | $0 \le N \le 100$ | Level of risk taking to find a better location if settled | Fixed | User input |
| strict2 | $0 \le R \le 1$ | Sensibility to leave a chosen location again | Fixed | User input |
| *N*umFirms | $0 \le N$ | *N*umber 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 | $0 \le R \le 1$ | Quota of generated firms that find a location | Volatile | Computed |
| *N*umber of located firms | $0 \le N$ | *N*umber of firms that are located | Volatile | Computed |
| Firms in Core — city | $0 \le N$ | *N*umber of firms by branches located in the region | Volatile | Computed |
| Firms in Core — zone | $0 \le N$ | *N*umber of firms by branches located in the region | Volatile | Computed |
| Firms in Malcantone region | $0 \le N$ | *N*umber of firms by branches located in the region | Volatile | Computed |
| Firms in Vedeggio / Capriasca region | $0 \le N$ | *N*umber of firms by branches located in the region | Volatile | Computed |
| Firms in Lake Lugano region | $0 \le N$ | *N*umber of firms by branches located in the region | Volatile | Computed |
| ValueLoc | $0 \le R$ | Value of actual location | Volatile | Computed |
| MaxValueLoc | $0 \le R$ | 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 |
| *N*umFirmsLocated | $0 \le N$ | *N*umber of branches | Fixed | Set up |
| Concentration | $0 \le R \le 1$ | Quota of located firms | Volatile | Computed |
| *N*umber | $0 \le N$ | *N*umber of firms that are not assigned to a branch | Volatile | Computed |
| *N*umber | $0 \le N$ | *N*umber of patches that have been assigned to a zone | Volatile | Computed |

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.

## 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 (Table 5):

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

Table 5

**First results**

| Branch Type | Core city | | Core zone | | Malcantone | | Vedeggio / Capriasca | | Lake Lugano | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *1 year* | **Firms** | **%** | **Firms** | **%** | **Firms** | **%** | **Firms** | **%** | **Firms** | **%** | **Firms** |
| 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

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 Vedeggio / 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 Vedeggio / 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. The 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. The 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 Vedeggio / Capriasca and the Lake Lugano region. Both of them could not gain the 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.

## 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 the 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 designing 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 into more, distinguished sub-branches. [1]

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. [15; 20]

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.

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