Quantification of the immigration effects on rents in Canton Zurich between 2009-2013

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Abbreviations

AIC	Akaike Information Criterion
BfS	Swiss Federal Statistical Office
ETH	Swiss Federal Institute of Technology
GWR	Geographically Weighted Regression
IVT	Institute for Transport Planning and Systems of ETHZ
OLS	Ordinary Least Square
SAC	General Spatial Autoregressive Model
SAR	Spatial Simultaneous Autoregressive Model
SE	Standard Error

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Abstract

The effect of immigration on rents in Canton Zurich between 2009 and 2013 is quantified with the help of hedonic pricing models. Two groups of models are created: the first one uses the monthly gross rent as dependent variable, the second one the rental price per m^2. They both take into account foreigners in different definitions and groupings: Foreigners, Schengen, Northwestern Schengen, Southern/Eastern Schengen and Outside Schengen. These models are extended into SAR models, in order to account for the spatial autocorrelation of the data. The SAR*error* model, using a neighborhood weighting matrix computed with 10 nearest neighbors and accounting for a reduction of influence based on the distance to the observation point, appears to be the most appropriated regression model. All foreigner categories show an inflationary effect on rents, with the exception of the category Southern/Eastern Schengen, which leads to a decrease of 0.19% of the rents, respectively of 0.10 CHF/(month·m^2) for a 1% point increase of this population. The group Northwestern Schengen has the higher effect, e.g. +2.61% of the rent, respectively +0.61 CHF/(month·m^2), for a 1% point increase. The other tested categories seem, in contrast, to have only a marginal influence on the dependent variables.

Keywords

Immigration; Real estate; Housing price; Spatial regression; Hedonic Pricing

Preferred Citation Style

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1 Introduction

The Swiss vote of 9th February 2014, which should lead to the reintroduction of quotas for immigrants, is the highlight of a series of referenda that reacted to growing population influx from foreign countries into Switzerland. Indeed, rising crime, wage dumping or pressure on the real estate market, are some examples of negative effects that the Swiss population perceives as being related with the higher immigration rate that the country experienced since 2008, when the free movement of persons started. Among these effects, rent inflation is often pointed out as a major issue, which arises from the enhanced population growth due to strong immigration. Even if several clues tend to indicate that the number of newcomers into a region correlates with the rent level, it would be interesting to determine to what extent these may influence the housing prices. Indeed, growing living space requirement per capita, decreasing household size or inland population movements are other factors, which also induce rent price inflation in Switzerland.

Thus, the aim of this thesis is to quantify the effects of migration on the rent prices of Canton Zurich over the time period 2009 till 2013. The canton Zurich is especially interesting, because it absorbs a significant part of the immigration into Switzerland and is considered as a main hotspot of the Swiss real estate market. This analysis uses hedonic regression modeling with demographic, real estate market and spatial data. Once built, the global model is extended into a simultaneous autoregressive model (SAR) to account for the issues related to the spatial autocorrelation of the data. In the models, immigrants are divided into several classes (e.g. Northwestern Europe immigrants vs others) to try to isolate groups with higher purchasing power, which may have more influence on housing prices level. Thus, variation among immigrants themselves can be studied through this approach.

First, important concepts are introduced in Chapter 2. Chapter 3 presents the whole methodology, which has been applied in the data analysis. Descriptive statistics of the demographic and rental market data are presented in Chapter 4. The results of various regression models are analyzed in Chapter 5. Finally, the results of this work as well as possible extensions are discussed in Chapter 6.

2 Background

This chapter introduces various themes and concepts, which are relevant to understand the further parts of the study.

2.1 Region studied

The present study focusses on the city of Zurich and its Canton. The Canton Zurich hosts about 1’400’000 inhabitants[1], which makes it the largest Swiss Canton in term of population. Its territory of 1’729 km^2 is organized into 12 districts (Figure 1), which are themselves divided into a total of 171 municipalities (in 2013). The two major lakes of the Canton are the Lake of Zurich *(Zürichsee)* and the Greifensee.

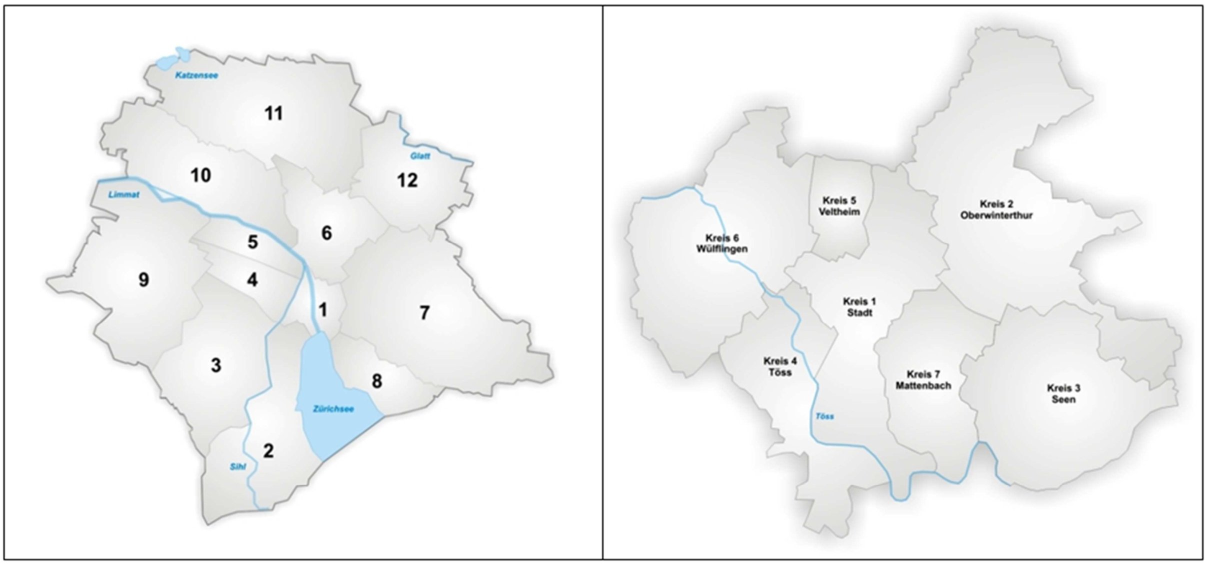
Figure 1 Districts of Canton Zurich since 1989

Source: Tschubby (2008), http://upload.wikimedia.org/wikipedia/commons/b/b3/Karte_
Kanton_Z%C3%BCrich_Bezirke.png, consulted on 04/23/2014.

[1] Statistical Office of Canton Zurich (2014)

Furthermore, the cities of Zurich and Winterthur are split into 12 and 7 Quarters (Figure 2). Note that these administrative organizations are relevant for the further analysis.

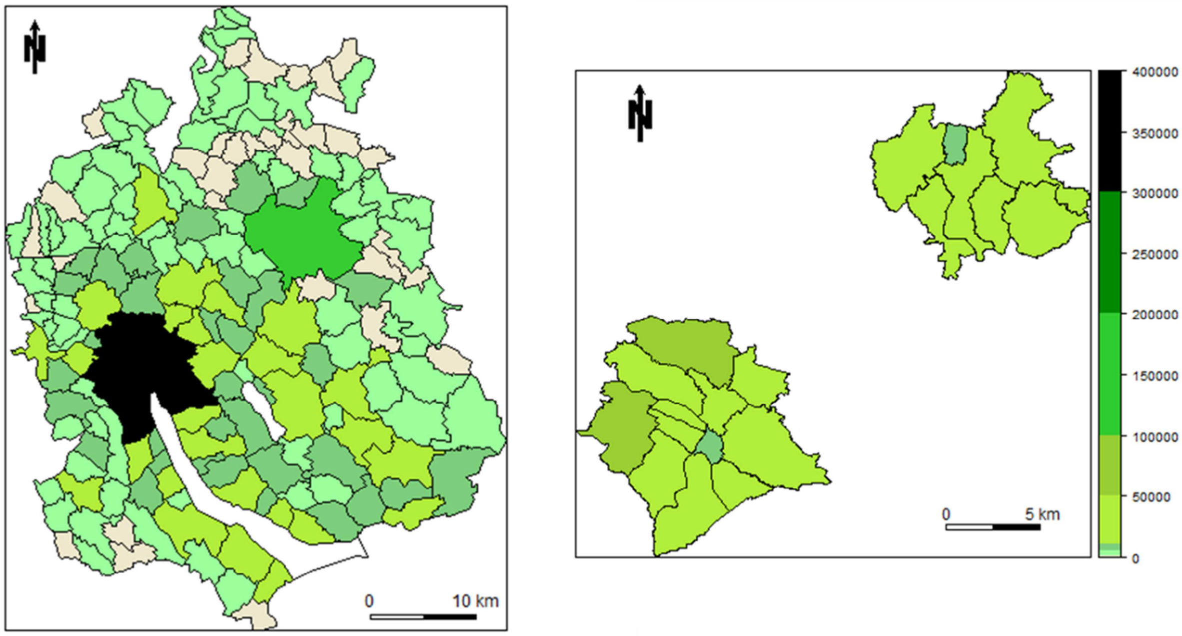
Figure 2 Quarters of the cities of Zurich (left) and Winterthur (right) in 2014



Sources: (left picture)Tschubby (2009), http://upload.wikimedia.org/wikipedia/commons/3/33/Karte_Stadtkreise_Z%C3%BCrich.png?uselang=de, consulted on 04/23/2014.
(right picture) Tschubby (2008), http://upload.wikimedia.org/wikipedia/commons/8/83/Karte_Winterthur_Stadtkreise.png?uselang=de, consulted on 04/23/2014.

Figure 3 introduces the number of inhabitants per municipality of Canton Zurich, as well as for Zurich and Winterthur, per Quarter in 2012. It can be noticed that the cities of Zurich and Winterthur are the only municipalities that are inhabited by more than 100’000 people. Indeed, most of the locations shown in Figure 3 have less than 10’000 inhabitants. The majority of the Quarters of Zurich and Winterthur have a population smaller than 50’000 people. Only the Quarters 9 and 11 of Zurich show higher numbers.

Figure 3 Population per municipality of Canton Zurich (left picture) and per Quarter of the cities of Zurich and Winterthur (right picture) in 2012.



Data: (left picture) Statistical Office of Canton Zurich (2013)

(right picture) City of Zurich, Statistics Department (2013)

(right picture) City of Winterthur, Statistics Department (2013)

Boundaries: Swiss Federal Statistical Office (2013).

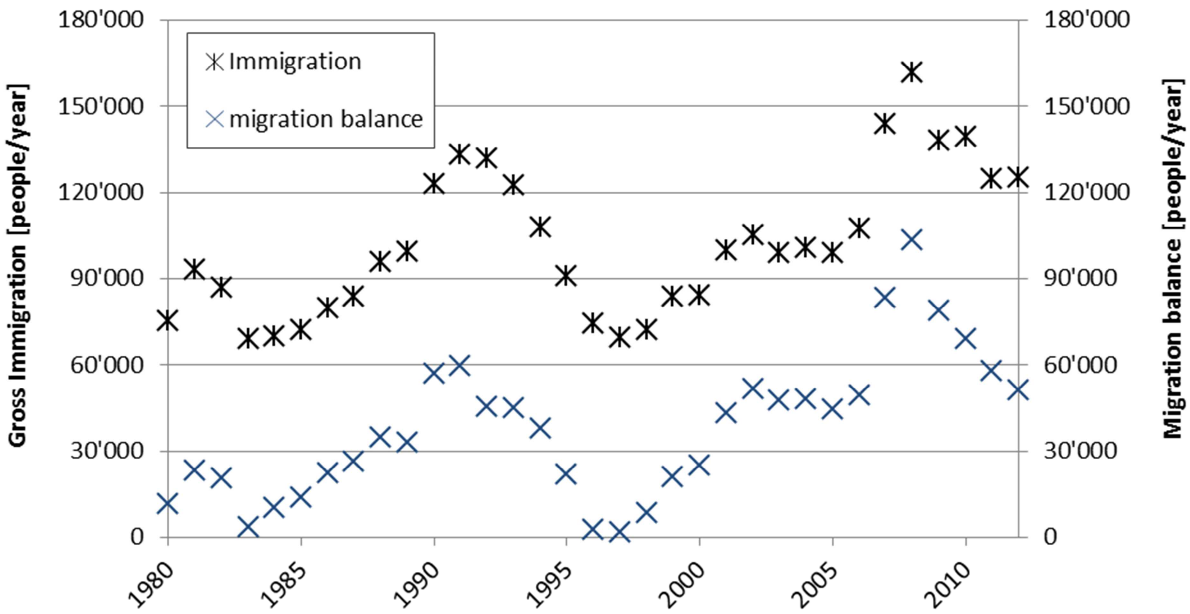
2.2 Immigration into Switzerland

This section presents immigration into whole Switzerland and into Canton Zurich over the last decade, as well as the Swiss popular opinion regarding this development.

2.2.1 Evolution in Switzerland

Observing immigration data for Switzerland between the 1980ies and today, it can be stated that gross immigration commonly ranges between about 60’000 and 160’000 people per year. The yearly value of the migratory balance lies between 0 and 100’000 immigrants per year for this time period (Figure 4).

Figure 4 Gross immigration and migratory balance of Switzerland between 1980 and 2012



Data: Swiss Federal Statistical Office (2013)

Figure 4 indicates that immigration fluxes into Switzerland are correlated with the business cycle of the country. Indeed, both gross immigration and migratory balance show a deep reduction between about 1993 and 1998, which is probably related with the crisis of the 90ies, and which contrasts with the great fluxes during the booming late 1980ies. However, it can be observed that the migratory response usually shows a small lag (1-2 years) compared to the economic cycle, so that its shape is similar to broad bell curve (Wüest & Partner Ltd, 2010, p. 45). Graf et al. (2012, p. 9) confirm this assumption by stating that "an employment contract in Switzerland is for three quarters of all newcomers into Switzerland [...] the immigration trigger". A different feature can be observed for the 2008 peak. In this case, augmentation of immigration fluxes is not only related to an enviable economic situation compared to the rest of Europe, but also to the entry into force of the Bilateral Agreements II between Switzerland and European Union. Indeed, one part of this agreement concerns the total opening of the Swiss labor market to European citizens since 1 June 2007 (SECO, 2007). According to Graf et al. (2012, pp. 10-11), an important trigger of the recent immigration wave is also the evolution of the Swiss economy, which needs an always greater percentage of highly qualified employees whose the Swiss representatives cannot cover this demand. Indeed, data show that, in contrast with the previous migration peaks, the major part of the new immigrants are young and very qualified people. According to Wüest & Partner Ltd (2010, p. 44), 60% of the immigrants of the 2008-2010 peak are between 20 and 39 years old and have a tertiary education. Thus, it seems to be clear that a significant part of immigrants in the last years belong to higher social classes with, mostly, high purchasing power. Hence, this kind of population could likely influence the housing prices in an inflationary way.

2.2.2 Evolution in Region Zurich

According to Wüest & Partner Ltd (2012, p. 56), the Canton Zurich absorbs, with the Cantons Vaud and Geneva, the highest immigrant number of Switzerland. Between 2007 and 2009, the agglomerations of Zurich and Geneva have welcomed about one third of the immigrant fluxes coming into the country (Wüest & Partner Ltd, 2010, p. 44). Actually, the young and well-qualified immigrants are most likely attracted by interesting job opportunities that can be found in these two economic centers. Furthermore, these two regions may have a stronger international character (e.g. international schools) than any other place in Switzerland, which is of certain interest for expatriates. For these reasons, it can be expected that the canton Zurich may be more affected by the effects related to high immigration fluxes than the majority of the cantons.

2.2.3 Popular opinion

Even if it is difficult to make a statement about the average Swiss popular opinion concerning immigration, there are clear signs of a strong concern among the population in the last years. Indeed, the recent referendum topics as well as their results, for instance the initiative on the expulsion of foreign criminals or the one against mass immigration, demonstrate a certain fear about negative effects related to an uncontrolled immigration. It can be noticed that this referendum wave, that has been quite hostile to foreigners, started in 2009 with the vote against minaret construction. This was about one year after implementation of the Schengen-Dublin agreements on Swiss territory. The initiative against mass immigration, which was accepted by 50.3%[2] of voters, is quite interesting regarding this study. Indeed, it denotes that, for a certain part of the Swiss population, Switzerland is a small country that currently receives too many immigrants with all the negative effects that are assumed to be related with this, such as a rise of real estate prices. Even if one conservative party is often responsible for starting the described votes (SVP), the whole range of Swiss political parties identifies issues arising from immigration and suggests various strategies to solve them. In 2009 criticized the

[2] http://www.admin.ch/ch/f/pore/va/20140209/det580.html, consulted on 04/21/2014.

young leader of the Greens, Bastien Girod, with his party colleague Yvonne Gilli, the negative effects of uncontrolled immigration, e.g. higher rent prices, gentrification and transport congestion, in a paper (Rau, 2009). The Swiss socialist party presented in 2012 a report to regulate immigration fluxes, among others because these should put pressure on wages and rents, especially in the regions of Zurich and Geneva Lake (Blumer, 2011). Even the Liberals, who are traditionally attached to the free movement of persons, published in 2010 a paper containing strategies designed for managing immigration fluxes to ensure benefits for Switzerland (Tages Anzeiger, 2010a). Furthermore, the Swiss Authorities invoked in April 2012 the safeguard paragraph of the Schengen agreements to control the migrant fluxes from 8 countries of Eastern Europe. This limitation has been confirmed in 2013 and even extended to all the other member countries for a one year term. This last fact tends to indicate that the immigration problem goes beyond popular opinion and that real issues may be related to the higher fluxes that have entered into Switzerland during the last years. Nevertheless, positive sides of the immigration are also pointed out, such as an enabling effect for the economic growth resulting from the arrival of foreigners, especially from their additional consumption (Tages Anzeiger, 2010b).

2.3 Situation of the Swiss real estate market

In this part, various mechanisms of real estate market functioning as well as specificities of the Swiss case are introduced.

2.3.1 Background

Real estate objects have the particular feature of being both used as an investment and as a consumption good (Hott, 2009). Thus, asset characteristics of real estate can lead to speculative events, so that a non-optimal outcome of the market occurs. Furthermore, housing supply only reacts slowly to demand variations due, among others, to the time needed for realizing real estate projects, such as the funding, design or building phases. According to DiPasquale and Wheaton (1994), this adjustment process can last several years, so that in the short-run an imbalance occurs on the market. This discrepancy usually leads to housing price adjustment in order to clear the market.

More generally, the outcome of the real estate market may be influenced by various so called demand-shifting variables such as for instance the interest rate level (Steiner, 2010, p. 5). Within the context of this study, the demand-shifting variables “population” and “income level” are especially of interest, because they are very likely influenced by immigration fluxes, which may in turn impact housing price level. Furthermore, Steiner (2010, p. 11) makes the statement that "it is not the size of the population that is relevant but how much that population is actually earning": According to this position, the emphasis of the present study should rather be put on well earning foreigners than on all immigrant classes.

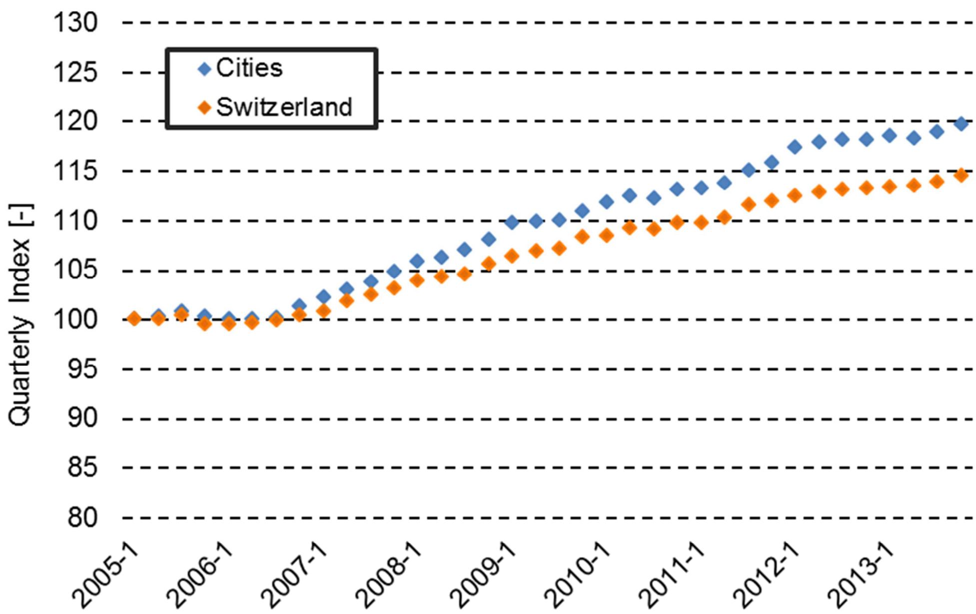
2.3.2 Swiss market characteristics

According to Degen and Fischer (2010, pp. 5-6), the Swiss real estate market is mainly characterized by both nationwide rent control and low demand for owner occupancy. In fact, Swiss home ownership rate is only of 37.2% for 2012[3], which is, for instance, almost two times smaller than in a country like the United States (67.8%, 2000[4]). Both characteristics should logically contribute to a slow growth rate of Swiss housing prices. According to Wüest & Partner Ltd (2012), statistical records show an average real price increase for Swiss housing of 1.3 % per year for the period 1930 to 2010. This is a moderate value compared, for instance, to the 4.1% average real increase of Great Britain for the time period 1970 to 2006 (Degen and Fischer, 2010, p. 24). Focusing on a more recent time period of 2005 to 2013, the following pattern can be observed for the Swiss housing rent price evolution in Figure 5.

[3] Swiss Federal Statistical Office (2013)

[4] Degen and Fischer (2010, p.5)

Figure 5 Hedonic Index of an average apartment price evolution per quarter (2005 till 2013)



Data: Wüest & Partner Ltd (2014)

According to the data of Figure 5, the average annual rise of apartment rent is 1.6% for whole Switzerland and 2.1% for the cities. Compared to the previous numbers, these values indicate that the last years constitute a period of slightly higher inflation on the Swiss real estate market than over the long-term.

It is important to notice, that all the values discussed in this section are not separated into existing and new rents. Indeed, new built apartments and rental units with high turnover rate show typically a greater yearly price increase than the average.

2.3.3 Situation in Region Zurich

With the Geneva Lake Region, the Region of Zurich can be considered the tightest Swiss real estate market. Indeed, the economic dynamics of this zone attract a notable percentage of the immigrant population into Switzerland (Section 2.2.2) and also Swiss citizens, usually young and well educated, coming from other regions of the country (Arnet, 2011). According to Wüest & Partner Ltd (2008, p. 38), the difference between the growth rate of the housing stock and the growth rate of the population in the Canton Zurich is positive with 2.3% for the years 2000 till 2006, but smaller than the Swiss average of 2.5%. Even if focusing on the later time period of 2006 to 2013, this could indicate that building rate in the Canton Zurich may be slightly smaller compared to the settlement rate of new inhabitants, which may induce a higher housing price inflation rate than at others locations in Switzerland. Indeed, the average yearly growth rate of the offered housing prices for the city of Zurich is 3.1% for the time period 2005 to 2013. Even if the values of the same period for whole Switzerland (1.6%) and Swiss cities (2.1%) are computed with a different methodology (quality-adjusted index for a particular apartment type), comparing them with the previous value may indicate that, in fact, the region of Zurich tends to have a higher housing price increase than in most places in the country.

2.4 Immigration effects on real estate markets

Outcome in the real estate market may be influenced by various demand-shifting variables. Within the context of this study, variables related to the demographic characteristics, e.g. the proportion of foreigners and their assumed average income, are the focus. Effects of immigration on housing markets have been already treated in several research works around the world. Their conclusions suggest that proportion of foreigners tends to correlate positively with housing price levels. Saiz (2007), for instance, states that a 1% increase of foreigner percentage in an American city leads to a 1% growth of the average housing and rent values. However, Stillman and Mare (2008) point out that the effects on real estate prices may vary according to the analyzed foreigners groups. Indeed, according to their work about the immigration effect on housing prices level in New Zealand, New Zealanders coming back to their country have an inflationary effect, but the other categories do not. Regarding the situation in Switzerland, Degen and Fischer (2010, p. 4) estimate the influence of the migratory flux on single-family homes price for the time period 2001-2006. According to their results, a 1% immigrant inflow into an area would lead to a 2.7% increase of its average housing price level. Thus, this would indicate that the Swiss housing market specificities (Section 2.3.2) are not able to prevent the occurrence of inflationary effects resulting from immigration. Nevertheless, this work studies only the effect of foreigners on the property market, which may be very different of the effect on the rent level. Indeed, Heye and Hermann (2012, p. 24) indicate that the immigration into the Canton Zurich, between 2000 and 2010, may have had an inflationary influence on house prices, but not on rents. Thus, as discussed above, the effective relation between immigration and rent price level is quite controversial. For the further approach of this work, it should be kept in mind that immigration may have, plausibly, a positive correlation with housing price levels and that a division of the foreigners groups into subclasses, as already noticed in Section 2.3.1, could lead to further conclusions.

3 Hedonic pricing methodology

A house price model is used in this thesis in order to approximate and quantify a possible relationship between immigration into Switzerland and evolution of housing prices. The regression model is estimated with the help of the statistics software R©[5]. The hedonic pricing method, its issues in dealing with spatial data as well as advanced approaches are briefly presented in the following section.

3.1 Background

The price of a good can be considered as a value measurement, on one hand, of the good itself and on the other hand of some characteristics that are related to it. The second approach constitutes the basis of hedonic pricing modelling. Indeed, this method considers that a price can be described by various properties of this good, which are combined with the help of weighting parameters.

$$P = \beta_0 + \beta_1 \cdot x_1 + \beta_2 \cdot x_2 + \beta_3 \cdot x_3 + \cdots + \beta_n \cdot x_n + u \qquad (1)$$

Price P (explained variable) is the sum of different characteristics x (explanatory variables) weighted with parameters β. The term β_0 is a constant, which results from the regression process. Term u (also called error-term) is necessary for modelling the random variations arising from characteristics, that are not considered in the estimated equation but that may also influence the P value (Woolridge, 2009, p. 23). Assuming that other characteristic values are held fixed (*ceteris paribus*), it is possible to approximate the effect of variations of a single explanatory variable (for instance x_1) on price P. Indeed, the size of this effect is described by the associated parameter β_1. In the case of the linear regression presented above, β_1 gives in absolute value the relation between a change ΔP in response to a variation of a single factor Δx_1. According to which kind of relations has to be modeled, it can be desirable to use other kinds of regression than the simple linear one. For instance, a log-level model is commonly applied for modeling real estate price (Du and Mulley, 2012, p. 50).

[5] http://www.r-project.org/, consulted on 09/08/2014.

$$ln(P) = \beta_0 + \beta_1 \cdot x_1 + \beta_2 \cdot x_2 + \beta_3 \cdot x_3 + \cdots + \beta_n \cdot x_n + u \qquad (2)$$

In this approach, a percentage change of ΔP is obtained by multiplying the variation of the independent factor Δx_1 with $100\beta_1$ (Woolridge, 2009, p. 46). Applying the principles described above to the present study, it is actually possible to derive the effect of the variable "foreigner population" on the dependent variable "average monthly rent" for a certain location. A general form of the estimated model can be written as:

$$ln(P) = \alpha_0 + \sum_{i=1}^{n} \beta_i \, C_i + \sum_{i=1}^{n} \gamma_i \, L_i + \sum_{i=1}^{n} \delta_i \, D_i + u \qquad (3)$$

with C_i a set of housing entity characteristics (e.g. living area), L_i variables about structural location specificities (e.g. lake view or accessibility) and D_i socio-demographic location specificities (e.g. proportion of foreigners).

3.2 Spatial data related issues

Applying hedonic pricing method for rent values implies the use of data with spatial properties. However, such data are commonly related to characteristics that violate the assumptions on which basic linear regression models rely. According to Charlton and Fotheringham (2009, p. 3), these may produce biased and inefficient parameter estimates, which in turn reduce the outcome reliability of the computed regression model.

For Löchl and Axhausen (2010, p. 40), two properties of spatial data are of major concern: spatial dependence (denoted as spatial autocorrelation) and spatial heterogeneity (denoted as spatial non-stationarity). According to Anselin (1988, p. 8), spatial dependence implies that a functional relationship exists between properties of one point in space and the properties of other points situated elsewhere. In other terms, it could be often stated that "high variable values are found near other high values and low values appear in geographical proximity" (Páez and Scott, 2004, p. 55) or also that "Everything is related to everything else, but near things are more related than distant things" (Tobler, 1970). Spatial heterogeneity refers to the fact, that relationship being interpreted by a regression model may be not homogeneous when dealing with spatial data (Charlton and Fotheringham, 2009, p. 3). But homogeneity of analyzed relationship is always assumed for fitting a regression model. However, such assumption cannot be observed as the explanatory variables are dependent on the place, on a micro-scale, where they are located. A further issue that commonly arises from linear regression using spatial data is the existence of high correlations between two or more explanatory variables, also called multicollinearity. In contrast to the two previous problematic characteristics (spatial dependence and heterogeneity), multicollinearity does not violate the assumptions of basic linear regression. Thus, exact effect of multicollinearity on model predictions quality is not very clear, but this should lead to greater variance of parameter estimates (Woolridge, 2009, pp. 96-97). What seems to be important is, that the independent variable of interest (in the present study case “immigration”) remains as much as possible free of multicollinearity.

3.3 Spatial simultaneous autoregressive models (SAR)

Simultaneous autoregressive (SAR) modeling is a convenient approach to avoid issues related to the presence of autocorrelation among spatial data, which are used for the regression. Indeed, this approach allows a correction of the regression equation, so that biasing effects that result from spatial autocorrelation can be reduced. Thus, a more reliable outcome may be obtained with this method compare to an ordinary least square (OLS) regression. Basically, spatial autocorrelation may affect a regression in all its three component groups: the response variable, the explained variables and the error term. Thus, several versions of the SAR model are available, depending on which component of the model has to be corrected for autocorrelation.

The classical SAR model, the spatial simultaneous autoregressive lag model (SAR*lag*), is computed in order to take into account spatial dependency among the observations, e.g. the explained variable price *P* (Hackney et al., 2007, p. 400). The general model takes the following form:

$$P = \rho \cdot W \cdot P + \beta \cdot X + u \qquad (4)$$

The parameter ρ corresponds to a spatial autocorrelation parameter and *W* to a neighborhood weighting matrix. If the aim of the used model is to account for autocorrelation in the error term *u*, the use of a spatial simultaneous autoregressive error model (SAR*error*) is indicated (Hackney et al., 2007, p. 400):

$$P = \beta \cdot X + error \qquad (5)$$

with, in contrast to the usual assumed uncorrelated normal distribution of the error term *u*:

$$error = \lambda \cdot W \cdot error + u \qquad (6)$$

The parameter λ is the spatial autoregressive coefficient. If both previous SAR-models are combined, the general spatial autoregressive model with a correlated error term (SAC) is obtained (Hackney et al., 2007, p. 400):

$$P = \rho \cdot W \cdot P + \beta \cdot X + error \qquad (7)$$

As a last option, it may make sense to account for the correlation existing among the explanatory variables. The spatial Durbin model, or SAR*mix*, allows this treatment while considering also the autocorrelation of the explained variable, like in the SAR*lag* model (Löchl and Axhausen, 2010, p. 42):

$$P = \rho \cdot W \cdot P + \beta \cdot X \cdot + W \cdot X \cdot \gamma + \ u \quad (8)$$

where γ is a further autoregression coefficient.

3.4 Geographically weighted Regression (GWR)

In order to account for issues related to spatial heterogeneity of the data (Section 3.3), the geographically weighted regression (GWR) method constitutes a good option. The idea of a GWR model is to compute coefficient estimators that are obtained up to specific characteristics of a point location. Thus, a global regression model is adapted into a local model, which takes into account microscale properties. Different coefficient estimates as well as independent error terms are obtained by using this approach (Löchl and Axhausen, 2010, p. 43). According to Charlton and Fotheringham (2009, p. 5), the general form of a GWR-model is:

$$P(l_i) = \beta_0(l_i) + \beta_1(l_i) \cdot x_{1i} + \beta_2(l_i) \cdot x_{2i} + \beta_3(l_i) \cdot x_{3i} + \cdots + \beta_n(l_i) \cdot x_{ni} + u_i \quad (9)$$

where l_i represents a specific space point, which is given, for instant, by its coordinates. Other parameter descriptions remain the same as in Chapter 3.1. The coefficients are estimated in the following way (Charlton and Fotheringham, 2009, p. 5):

$$\beta(l_i) = (X^T \cdot W(l_i) \cdot X)^{-1} \cdot X^T \cdot W(l_i) \cdot P(l_i) \qquad (10)$$

with $\beta(l_i)$ the vector of coefficient estimates at various locations l_i, X the matrix of independent variables, $W(l_i)$ the matrix containing geographical weights up to l_i and $P(l_i)$ the vector of observed price values (e.g. rents). The weighting matrix W is computed with the help of a weighting scheme, a so called "kernel" (Charlton and Fotheringham, 2009, p. 6). This approach enables to take into account observations values of neighboring locations of an observation point and to weight the influence they have on this point, for example, according to their distance.

Although GWR has many advantages for dealing with spatial data, it has also issues that may reduce the model outcome reliability. For instance, the existence of multicollinearity among the local estimated coefficient may be of concern when interpreting the individual GWR parameter estimates influence on the dependent variable. Indeed, Wheeler and Tiefelsdorf (2005) state that GWR-models suffer substantially more of multicollinearity effects than standard global regression models.

3.5 Potentially relevant variables

Table 1 introduces potentially relevant variables that may be used for the following hedonic modelling. As described in section 3.1, the variables are organized into three main groups: building characteristics, location structural and location socio-economic characteristics. This large set will be afterwards reduced by testing the inclusion of each variable based on its statistical significance. The data describing the following variables have three different origins. Most of the building's characteristics come from free data of web-based advertisements (Web). Further information concerning the building, as well as its location, has been provided by the Institute for Transport Planning and Systems (IVT) of ETH Zurich. Finally, the majority of the socio-economic data come from the Swiss Federal Statistical Office (BfS).

Table 1 Potentially relevant variables to model the relation between housing rental price and immigration level

Variable	Description	Unit	Origin
Dependent Variable			
Rent	Monthly gross rent	[CHF]	Web
RentPerSQM	Monthly gross rent per m^2	[CHF]	Web
Building related explanatory variables			
Room	Number of rooms	[-]	Web
Living_Area	Net living Area	[m^2]	Web
Story	Story	[-]	Web
Stories	Number of building stories	[-]	IVT
Res_Units	Number of dwelling units in building	[-]	IVT
Parcel_Size	Parcel size	[a]	IVT
Land_Value	Built land value	[CHF/m^2]	IVT
Attic	Dwelling unit is an attic	[dummy]	Web
Balcony	Dwelling unit has a balcony	[dummy]	Web
Fire	Dwelling unit has a fireplace	[dummy]	Web
Garden	Dwelling unit has a garden	[dummy]	Web
Terrace	Dwelling unit has a terrace	[dummy]	Web
Age1	Constructed till 1930	[dummy]	Web
Age2	Constructed between 1931 and 1950	[dummy]	Web
Age3	Constructed between 1971 and 1990	[dummy]	Web
Age4	Constructed since 1991	[dummy]	Web

Age5*	Constructed between 1951 and 1970	[dummy]	Web
Resi_Perc	Proportion of residential use	[%]	IVT
Retail_Perc	Proportion of retail use	[%]	IVT
Office_Perc	Proportion of office use	[%]	IVT
Indus_Perc	Proportion of industrial use	[%]	IVT
Owner	Ownership share	[%]	IVT
Location related explanatory variables: structural			
Dist_Highway	Distance to highway ramp (as the crow flies)	[100 m]	IVT
Highway	Highway within a 100 m radius	[dummy]	IVT
Dist_Station	Distance to railway station (as the crow flies)	[100 m]	IVT
Acc_Car	Accessibility by car	[LN of acc. index]	IVT
Acc_PT	Accessibility by public transp.	[LN of acc. index]	IVT
Acc_Tot	Sum of Acc_Car and Acc_PT	[LN of acc. index]	IVT
Dis_School	Distance to school (as the crow flies)	[100 m]	IVT
Dis_Kindergarten	Distance to childcare facility (as the crow flies)	[100 m]	IVT
Dis_CBD_ZH	Distance to the CBD of Zurich (as the crow flies)	[100 m]	IVT
Dis_CBD_Winterthur	Distance to the CBD of Winterthur (as the crow flies)	[100 m]	IVT
Slope	Land slope	[degree]	IVT
Lake_View	Visibility of lake surface	[100 ha]	IVT
Lake_dummy	Dwelling unit has lake visibility	[dummy]	IVT
Sun_Eve	Evening solar exposure index	[-]	IVT
Location related explanatory variables: socio-economic			
Univ	Share of universitary graduates	[%]	IVT
H_300m	Density of households within a 300 m Radius	[ha^{-1}]	BfS
H1_300m	Density of 1 people households within a 300 m Radius	[ha^{-1}]	BfS
H2_300m	Density of 2 people households within a 300 m Radius	[ha^{-1}]	BfS
H3_300m	Density of 3 people households within a 300 m Radius	[ha^{-1}]	BfS
H4_300m	Density of 4 people households within a 300 m Radius	[ha^{-1}]	BfS
H5_300m	Density of 5 people households within a 300 m Radius	[ha^{-1}]	BfS
H6_300m	Density of 6 people households within a 300 m Radius	[ha^{-1}]	BfS
H_500m	Density of households within a 500 m Radius	[ha^{-1}]	BfS
H1_500m	Density of 1 people households within a 500 m Radius	[ha^{-1}]	BfS
H2_500m	Density of 2 people households within a 500 m Radius	[ha^{-1}]	BfS
H3_500m	Density of 3 people households within a 500 m Radius	[ha^{-1}]	BfS
H4_500m	Density of 4 people households within a 500 m Radius	[ha^{-1}]	BfS
H5_500m	Density of 5 people households within a 500 m Radius	[ha^{-1}]	BfS
H6_500m	Density of 6 people households within a 500 m Radius	[ha^{-1}]	BfS
H_01km	Households density within a 1 km radius	[ha^{-1}]	BfS
H_05km	Households density within a 5 km radius	[ha^{-1}]	BfS
Pop_300m	Population density within a 300 m radius	[ha^{-1}]	BfS
Pop_500m	Population density within a 500 m radius	[ha^{-1}]	BfS
Children_500m	Children (<18 years old) density within a 500 m radius	[ha^{-1}]	BfS
Foreigners_500m	Foreigner population’s density within a 500 m radius	[ha^{-1}]	BfS

Swiss_500	Swiss population’s density within a 500 m radius	$[ha^{-1}]$	BfS
Retail_300m	Number of working places in retail in a 300 m radius	[100 WP]	IVT
Retail_1000m	Number of working places in retail in a 1000 m radius	[100 WP]	IVT
Hotel_300m	Number of working places in hotels in a 300 m radius	[100 WP]	IVT
Hotel_1000m	Number of working places in hotels in a 1000 m radius	[100 WP]	IVT
Perc_Foreigners	Proportion of foreigners (F.) in municipality	[%]	BfS
Perc_Schengen	Proportion of Schengen F. in municipality	[%]	BfS
Perc_NW	Proportion of Northwestern Schengen F. in municipality	[%]	BfS
Perc_SE	Proportion of South/Eastern Schengen F. in municipality	[%]	BfS
Perc_OutSchengen	Proportion of Outside Schengen F. in municipality	[%]	BfS
Year_2009*	Advertisement of year 2009	[dummy]	Web
Year_2010	Advertisement of year 2010	[dummy]	Web
Year_2011	Advertisement of year 2011	[dummy]	Web
Year_2012	Advertisement of year 2012	[dummy]	Web
Year_2013	Advertisement of year 2013	[dummy]	Web

*Base value

4 Data analysis and description

In this chapter, the descriptive statistics of the dataset used to build the hedonic regression models are presented.

4.1 Immigration data

In this section, the immigration data are described and analyzed. Data from 2006 to 2008 are included in order to account for the whole effect of the free movement agreement's adoption in 2007.

4.1.1 Data description

To evaluate the immigration into Canton Zurich between 2006 and 2013, two datasets of the Swiss Federal Office for Migration and of the Statistical Office of Canton Zurich have been used. The first one records the number of foreign citizens according to their nationality for each year and municipality. The second one concerns the whole population data of the municipalities of Canton Zurich for the time range 2006 to 2013. Based on these sets, percentages of each nationality have been calculated for all municipalities of Canton Zurich. For the cities of the Zurich and Winterthur, the calculated values concern the whole municipalities and, unfortunately, not the particular Quarters.

4.1.2 Analysis

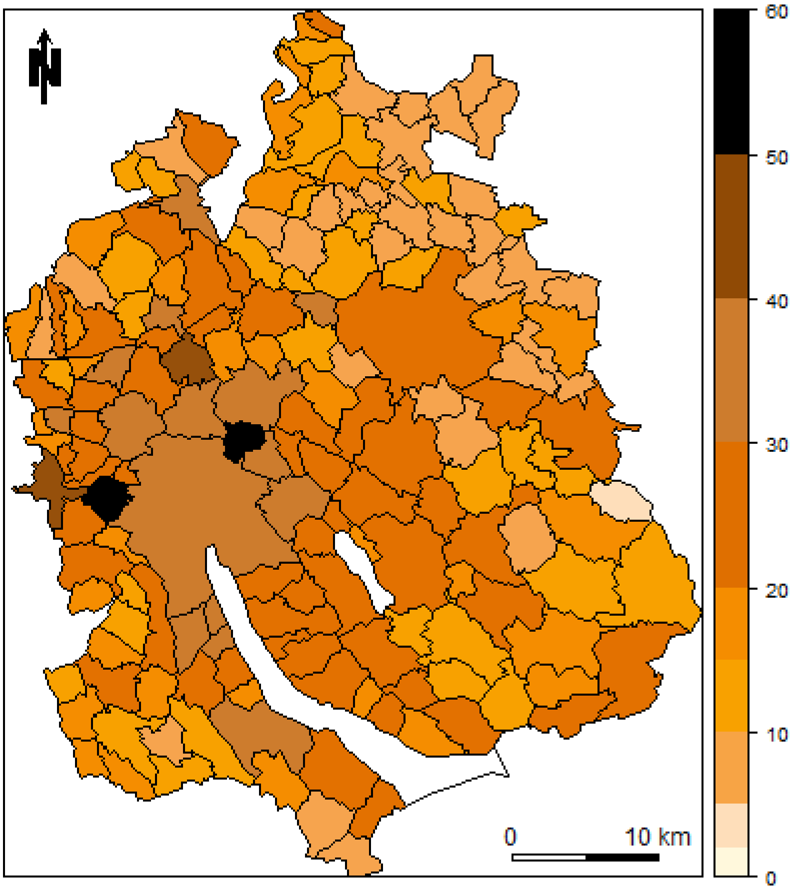
In order to capture variations among the various immigrant housing styles, foreigners have not only been studied as an aggregate, but also in various categories. In fact, groups have been built, for instance, for foreigners with nationality of a Schengen zone country or also only for Northwestern Europeans. This second group is especially interesting, because it is expected that such foreigners class tends to be highly qualified and therefore to have a higher purchasing power. So, this population category could likely have a greater influence on rental prices level than any other one. The various foreigner groups analyzed are detailed in Annex A 1.

Foreign population in 2013

Considering the percentages of foreigners per municipality for the year 2013 (Figure 6), it can be noticed that the greatest concentrations are in close vicinity of the city of Zurich, especially Zurich itself, the Glatttal municipalities (Southern Dielsdorf and Bülach districts), the

Limmattal (close to Dietikon) as well as some towns along the South side of the Lake of Zurich (district of Horgen). Schlieren and Opfikon have the highest values with 59.6% respectively 56.6% of foreigners. The countryside like the Zurich Oberland (South East of the map) and the border to Canton Zug (South West of the map) host, on the contrast, the lowest shares of foreign population.

Figure 6 Percentage of foreigners per municipality in Canton Zurich 2013

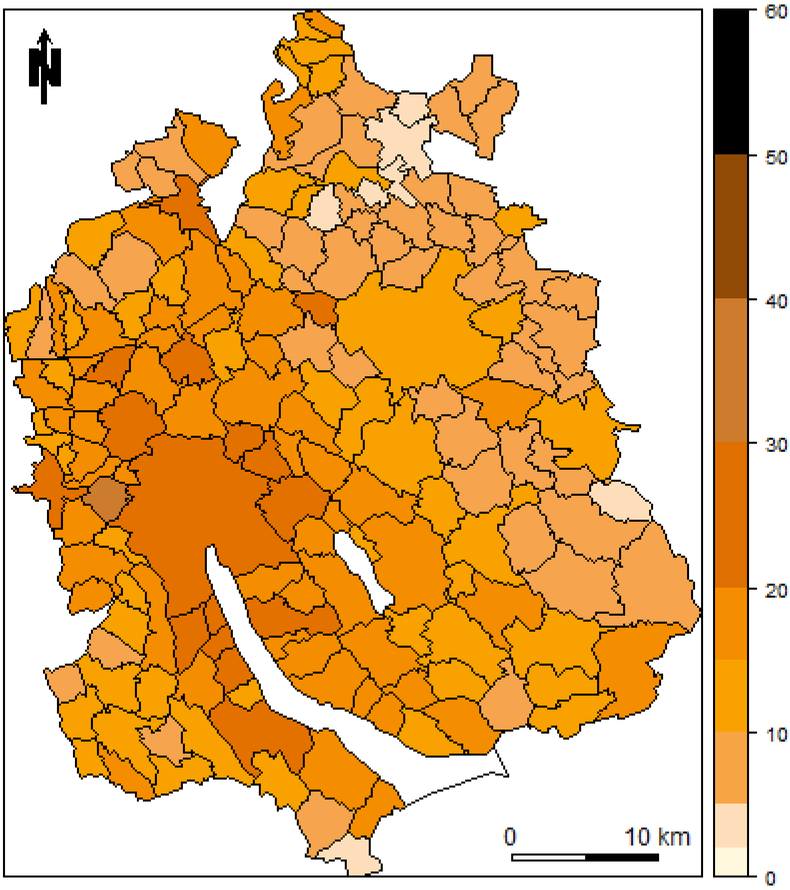


Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

The spatial distribution trend shown for all foreigners holds as well for the Schengen zone citizens (Figure 7). Also in this case, the immigrants cluster around the city of Zurich and its neighboring municipalities.

Figure 7 Percentage of citizens coming from Schengen countries per municipality in Canton Zurich 2013

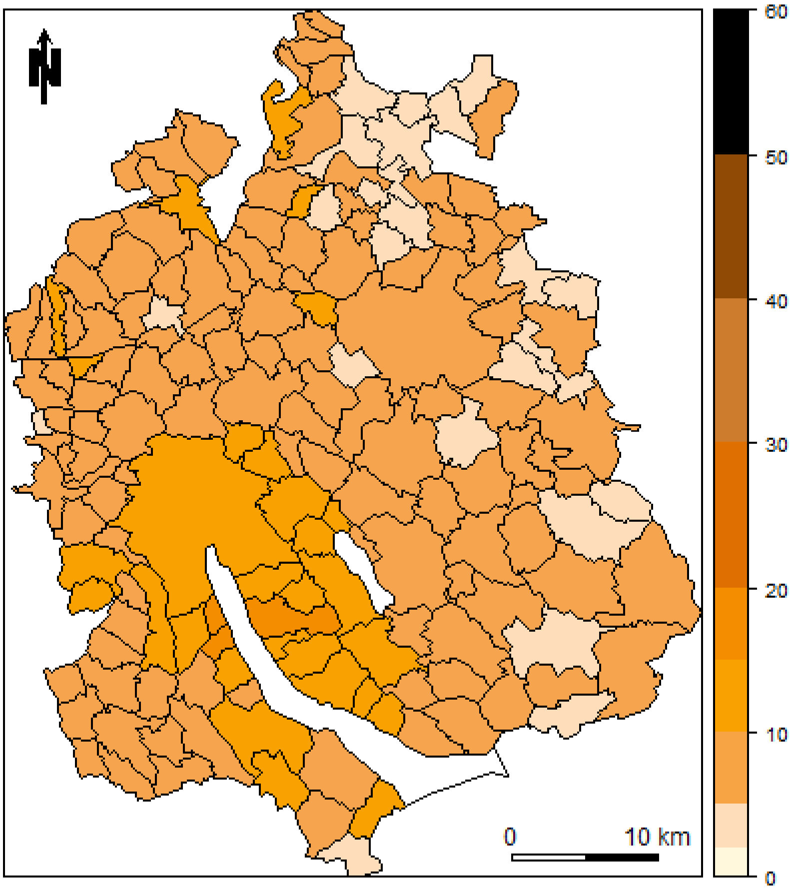


Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

In a further step, dividing the Schengen population into its Northwestern and its Southern/Eastern part indicates some differences among this group. Values for the Northwestern countries of the Schengen group show a quite different picture to the previous ones (Figure 8). In this case, the studied population clearly prefers attractive locations such as the city of Zurich and both lake coasts, which argues in favor of the assumption that this demographic group tends to have a higher purchasing power than the average. The other municipalities of Canton Zurich show a more or less uniform distribution of lower percentages of this population. A few places located in the East of the Canton have smaller values.

Figure 8 Percentage of citizens coming from Northwestern Schengen countries per municipality in Canton Zurich 2013

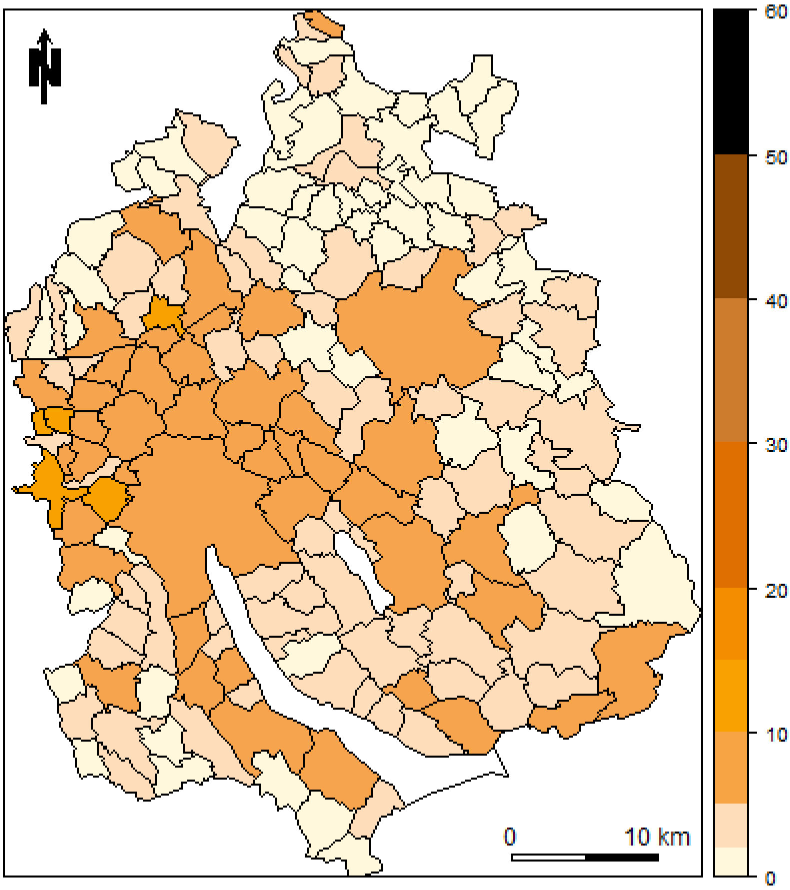


Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

Considering the population coming from Southern and Eastern Schengen countries, a slightly different pattern than the Northwestern one can be observed. Indeed, this group seems to behave in a similar way as the global foreigner population, e.g. with higher percentages in the city of Zurich and its whole agglomeration, as well as Winterthur (Figure 9). However, highest concentrations are present in Limmattal municipalities (around Dietikon), where the Northwestern show comparatively low values. Furthermore, prestigious locations along the "Gold Coast" (Northern Coast of the Lake of Zurich) have very small percentages of Southwestern and Eastern Europeans. These facts may indicate that this group has a lower earning power than the Northwestern one and should influence rents to a smaller extent.

Figure 9 Percentage of citizens coming from Southern and Eastern Schengen countries per municipality in Canton Zurich 2013

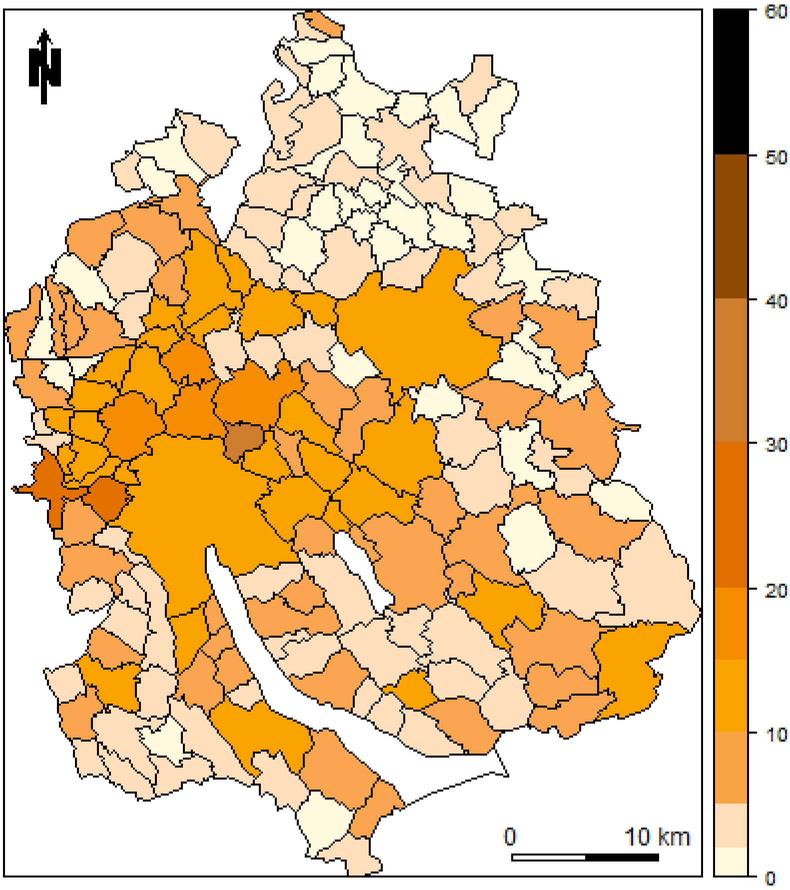


Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

Finally, the spatial distribution of the foreign population, which comes from countries outside the Schengen zone follows as well a similar trend as the one shown by the total population of foreigners. However, the municipalities of the Glatttal (close to Dietikon) and Limmattal (Southern Dielsdorf and Bülach districts), which are known for their cheaper rents, have the peak values for this demographic group.

Figure 10 Percentage of citizens coming from outside of Schengen per municipality in Canton Zurich 2013



Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

Further maps, which show the relative percentage of the various demographic categories compared to the foreigner populations of each municipality for 2013, are available in Annex A 1.

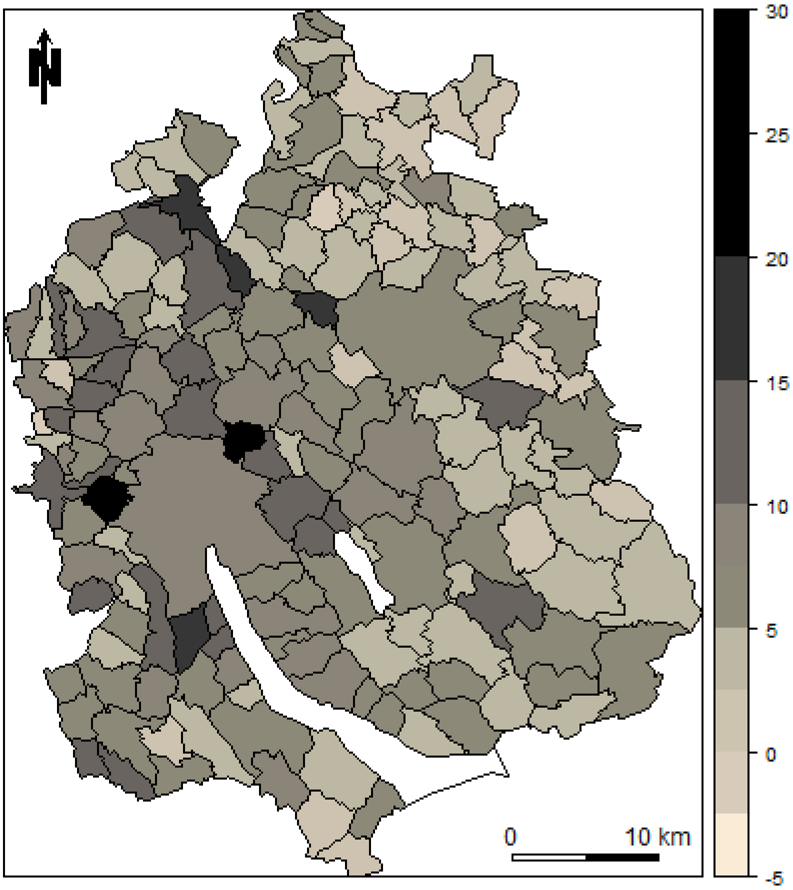
Evolution since 2006

Looking at the evolution of the analyzed groups between 2006 and 2013, it can be observed that the main settlements, which have been discussed in previous section, are usually the same locations where the highest growth has taken place. Indeed, the aggregated population of foreigners shows a greater increase in the vicinity of Zurich (values of about 15% growth) than in the other municipalities in the countryside (value range between 0 and 5% growth).

However, some municipalities lying at the border with Germany (Northern part of the district of Bülach and Western border of the district of Andelfingen) also show high growth values for the studied time period (Figure 11). This fact appears also when observing the values for the citizens coming from Northwestern Schengen countries (Figure 12) and seems to be mainly due, on one hand, to the arrival of German citizens and, on the other hand, to the relative small size of the concerned municipalities, e.g a few 1'000 of inhabitants or less (district of Bülach, Figure 32). It should also be noticed, that, for any municipality, no reduction in the number of the foreigners can be observed. The percentage changes of the foreigner groups shown in the following maps are calculated in this way:

$$\Delta Percentage = Percentage_{2013} - Percentage_{2006} \qquad (11)$$

Figure 11 Change [in % of the municipal population] of the foreigner proportion per municipality in Canton Zurich between 2006 and 2013

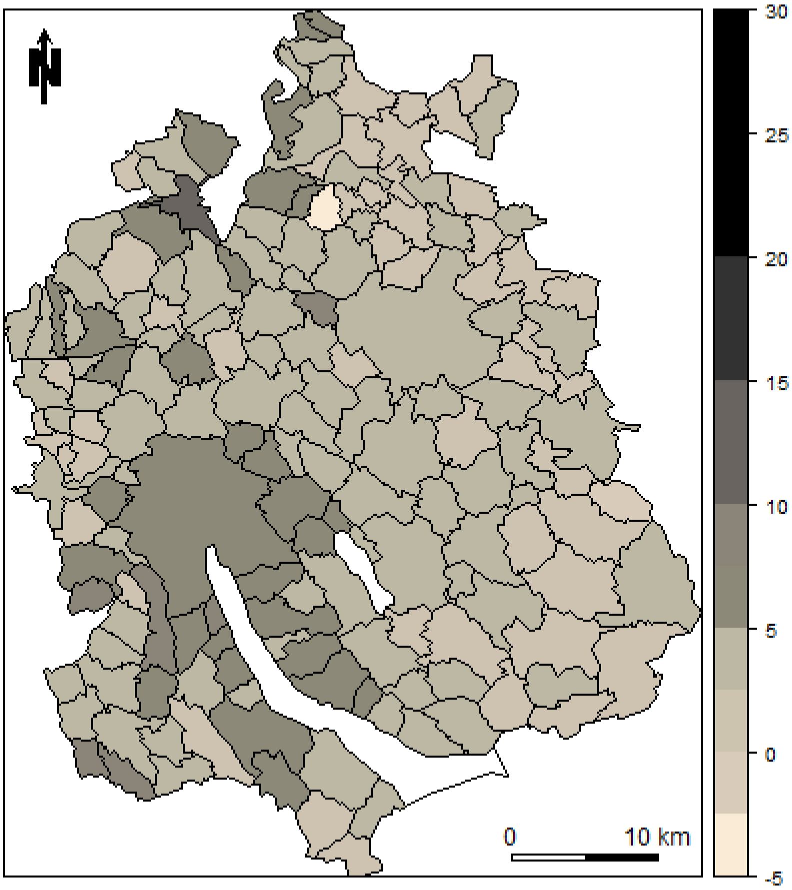


Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

Basically, the evolution of the concentrations for Northwestern Schengen citizens observed in Figure 12 is consistent with the statements made during the analysis of the percentages of year 2013. In fact, highest growth of this population group took place in the most prestigious locations of Canton Zurich, e.g. the city of Zurich itself as wells as the coasts of the Lake of Zurich. However, in contrast to this, some municipalities of the Glatttal as well as the suburb of Schlieren saw also a great change of the analyzed population, even if they traditionally are of poorer reputation. Thus, beside of the location amenity, the proximity to Zurich city seems to be of high importance for this demographic group. As an exception, some border municipalities in the North of the canton seem to be also very attractive for the Northwestern Schengen citizens.

Figure 12 Change [in % of the municipal population] of the proportion of Northwestern Schengen citizens per municipality in Canton Zurich between 2006 and 2013



Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

Further maps describing the evolution of the other demographic groups can be consulted in the Annex A 1. The percentage change of these groups, which is also presented in the Annex (maps of brown color), is calculated in the following manner:

$$\Delta Change[\%] = \frac{Group{,}population_{2013} - Group{,}population_{2006}}{Group{,}population_{2006}} \cdot 100 \quad (12)$$

4.2 Real estate data

This section describes and analyses the real estate data. In contrast to the demographic data, the real estate data cover only the time period 2009 till 2013.

4.2.1 Data description

The real estate data, which are used to estimate the regression models, are web based advertisements with the addition of data provided by the Institute of Transport Planning and Systems of ETH Zurich. The internet data contain information about the rental unit characteristics such as the gross rent price per month, the number of rooms or the living area's size. Additional data of IVT concern mainly the location characteristics of the real estate (e.g. accessibility, lake view, etc.). In total, the used dataset includes about 300'000 unique observations, which range over the years 2009 to 2013.

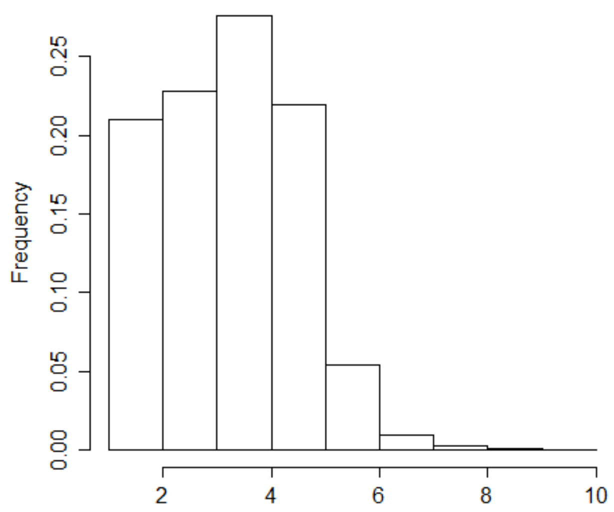
4.2.2 Analysis

The analysis of the real estate data focusses on the variables number of rooms, net living area, monthly gross rent and gross rent per m^2. More information about further variables of the housing dataset can be found in Annex A 2. It should be noted that all the rent values, which are used in this study, are asking prices of the open market. Thus, these rents may fairly differ from the transaction values of the entire real estate market. Furthermore, these values only reflect the price level of the new rentals, but not of the existing ones.

Number of rooms

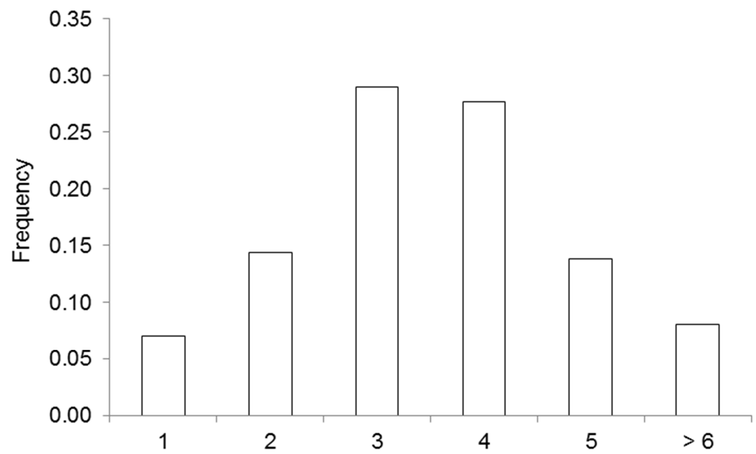
According to Figure 13, the number of rooms per dwelling unit is about uniformly distributed, in the housing dataset, between 1 to 5 rooms. A slightly higher peak occurs for the category 3 to 4 rooms. Housing sizes greater than 5 are only present in very few examples. Comparing now the survey's distribution with the one of Canton Zurich in 2012 (Figure 14), it can be stated that the housing dataset clearly includes an over-representation of residential units of smaller sizes (e.g. 2 rooms and less). Nevertheless, the data of Canton Zurich concern rental units that are permanently inhabited and not the ones that are on the real estate market. It is also probable, that apartments of smaller size have a greater turnover rate than the other ones, explaining this over-representation.

Figure 13 Distribution of the number of rooms per dwelling unit



Data source: web based housing advertisements (2009-2013)

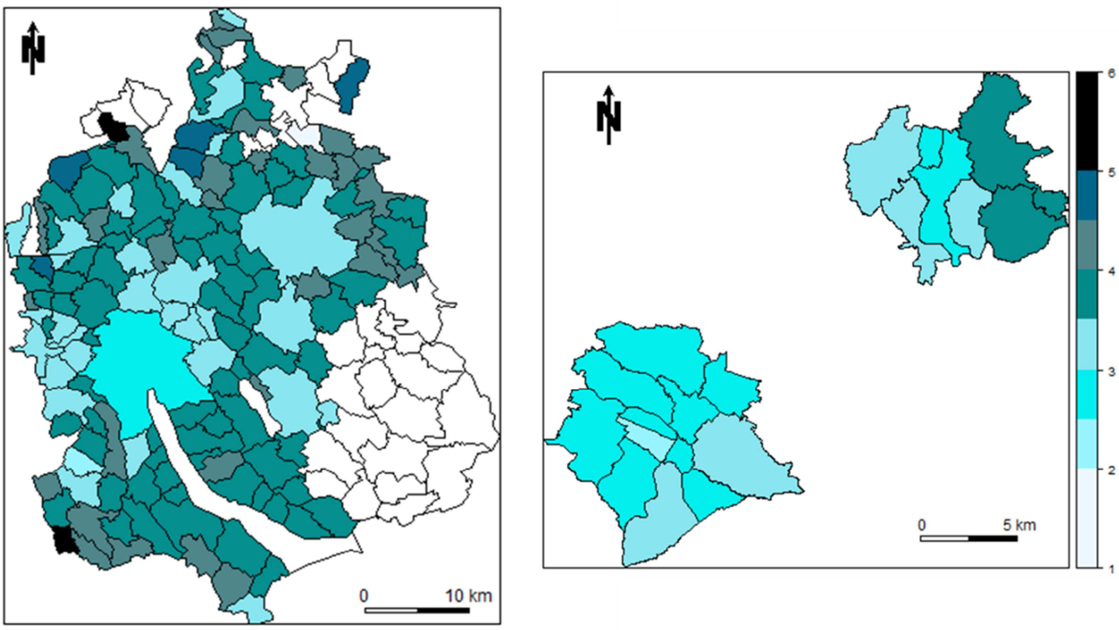
Figure 14 Distribution of the number of rooms per dwelling unit in Canton Zurich 2012



Data source: Statistical Office of Canton of Zurich (2013)

Figure 15 illustrates the spatial distribution of the average number of rooms per dwelling unit and per municipality, according to the web based advertisements. The white areas concern municipalities that do not have any data and that, thus, cannot be analyzed. The represented spatial pattern indicates that urban areas such as the cities of Zurich and Winterthur, as well as most of the suburbs of Zurich, show the smallest sizes of dwelling unit. Considering the higher demographical pressure occurring in these areas, this fact is not surprising. In contrast, it can be stated that the highest values are found in some countryside's towns. The shores of the Lake of Zurich, as traditional residential zones, are also related with slightly higher sizes of dwelling units than in the vicinity of Zurich City. Within the cities of Zurich and Winterthur, some variations may be noticed among the Quarters. Indeed, the Eastside of Winterthur seems to have rental units of greater size than the rest of the city. In Zurich, the distribution is quite uniform (main range between 2.5 and 3 rooms), with slightly higher values for the Quarters 2 and 7, respectively slightly smaller for the Quarter 4.

Figure 15 Average number of rooms per dwelling unit and per municipality (left picture) respectively per Quarter (right picture)

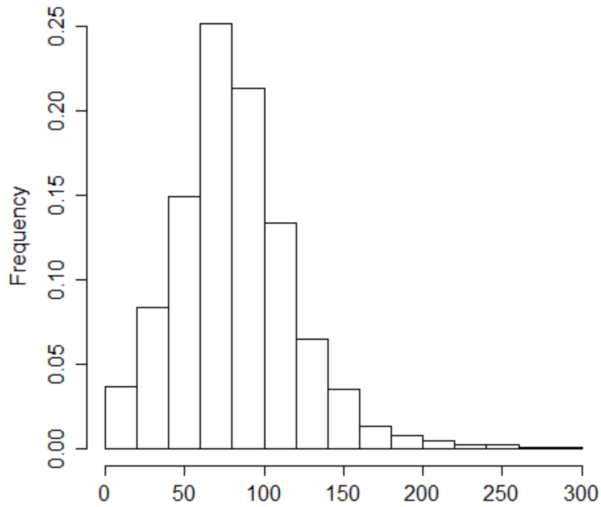


Data source: web based housing advertisements (2009-2013)

Net living area

The variable net living area shows a kind of normal distribution around its average value of 83 m^2, but with a tail on the right (after 150 m^2). This average dwelling unit size is quite smaller than the Canton Zurich effective average value of 97 m^2.[6] This fact can be explained by the over-representation in the housing dataset of apartments having a small number of rooms and the differences existing between apartments durably inhabited and the ones that are offered on the real estate market, as mentioned in the previous subsection.

Figure 16 Distribution of the net living area [m^2] per dwelling unit

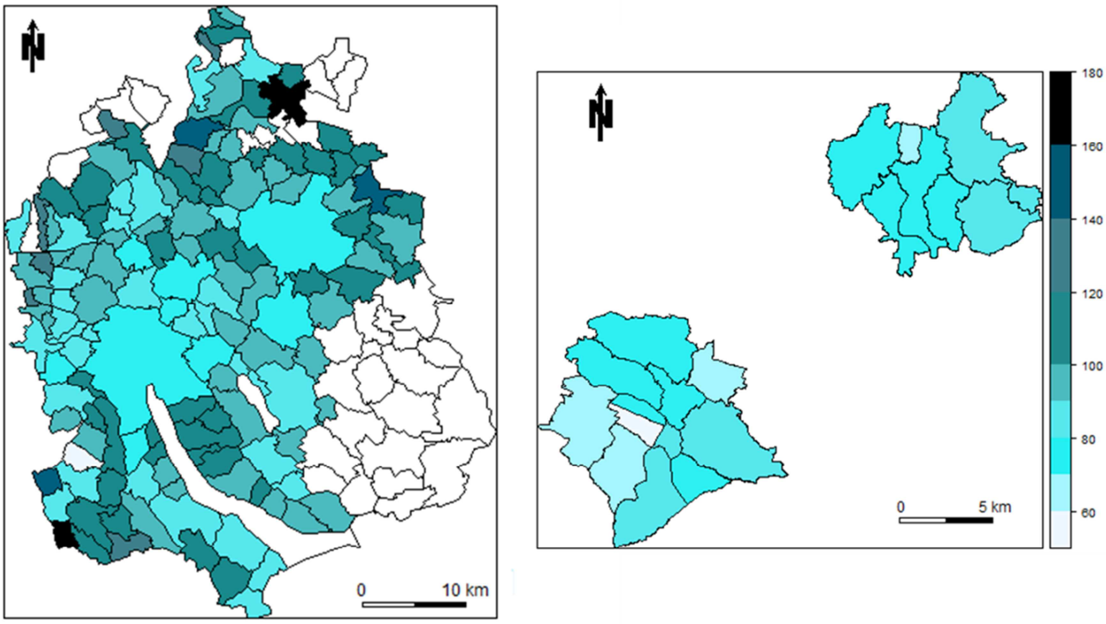


Data source: web based housing advertisements (2009-2013)

The presence of smaller dwelling units in urban areas compared to the countryside, which is described in the analysis of the number of rooms per apartment, can be also observed in the spatial distribution of the average net living area over the Canton Zurich (Figure 17). Considering the cities of Zurich and Winterthur, it can be observed that all the Quarters show values that are equal to or smaller than the average, like in the other dense-built areas of Canton Zurich. It can be noticed that, for the city of Zurich, the pattern for the living area size is consistent with the one for the number of rooms. Indeed, extreme values are found in Quarters 2 and 7, respectively in Quarter 4.

[6] Statistical Office of Canton Zurich (2013)

Figure 17 Average net living area [m²] per dwelling unit and per municipality (left picture) respectively per Quarter (right picture)



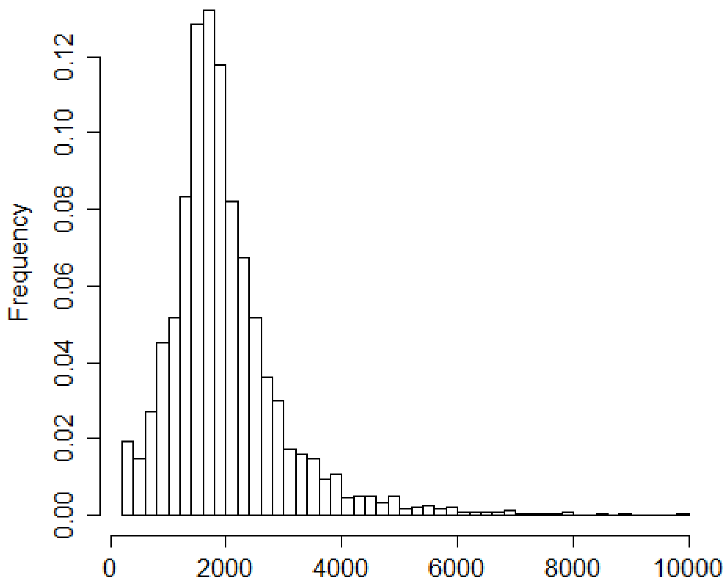
Data source: web based housing advertisements (2009-2013)

Monthly gross rent

Figure 18 represents the distribution of the monthly gross rent variable. It can be observed that most of the values range between 1'500 and 2'500 CHF per month, with an average of 2'008 CHF per month. Removing the average extra rent of the sample (220 CHF per month) from this value, we obtain an average monthly net rent of about 1'790 CHF per month. This value is considerably higher than the cantonal average of 1'525 CHF[7]. Nevertheless, it has to be mentioned that the cantonal average concerns rental units that are durably inhabited and that typically show lower average rents than new apartments, or real estate objects with higher turn-over rate. Furthermore, the rental prices of the housing dataset are advertisement values, which might differ from market values.

[7] Swiss Federal Statistical Office (2013)

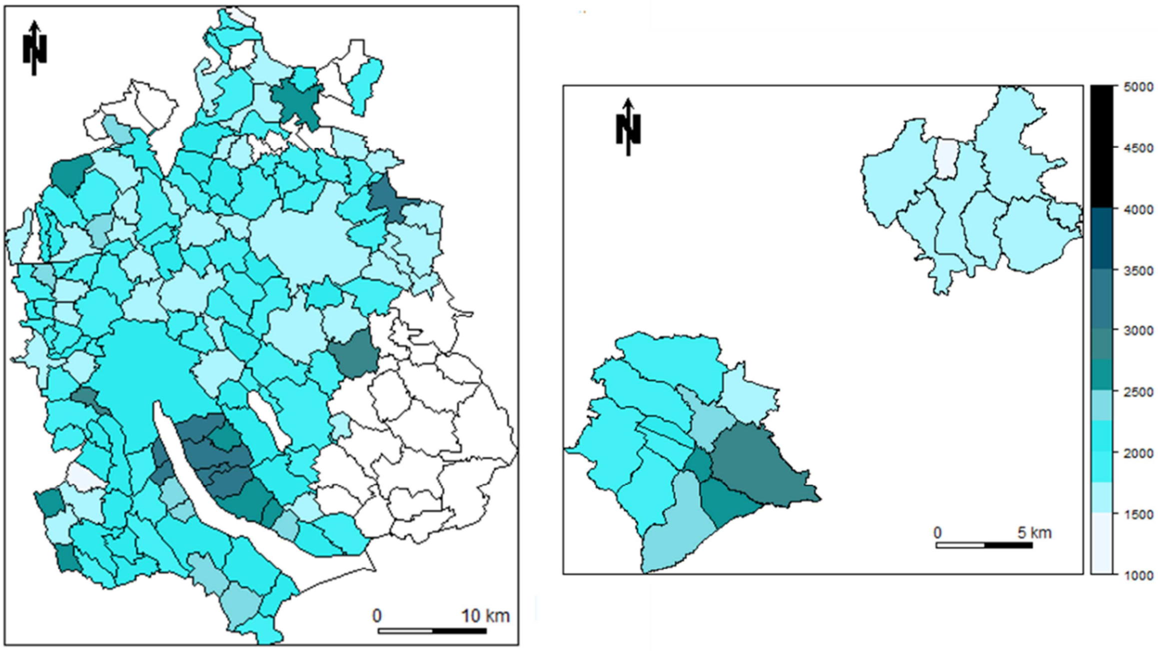
Figure 18 Distribution of the monthly gross rent [CHF] per dwelling unit



Data source: web based housing advertisements (2009-2013)

The spatial pattern of the average monthly gross rent (Figure 19) shows that the majority of the municipalities of Canton Zurich, the cities of Zurich and Winterthur included, have values ranging between 1’500 and 2’200 CHF/month. However, there is a hotspot situated in the vicinity of Zurich, along the lake. Especially the municipalities of the “Gold Coast” (District Meilen) show higher gross rental prices than the rest of the Canton, with average values ranging between 3’500 and 4’000 CHF per month. The city of Winterthur shows a quite uniform spatial pattern, with average rental prices of 1’750 CHF per month, or less. Concerning the city of Zurich, the Quarters situated downtown and on the shore of the lake clearly show higher average gross rent values than the rest of the city, which is not surprising.

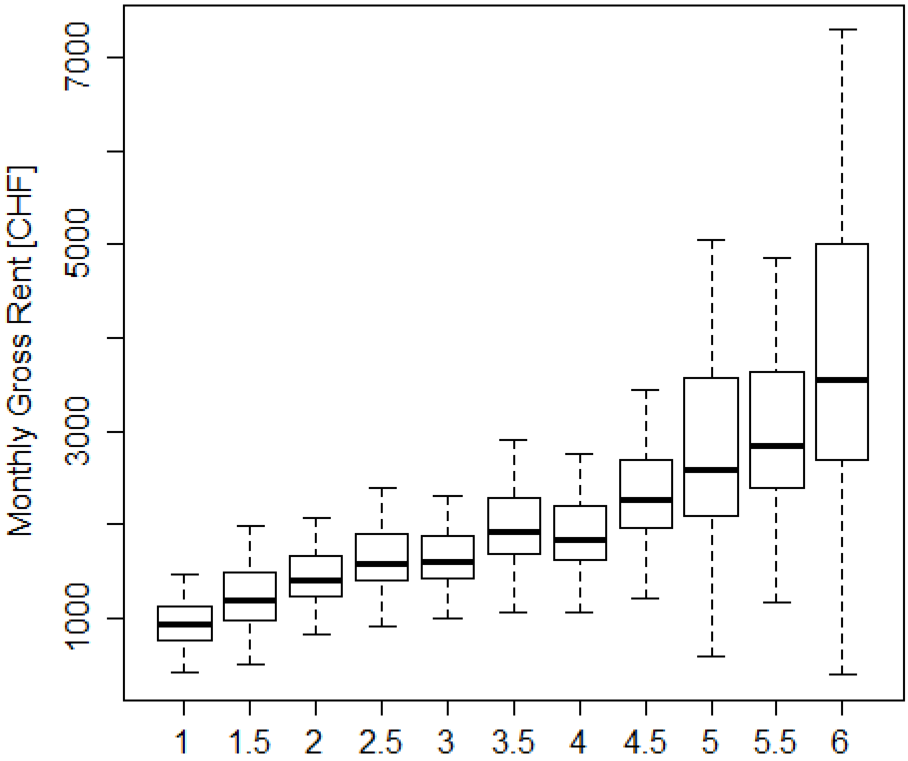
Figure 19 Average monthly gross rent [CHF] per dwelling unit and per municipality (left picture) respectively per Quarter (right picture)



Data source: web based housing advertisements (2009-2013)

Figure 20 describes the relation between the number of rooms of a rental unit and its monthly gross rent. It can be noticed, that this relation shows first a linear increase between 1 and 2.5 rooms, afterwards a slighter rent augmentation till a 4 rooms size and finally a higher increase than before till 6 rooms per apartment. Basically, this states that the used sample shows a positive, but non-linear, correlation between the number of rooms and the rental price, which makes actually sense. However, the comparison between Figure 15 and Figure 19 indicates that further local characteristics may greatly influence the rent level. For instance, the city of Winterthur shows a quite high average number of rooms but, in contrast, a low level of average rental prices.

Figure 20 Boxplots of the average monthly gross rent [CHF] in relation to the number of rooms of the dwelling unit

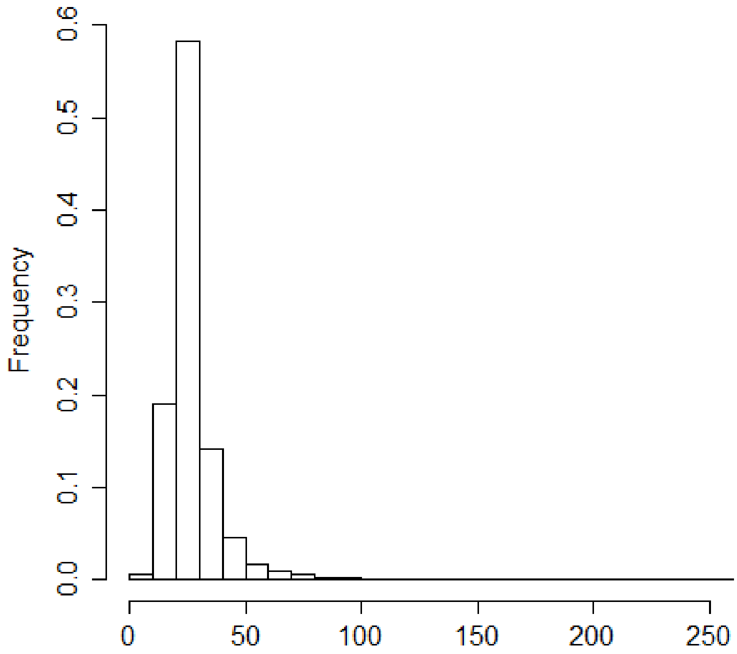


Data source: web based housing advertisements (2009-2013)

Monthly gross rent per m²

Figure 21 indicates that the most of the monthly gross rents per m^2 range between 10 and 50 CHF per m^2, with a proportion of about 60% between 30 and 40 CHF per m^2. Values higher than 50 CHF per m^2 are, for this dataset, really exceptional.

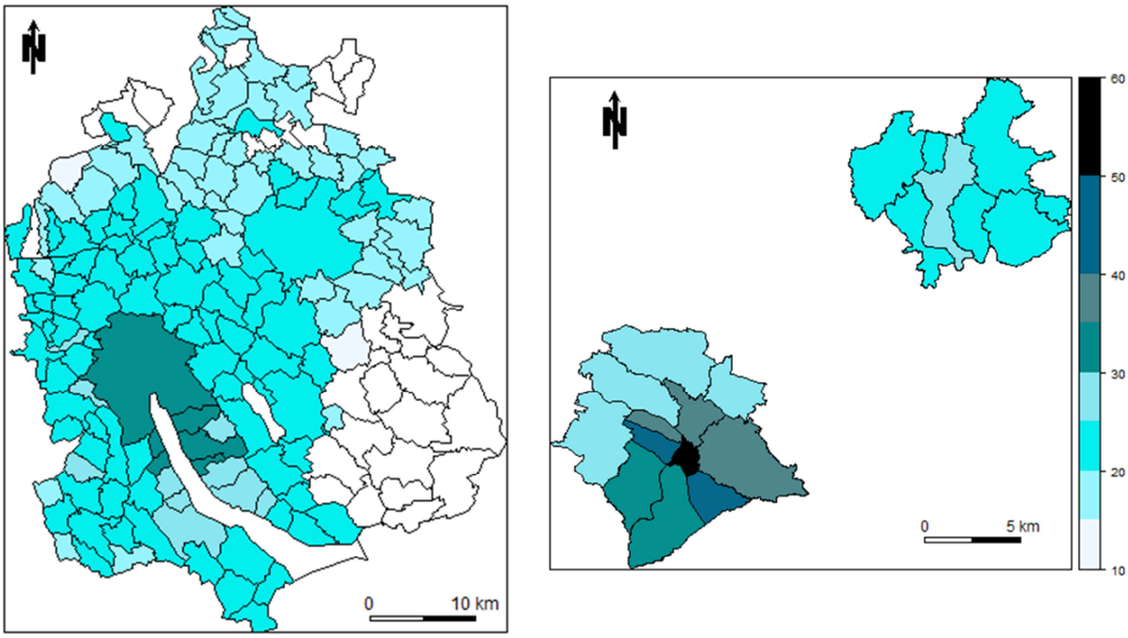
Figure 21 Distribution of the monthly gross rent per m^2 [CHF] and per dwelling unit



Data source: web based housing advertisements (2009-2013)

The spatial pattern for the gross rent per m^2 (Figure 22) slightly differs from the one for the monthly gross rent (Figure 19). In fact, we can observe that a majority of the municipalities of Canton Zurich shows average values ranging between 20 and 25 CHF per m^2. The municipalities situated in the North of the Canton diverge from this trend, having average monthly rents per m^2 of less than 20 CHF. In contrast, the municipalities lying on the shores of the Lake of Zurich, the city of Zurich included, show values that are above the cantonal average. This seems to indicate that the farer from the Lake and the city of Zurich the municipalities are situated, the lower are, in average, their monthly rental prices per m^2. This pattern (distance to Downtown Zurich and Lake) is also verified within the boundaries of the city of Zurich.

Figure 22 Average monthly gross rent per m² [CHF], per dwelling unit and per municipality (left picture) respectively per Quarter (right picture)



Data source: web based housing advertisements (2009-2013)

Further maps describing the change of the monthly gross rent, respectively of the monthly gross rent per m^2, are presented in the Annex A 2. The plotted values are calculated, for each municipality, in the following way:

$$Change[\%] = \frac{AverageRent_{2013} - AverageRent_{2009}}{AverageRent_{2009}} \cdot 100 \qquad (13)$$

4.3 Potentially relevant variables

Table 2 introduces the descriptive statistics of the potentially relevant variables that may be used for the hedonic modelling.

Table 2 Descriptive statistics of potentially relevant variables to model the relation between housing price and immigration level

Variable	Unit	Min	Mean	Median	Max	SE
Dependent Variable						
Rent	[CHF]	200.000	2'008.000	1'800.000	10'000.000	1'063.594
RentPerSQM	[CHF]	0.772	26.755	23.890	260.000	10.732
Building related explanatory variables						
Room	[-]	1.000	3.323	3.500	10.000	1.279
Living_Area	[m^2]	10.000	82.970	80.000	300.000	37.019
Story	[-]	0.000	1.720	2.000	20.000	1.486
Stories	[-]	1.000	4.495	4.000	43.000	2.308
Res_Units	[-]	1.000	10.920	8.000	155.000	11.066
Parcel_Size	[a]	0.034	4.169	1.600	1'713.162	11.115
Land_Value	[CHF/m^2]	220.600	1'083.400	841.000	2'203.100	477.293
Attic	[dummy]	0.000	-	-	1.000	-
Balcony	[dummy]	0.000	-	-	1.000	-
Fire	[dummy]	0.000	-	-	1.000	-
Garden	[dummy]	0.000	-	-	1.000	-
Terrace	[dummy]	0.000	-	-	1.000	-
Age1	[dummy]	0.000	-	-	1.000	-
Age2	[dummy]	0.000	-	-	1.000	-
Age3	[dummy]	0.000	-	-	1.000	-
Age4	[dummy]	0.000	-	-	1.000	-
Age5*	[dummy]	0.000	-	-	1.000	-
Resi_Perc	[%]	0.000	84.110	96.920	100.000	25.114
Retail_Perc	[%]	0.000	4.188	0.000	100.000	13.485
Office_Perc	[%]	0.000	5.781	0.000	100.000	15.564
Indus_Perc	[%]	0.000	4.636	0.000	100.000	13.837
Location related explanatory variables: structural						
Dist_Highway	[100 m]	0.164	19.537	15.850	95.407	13.123
Highway	[dummy]	0.000	-	-	1.000	-
Dist_Station	[100 m]	0.707	8.577	7.382	56.502	5.906
Acc_Car	[LN of acc. index]	7.825	9.977	10.017	10.720	0.330
Acc_PT	[LN of acc. index]	-18.590	11.460	11.640	12.900	1.335
Acc_Tot	[LN of acc. index]	8.607	11.752	11.827	12.989	0.703
Dis_School	[100 m]	0.020	3.870	3.430	19.830	2.388
Dis_Kindergarten	[100 m]	0.020	3.540	2.860	19.990	2.770
Dis_CBD_ZH	[100 m]	1.300	97.640	84.980	363.150	64.647
Dis_CBD_Winterthur	[100 m]	0.430	181.740	192.710	371.750	75.440
Slope	[degree]	0.000	3.558	2.561	32.602	3.378
Lake_View	[100 ha]	0.000	4.596	0.000	81.540	10.755
Lake_dummy	[dummy]	0.000	-	-	1.000	-
Sun_Eve	[-]	0.000	14.051	0.585	1'104.361	96.264

Univ	[%]	1.200	8.924	7.061	19.223	4.183
Owner	[%]	6.570	20.560	20.620	67.400	13.485
Location related explanatory variables: socio-economic						
H_300m	[ha^{-1}]	0.000	32.720	27.910	144.480	19.935
H1_300m	[ha^{-1}]	0.000	13.267	9.903	75.970	11.055
H2_300m	[ha^{-1}]	0.000	9.790	8.594	42.017	5.649
H3_300m	[ha^{-1}]	0.000	3.993	3.749	13.687	1.920
H4_300m	[ha^{-1}]	0.000	3.317	3.218	9.691	1.366
H5_300m	[ha^{-1}]	0.000	1.511	1.485	5.022	0.627
H6_300m	[ha^{-1}]	0.000	0.842	0.743	3.643	0.496
H_500m	[ha^{-1}]	0.000	28.750	24.090	126.390	18.529
H1_500m	[ha^{-1}]	0.000	8.878	5.006	90.721	11.206
H2_500m	[ha^{-1}]	0.000	6.785	5.564	31.424	5.237
H3_500m	[ha^{-1}]	0.000	2.249	2.001	10.746	1.492
H4_500m	[ha^{-1}]	0.000	2.110	2.012	8.395	1.141
H5_500m	[ha^{-1}]	0.000	0.856	0.779	3.808	0.558
H6_500m	[ha^{-1}]	0.000	0.327	0.229	3.031	0.404
H_01km	[ha^{-1}]	0.029	17.943	14.451	75.303	13.495
H_05km	[ha^{-1}]	0.000	24.310	20.270	108.030	16.605
Pop_300m	[ha^{-1}]	0.000	64.150	57.050	259.810	36.761
Pop_500m	[ha^{-1}]	0.000	50.500	44.310	197.120	30.700
Children_500	[ha^{-1}]	0.000	11.522	11.064	30.329	4.914
Foreigners_500	[ha^{-1}]	0.000	15.200	12.060	71.720	11.670
Swiss_500	[ha^{-1}]	0.000	35.410	31.420	127.180	20.000
Retail_300m	[100 WP]	0.000	0.748	0.240	41.920	2.046
Retail_1000m	[100 WP]	0.000	5.929	2.523	93.283	11.835
Hotel_300m	[100 WP]	0.000	0.783	0.200	25.763	1.918
Hotel_1000m	[100 WP]	0.000	5.505	1.363	108.980	12.736
Perc_Foreigners	[%]	4.326	28.358	29.073	59.595	7.912
Perc_Schengen	[%]	2.765	17.943	18.266	33.740	4.426
Perc_NW	[%]	1.382	9.771	9.781	18.589	3.030
Perc_SE	[%]	0.327	8.172	8.225	26.307	3.038
Perc_OutSchengen	[%]	0.166	10.414	10.943	30.065	4.527
Year_2009*	[dummy]	0.000	-	-	1.000	-
Year_2010	[dummy]	0.000	-	-	1.000	-
Year_2011	[dummy]	0.000	-	-	1.000	-
Year_2012	[dummy]	0.000	-	-	1.000	-
Year_2013	[dummy]	0.000	-	-	1.000	-

*Base value

5 Hedonic regression

This chapter first introduces the estimation of the global hedonic models and, subsequently, of the SAR models. Among others, justifications for the exclusion of some variables are provided. Then, the results of both OLS and SAR models are introduced and described.

5.1 Model estimation

This section presents the process applied for the estimation of the global and of the SAR models.

5.1.1 Global models

Two main groups of models have been estimated, according to the independent variable. The aim of the first group is to describe the natural logarithm of the monthly gross rent, while the second group has to explain the monthly gross rent per m^2. Furthermore, both groups are separated into three further types, according to which foreigner category is included into the model. Finally, there are 6 different regression models, which are estimated in the context of this thesis. The relevant variables of these six model types are introduced in the following subsections. The model numbers 1 to 3 concern the independent variable *Ln(Rent)* and the numbers 4 to 6 the variable *RentPerSqm*.

OLS models 1 to 3 (Rent)

Table 3 introduces the relevant variables for the OLS models 1 to 3, after the exclusion of several explaining variables because of statistical insignificance or correlation with other significant variables (Table 17 to Table 24). Numbers in brackets specify for variables, which are only included in some of the three models, to which model they belong. The share of university graduates cannot, for instance, be included together with the proportion of foreigners coming from Northwestern Schengen countries, because of high correlation existing between these two variables (Table 23). The same problem occurs between the proportion of citizens coming from countries of the Southern/Eastern Schengen zone and the ones coming from outside of the Schengen zone.

Concerning the structural characteristics of the building, the variable *Balcony* has been excluded because of the peculiar relation it shows with *Ln(Rent)* and *RentPerSqm*, within the used dataset. Indeed, according to the housing dataset, the presence of a balcony would be related with a lower rental price, which is not intuitive (Figure 37 and Figure 38). It has been tried to find an explanation to this relation (for instance a higher presence of balcony in apartments of smaller sizes), but without any success. Thus, this variable has been removed to avoid the modeling of misleading effects.

About the structural part of the spatial explanatory variables, the distance to Zurich (*Dist_CBD_ZH*) has been removed because of its correlation with several foreigner categories and with the highly statistically significant *Acc_Tot* variable (Table 21). However, the distance to Winterthur (*Dist_CBD_Winterthur*) has been excluded because of statistical insignificance. To account for the effect of the view on a lake on the rental prices level, the dummy variable *Lake_dummy* has been preferred to the visible lake's area *Lake_View*. This approach is among others motivated by the fact, that about 75% of the observations do not have any view on a lake.

Concerning the socio-economic explanatory variables, the variable *Pop_300m* is preferred to the variable *Foreigners_500m* in order to account for the total population's density in the vicinity of the unit. Indeed, both variables cannot be used at the same time in the regression model because of high correlation existing among them (Table 21). It has to be noticed, that *Foreigners_300m* has a deflationary effect on the rent level. However, this explanatory variable shows higher values for smaller rental units, which are traditionally related with lower rents and is overrepresented into the sample (Section 4.2.2). Always because of correlation issues with the variable *Pop_300m*, the whole set of variables concerning households densities cannot not be integrated into the models (Table 20). The correlation between *Retail_300m* and *Hotel_300m* prevents as well their combined use. The variable *Hotel_300m* is preferred because of its higher influence on the explained variable, for a similar statistical significance level. Finally, the integration of the dummy variables *Year_2010*, *Year_2011*, *Year_2012* and *Year_2013* is motivated by the need of taking the effects of the business cycle on the rental prices into account.

Table 3 Description of the relevant variables for the OLS Models 1, 2 and 3

Variable	Description	Unit
Dependent Variable		
Ln(Rent)	Monthly gross rent	[CHF]
Building related explanatory variables: structural		
Room	Number of rooms	[-]
Story	Story	[-]
Stories	Number of building stories	[-]
Attic	Dwelling unit is an attic	[dummy]
Garden	Dwelling unit has a garden	[dummy]
Terrace	Dwelling unit has a terrace	[dummy]
Age1	Constructed till 1930	[dummy]
Age2	Constructed between 1931 and 1950	[dummy]
Age3	Constructed between 1971 and 1990	[dummy]
Age4	Constructed since 1991	[dummy]
Spatial explanatory variables: structural		
Dist_Highway	Distance to highway ramp (as the crow flies)	[100 m]
Highway	Highway within a 100 m radius	[dummy]
Dist_Station	Distance to railway station (as the crow flies)	[100 m]
Acc_Tot	Sum of Acc_Car and Acc_PT	[LN of acc. index]
Slope	Land slope	[degree]
Lake_dummy	Dwelling unit has lake visibility	[dummy]
Ln(Sun_Eve)	Evening solar exposure index	[-]
Spatial explanatory variables: socio-economic		
Univ *(2) (3)*	Share of universitary graduates	[%]
Pop_300m	Population density within a 300 m radius	[ha^{-1}]
Hotel_300m	Number of working places in hotels/restaurants in a 300 m radius	[100 WP]
Perc_Foreigners *(3)*	Proportion of foreigners (F.) in municipality	
Perc_Schengen *(2)*	Proportion of Schengen F. in municipality	[%]
Perc_NW *(1)*	Proportion of Northwestern Schengen F. in municipality	[%]
Perc_SE *(1)*	Proportion of South/Eastern Schengen F. in municipality	[%]
Perc_OutSchengen *(2)*	Proportion of Outside Schengen F. in municipality	[%]
Year_10	Observation from 2010	[dummy]
Year_11	Observation from 2011	[dummy]
Year_12	Observation from 2012	[dummy]
Year_13	Observation from 2013	[dummy]

() Model number

OLS models 4 to 6 (RentPerSQM)

The estimation of the OLS models 4 to 6 mainly relies on the methodology applied for the previous models group. The only changes are the exclusions of the variables *Garden* and *Stories* because of statistical insignificance issues (Table 4).

Table 4 Description of the relevant variables for the OLS Models 4, 5 and 6

Variable	Description	Unit
Dependent Variable		
RentPerSqm	Monthly gross rent per m^2	[CHF]
Building related explanatory variables: structural		
Room	Number of rooms	[-]
Story	Story	[-]
Attic	Dwelling unit is an attic	[dummy]
Terrace	Dwelling unit has a terrace	[dummy]
Age1	Constructed till 1930	[dummy]
Age2	Constructed between 1931 and 1950	[dummy]
Age3	Constructed between 1971 and 1990	[dummy]
Age4	Constructed since 1991	[dummy]
Spatial explanatory variables: structural		
Dist_Highway	Distance to highway ramp (as the crow flies)	[100 m]
Highway	Highway within a 100 m radius	[dummy]
Dist_Station	Distance to railway station (as the crow flies)	[100 m]
Acc_Tot	Sum of Acc_Car and Acc_PT	[LN of acc. index]
Slope	Land slope	[degree]
Lake_dummy	Dwelling unit has lake visibility	[dummy]
Ln(Sun_Eve)	Evening solar exposure index	[-]
Spatial explanatory variables: socio-economic		
Univ *(5) (6)*	Share of universitary graduates	[%]
Pop_300m	Population density within a 300 m radius	[ha^{-1}]
Hotel_300m	Number of working places in hotels/restaurants in a 300 m radius	[100 WP]
Perc_Foreigners *(6)*	Proportion of foreigners (F.) in municipality	
Perc_Schengen *(5)*	Proportion of Schengen F. in municipality	[%]
Perc_NW *(4)*	Proportion of Northwestern Schengen F. in municipality	[%]
Perc_SE *(4)*	Proportion of South/Eastern Schengen F. in municipality	[%]
Perc_OutSchengen *(5)*	Proportion of Outside Schengen F. in municipality	[%]
Year_10	Observation from 2010	[dummy]
Year_11	Observation from 2011	[dummy]
Year_12	Observation from 2012	[dummy]
Year_13	Observation from 2013	[dummy]

() Model number

5.1.2 SAR models

The Moran's I statistics values for the residuals of the global models indicate that a slight, but very significant, positive spatial autocorrelation exists among the data (Table 5). Thus, the use of SAR methodology should, in the present case, lead to an improvement of the model reliability. The three following SAR model types have been tested in the context of this study:

the SAR*lag*, the SAR*error* and the SAR*mix* (also called Durbin model). Unfortunately, the computing of SAC models has not been successful because of the large dataset.

Table 5 Moran's I statistics for the residuals of the global OLS models 1 to 6*

Model	I Statistic	P-Value
1	0.0589	< 2.2e-16
2	0.0570	< 2.2e-16
3	0.0571	< 2.2e-16
4	0.0572	< 2.2e-16
5	0.0574	< 2.2e-16
6	0.0578	< 2.2e-16

* computed with a k-nearest weighting matrix using 10 neighbors and distance decay

There are several approaches that can apply when building a neighboring weighting matrix for computing SAR models. In this thesis, the k-nearest method has been elected. This means that we choose a fix number of neighboring points, whose potential influence on the observation point is taken into account during the model estimation. Only the data of the same year have been taken into account when computing the matrix. Several numbers of neighbors have been tested, ranging from 3 to 10. The models using 10 neighbors show, for all analyzed regressions, the best quality regarding the value of the adjusted R^2. Furthermore, a distance decay for the influence of the neighbors has been integrated into the weighting matrix. Indeed, the 10 neighbors are usually not distributed uniformly around the observation point and some neighbors may be situated a few meters around, while other ones are several kilometers away (especially in the countryside). Thus, this approach corrects the influence of a neighbor, according to the inverse of its distance to the analyzed observation point:

$$Factor_{reduction} = \frac{1}{Distance[in\ meters]} \qquad (14)$$

To solve the issue of a distance of 0 m between two observation points, a factor of 0.1 was computed, which corresponds in reality to a distance of 10 m. Including a distance decay when estimating the neighboring weighting matrix leads, in this context, to an improvement of the model's quality regarding the adjusted-R^2 value. Thus, all the SAR models that are presented in this study are computed with 10 nearest neighbors, whose weight was corrected by a reduction factor based on the distance as the crow flies to the observation point.

In order to account for spatial heterogeneity issues, it would have been desirable to also estimate GWR models. However, considering the large computing effort that would have been needed in addition to the tight timing, the realization of this extension has had, unfortunately, to be abandoned.

5.2 Regression results

This section presents the results of the global OLS models as well as the results of the SAR models.

5.2.1 Global models

The results of the global models are presented in the two further subsections, according to which independent variable they describe.

OLS models 1 to 3 (Rent)

Table 6 introduces the coefficient estimates of the model 2 with their statistics. The model shows an adjusted R^2-value of 0.6573, which means that about 65% of the variation of the dependent variable *Ln(Rent)* is explained by the variations of the model variables. It can be noticed that the great majority of the parameter estimates have high statistical significance. For the variables *Dist_Highway* and *Stories*, the statistical significance is a bit reduced according with p-values of 0.009, respectively 0.025, but remains notable. In contrast, one variable of the dummy series for catching the business cycle effects (*Year_10*) is less significant (p-value of 0.097).

The two further models of the first group are presented in the Annex (Table 25 and Table 26). They show similar values as the ones presented below. However, some differences can be observed for the variable *Dist_Highway* (positive in the OLS model 1) and for the set of dummy variables, which account for the business cycle variations (*Year_10*, etc.).

Table 7 summarizes the coefficient values and statistics for the variables that describe the foreigner groups. Furthermore, the coefficient estimates are interpreted in terms of effect (with units) on the dependent variable.

Table 6 Description of the global OLS model 2

Variable	Coefficient	SE	p-value
Intercept	5.78100	0.01632	< 2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22890	0.00046	< 2E-16
Story	0.01626	0.00040	< 2E-16
Stories	0.00064	0.00029	0.025
Attic	0.16520	0.00358	< 2E-16
Garden	0.02735	0.00234	< 2E-16
Terrace	0.11520	0.00272	< 2E-16
Age1	0.14810	0.00189	< 2E-16
Age2	0.08608	0.00185	< 2E-16
Age3	0.05136	0.00141	< 2E-16
Age4	0.20080	0.00160	< 2E-16
Spatial explanatory variables: structural			
Dist_Highway	-0.00013	0.00005	0.009
Highway	-0.07014	0.00436	< 2E-16
Dist_Station	-0.00161	0.00010	< 2E-16
Acc_Tot	0.04432	0.00150	< 2E-16
Slope	0.00366	0.00019	< 2E-16
Lake_dummy	0.12440	0.00140	< 2E-16
Log(Sun_Eve)	0.00541	0.00023	< 2E-16
Spatial explanatory variables: socio-economic			
Univ	0.02063	0.00027	< 2E-16
Pop_300m	-0.00025	0.00002	< 2E-16
Hotel_300m	0.02646	0.00034	< 2E-16
Perc_Schengen	0.00640	0.00025	< 2E-16
Perc_OutSchengen	0.00110	0.00023	2.5E-06
Year_10	-0.00349	0.00210	0.097
Year_11	0.00773	0.00198	9.5E-05
Year_12	0.02980	0.00198	< 2E-16
Year_13	0.02942	0.00205	< 2E-16

Adjusted R^2 = 0.6573

AIC = -2084.6

Table 7 Coefficient estimates of the foreigner groups variables with their statistical values for the OLS models 1 to 3

Variable	Model number	Estimate	SE	p-value	Effect*
Perc_Foreigners	3	0.00362	0.00009	<2E-16	0.36%
Perc_Schengen	2	0.00640	0.00025	<2E-16	0.64%
Perc_NW	1	0.02641	0.00027	<2E-16	2.64%
Perc_SE	1	-0.00172	0.00020	<2E-16	-0.17%
Perc_OutSchegen	2	0.00110	0.00023	2.5E-06	0.11%

*Effect on the dependent variable [in %] of a 1-% point change of the explanatory variable

OLS models 4 to 6 (RentPerSQM)

The coefficient estimates and statistics shown in Table 8 are similar to the values that are computed for the models 4 and 6 (Table 27 and Table 28). They are also mostly consistent with the estimates of the models 1 to 3. However, we may notice the deflationary effect of the variable *Room* on the rental price per m^2, which is, in contrast, inflationary for the dependent variable monthly gross rent. Also, for all the three models 4 to 6, the variable *Dist_Highway* has a positive effect on the explained variable. Furthermore, it can be observed that one of the building's age category (*Age3*) is statistically insignificant for all the three OLS models discussed in this subsection. When looking to the adjusted R^2- indicator of the model 5, it can be noticed that it is of poorer explanatory quality than the model 2 (Table 6). The coefficient estimates concerning the foreigner categories, as well as their main statistical values, are presented in Table 9. Although the majority of the estimates are consistent with the results of the previous models group (Table 7), the citizens coming from countries situated outside of the Schengen are, for the present model group, seem to have a deflationary effect on the rental prices.

Table 8 Description of the global OLS model 5

Variable	Coefficient	SE	p-value
Intercept	11.24498	0.59249	< 2E-16
Dependent variable			
RentPerSQM			
Building related explanatory variables: structural			
Room	-2.76378	0.01693	< 2E-16
Story	0.17275	0.01335	< 2E-16
Attic	3.19652	0.12598	< 2E-16
Terrace	1.03825	0.09649	< 2E-16
Age1	5.19411	0.06982	< 2E-16
Age2	0.67426	0.06783	< 2E-16
Age3	-0.03568	0.05094	0.484
Age4	1.36821	0.05656	< 2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.00397	0.00185	0.032
Highway	-2.64801	0.16338	< 2E-16
Dist_Station	-0.04048	0.00361	< 2E-16
Acc_Tot	1.10988	0.05441	< 2E-16
Slope	0.11448	0.00679	< 2E-16
Lake_dummy	2.99778	0.05056	< 2E-16
Log(Sun_Eve)	0.13868	0.00831	< 2E-16
Spatial explanatory variables: socio-economic			
Univ	0.44386	0.00957	< 2E-16
Pop_300m	0.02351	0.00065	< 2E-16
Hotel_300m	1.35822	0.01255	< 2E-16
Perc_Schengen	0.15772	0.00908	< 2E-16
Perc_OutSchengen	-0.03156	0.00845	1.87E-04
Year_10	-0.10333	0.07706	0.180
Year_11	0.33564	0.07226	3.41E-06
Year_12	1.03811	0.07210	< 2E-16
Year_13	0.67304	0.07451	< 2E-16

Adjusted R^2 = 0.4361

AIC = 1'351'100.0

Table 9 Coefficient estimates of the foreigner groups variables with their statistical values for the OLS models 4 to 6

Variable	Model number	Estimate	SE	p-value	Effect*
Perc_Foreigners	6	0.05907	0.00333	<2E-16	0.06
Perc_Schengen	5	0.15772	0.00908	<2E-16	0.16
Perc_NW	4	0.61154	0.00955	<2E-16	0.60
Perc_SE	4	-0.08762	0.00720	<2E-16	-0.09
Perc_OutSchegen	5	-0.03156	0.00845	1.87E-04	-0.03

*Effect on the dependent variable [in CHF/(month·m^2)] of a 1-% point change of the explanatory variable

5.2.2 SAR models

The results of the SAR models are presented in the two further subsections, according to which independent variable they describe.

SAR models 1 to 3 (Rent)

In order to estimate the improvement of the model's quality when using SAR models rather than OLS, the Akaike Information Criterions (AIC) of the different models are computed. As a reminder: a smaller AIC value means a better model quality. However, the interpretation of the AIC has to be relative: the greater the difference between the OLS model and its SAR version, the greater the quality improvement. Table 10 summarizes the differences between the criterion of the OLS and the criterion of the SAR models. First, it can be observed that all the SAR models lead to an improvement of the model's quality in comparison to the traditional OLS models. However, the SAR*error* and SAR*mix* models show systematically a greater improvement than the SAR*lag* model. Nevertheless, the estimated SAR*mix* models are, in this special case, related with missing computed statistical values for the lagged variables (Table 34 to Table 36). This issue may raise some concerns with respect to the reliability of the models outcome. For this reason, this subsection focusses on the results of the SAR*error* models, which seem to be the more accurate and stable SAR models in the present context. The results of the SAR*lag* (Table 29 to Table 31) and SAR*mix* (Table 34 to Table 36) models can be consulted in the Annex A 3.

Table 10 Difference between the AIC value of the OLS regressions and of the various types of SAR regressions*

Type	Model number		
	1	2	3
SAR*lag*	1605.1	1458.8	1485.5
SAR*error*	3365.1	3140.1	3145.8
SAR*mix*	3485.2	2991.2	3006.2

*The values correspond to (AIC_{OLS} - AIC_{SAR})

Table 11 introduces the coefficient estimates for the SAR*error* model 2. We can observe that the values computed by the SAR*error* model are consistent with the ones computed by the OLS regression (Table 6). The only differences to note concern the business cycle dummy variables (e.g. the positive and statistically significant coefficient estimate of *Year_10*). Also for the variables describing the foreigner groups (Table 12), only very slight variations of the estimates, in comparison to the OLS values, can be observed. The autoregression coefficient *Lambda* is, according to its p-value, very significant and shows a non-negligible value of 0.251.

Table 11 Description of the SAR*error* model 2

Variable	Coefficient	SE	p-value
Intercept	5.75340	0.01675	< 2.2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22834	0.00046	< 2.2E-16
Story	0.01632	0.00040	< 2.2E-16
Stories	0.00072	0.00029	0.012
Attic	0.16680	0.00356	< 2.2E-16
Garden	0.02774	0.00233	< 2.2E-16
Terrace	0.11456	0.00271	< 2.2E-16
Age1	0.14656	0.00190	< 2.2E-16
Age2	0.08443	0.00185	< 2.2E-16
Age3	0.05130	0.00143	< 2.2E-16
Age4	0.19894	0.00161	< 2.2E-16
Spatial explanatory variables: structural			
Dist_Highway	-0.00005	0.00005	0.390
Highway	-0.07149	0.00441	< 2.2E-16
Dist_Station	-0.00150	0.00010	< 2.2E-16
Acc_Tot	0.04632	0.00154	< 2.2E-16
Slope	0.00362	0.00019	< 2.2E-16
Lake_dummy	0.12317	0.00143	< 2.2E-16
Log(Sun_Eve)	0.00528	0.00024	< 2.2E-16
Spatial explanatory variables: socio-economic			
Univ	0.02042	0.00027	< 2.2E-16
Pop_300m	-0.00024	0.00002	< 2.2E-16
Hotel_300m	0.02605	0.00034	< 2.2E-16
Perc_Schengen	0.00630	0.00026	< 2.2E-16
Perc_OutSchengen	0.00099	0.00024	3.20E-05
Year_10	0.00558	0.00208	0.007
Year_11	0.01529	0.00205	9.28E-14
Year_12	0.03794	0.00208	< 2.2E-16
Year_13	0.03755	0.00217	< 2.2E-16

Lambda = 0.25102 (p-value = <2.22E-16)

AIC_{Error} = -5224.7

AIC_{OLS} = -2084.6

ΔAIC = 3140.1

Table 12 Coefficient estimates of the foreigner groups variables with their statistical values for the SAR*error* models 1 to 3

Variable	Model number	Estimate	SE	p-value	Effect*
Perc_Foreigners	3	0.00353	0.00010	<2.2E-16	0.35%
Perc_Schengen	2	0.00630	0.00026	<2.2E-16	0.63%
Perc_NW	1	0.02613	0.00028	<2.2E-16	2.61%
Perc_SE	1	-0.00191	0.00021	<2.2E-16	-0.19%
Perc_OutSchegen	2	0.00099	0.00024	3.2E-05	0.10%

*Effect on the dependent variable [in %] of a 1-% point change of the explanatory variable

SAR models 4 to 6 (RentPerSQM)

Because the creation of the models 4 to 6 relies on the experience gained by computing the models 1 to 3, the estimation of the SAR models 4 to 6 has been restricted to the best SAR*error* model type with a neighboring weighting matrix based on 10 nearest neighbors and distance decay.

Table 13 presents the results of the SAR*error* model 5. As mentioned for the models 1 to 3, the spatial autoregressive regression results are consistent with the ones of the OLS global regression (Table 8), except for the business cycle variables, which show major changes in term of coefficient size (e.g. variable *Year_11*). Concerning the variables of the foreigner groups (Table 14), there are also no significant changes that can be observed in comparison to the global OLS models (Table 9). Like for the SAR*error* model 2 (Table 11), the autoregression coefficient *Lambda* is highly significant. Its value of 0.259 is close to the one of SAR*error* model 2.

Table 13 Description of the SAR*error* model 5

Variable	Coefficient	SE	p-value
Intercept	10.35034	0.60768	< 2.2E-16
Dependent variable			
RentPerSQM			
Building related explanatory variables: structural			
Room	-2.79690	0.01692	< 2.2E-16
Story	0.16649	0.01332	< 2.2E-16
Attic	3.20179	0.12515	< 2.2E-16
Terrace	1.10002	0.09615	< 2.2E-16
Age1	5.24741	0.07014	< 2.2E-16
Age2	0.71132	0.06821	< 2.2E-16
Age3	-0.02763	0.05144	0.591
Age4	1.36360	0.05716	< 2.2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.00343	0.00190	0.072
Highway	-2.64899	0.16506	< 2.2E-16
Dist_Station	-0.03843	0.00368	< 2.2E-16
Acc_Tot	1.14031	0.05564	< 2.2E-16
Slope	0.09768	0.00689	< 2.2E-16
Lake_dummy	2.86583	0.05174	< 2.2E-16
Log(Sun_Eve)	0.12935	0.00851	< 2.2E-16
Spatial explanatory variables: socio-economic			
Univ	0.45719	0.00981	< 2.2E-16
Pop_300m	0.02337	0.00066	< 2.2E-16
Hotel_300m	1.31771	0.01252	< 2.2E-16
Perc_Schengen	0.14496	0.00931	< 2.2E-16
Perc_OutSchengen	-0.02453	0.00868	0.005
Year_10	0.87097	0.07570	< 2.2E-16
Year_11	1.08449	0.07480	< 2.2E-16
Year_12	1.77458	0.07574	< 2.2E-16
Year_13	1.43924	0.07886	< 2.2E-16

Lambda = 0.25933 (p-value = <2.22E-16)

AIC_{Error} = 1'348'200.0

AIC_{OLS} = 1'351'100.0

ΔAIC = 2900.0

Table 14 Coefficient estimates of the foreigner groups variables with their statistical values for the SAR*error* models 4 to 6

Variable	Model number	Estimate	SE	p-value	Effect*
Perc_Foreigners	6	0.05674	0.00721	<2E-16	0.06
Perc_Schengen	5	0.14496	0.00931	<2.2E-16	0.14
Perc_NW	4	0.60755	0.00983	<2.2E-16	0.61
Perc_SE	4	-0.09913	0.00739	<2.2E-16	-0.10
Perc_OutSchegen	5	-0.02453	0.00868	0.005	-0.02

*Effect on the dependent variable [in CHF/(month·m^2)] of a 1-% point change of the explanatory variable

6 Discussion and conclusion

This chapter analyzes, first, the results of the computed regression models. Based on this analysis, conclusions are then drawn. Finally, advices for further research about this thematic are enounced.

6.1 Analysis of the results

This section analyses the results of the selected best model type, the SAR*error* with 10 nearest neighbors accounting for distance decay. Because of the different dependent variables they describe, the results of the models 1 to 3 are presented separately from the ones of the models 4 to 6. It has to be noticed, that all the statements concerning the interpretation of the coefficient estimates are made under *ceteris paribus* assumption.

Models 1 to 3 (Rent)

According to the results of the SAR*error* model 2 (Table 11), the variable *Room* has a great influence on the monthly gross rent, which is actually not surprising. Indeed, an additional room would be related, everything else being equal, with a 23% increase of the rental price. If the rental unit is an attic or owns a terrace, the rental price would be as well notably higher (+17% respectively +11%). The variable *Story* seems also to have an inflationary effect on the rent level (the higher in the building, the higher the rent). The coefficient estimates for the building age variables mean, that all the age categories integrated into the models show higher rental prices than the basis category *Age5* (Table 1). Considering its p-value, the variable *Dist_Highway* seems to be insignificant for the modeled relationships. Nevertheless, the SAR*error* model 1 computed a positive and highly significant estimate for this variable. This would mean, that the farer from a highway ramp a housing unit is located, the more expensive is its rent. Thus, it would indicate that the negative effects related to, for instance, the noise coming from the highway are of higher relevance than the greater accessibility by car. This assumption is supported by the negative sign of the coefficient estimate of *Highway*. About the importance of accessibility by public transportation, the coefficient estimate for *Dist_Station* shows, that the closer to a railway station the observation is located, the higher is its rental price. Indeed, each 100 m distance step would be related with a rent reduction of 0.15%. Logically, the accessibility indicator (*Acc_Tot*) is as well of positive sign, meaning that a greater accessibility is related with higher rental prices. Interesting is the notable effect of the view on a lake on the rent level (variable *Lake_dummy*). In fact, holding the other parameters fix, a view on a lake would lead to a 12% higher rental price. Considering the analysis of the housing data, which shows that the highest rents are mainly found around the Lake of Zurich (Figure 19), this effect is plausible. Considering the socio-economic variables, the variable *Univ* seems to be related with a non-negligible inflationary effect (about 2% of rent increase per 1% point change). This high influence has been already underlined by Fuhrer (2012, p. 55). The density variable *Pop_300m* shows, in contrast, a negative sign. This may be a bit surprising when looking the map of the rental prices per municipality in Canton Zurich (Figure 19). Indeed, we observe that, as a main trend, higher average rents are found in the densely built up areas of the agglomeration of Zurich. On the other hand, these are only aggregated values per municipality. Thus, at a microscale, it is possible that larger and more expensive rental units are found in the less densely populated zones. Interesting is also the estimated inflationary effect of the number of working places in restaurants and hotels situated in the vicinity of the unit (variable *Hotel_300m*). Indeed, 100 additional working places would be related with a 2.6% higher rental price. Considering that a leisure area with lots of cafés and restaurants would be very attractive to live in, this positive relation seems to be quite logical. The business cycle's variables are a bit more complicated to interpret. In fact, the size and the statistical significance of their estimates vary from a model to another, so that no obvious and stable effect on the rental prices level can be observed (Table 15). For a further study, the removal of these variables could be considered.

Table 15 Comparison of the parameter estimates of the business cycle's variables for the models 1 to 3

	Model 1			Model 2			Model 3		
Variable	Coefficient	SE	p-value	Coefficient	SE	p-value	Coefficient	SE	p-value
Year_10	-0.00603	0.00209	0.004	0.00558	0.00208	0.007	0.00727	0.00208	4.67E-04
Year_11	-0.00286	0.00207	0.167	0.01529	0.00205	9.28E-14	0.01888	0.00203	< 2.2E-16
Year_12	0.01620	0.00209	9.1E-15	0.03794	0.00208	< 2.2E-16	0.04332	0.00203	< 2.2E-16
Year_13	0.00936	0.00216	1.5E-05	0.03755	0.00217	< 2.2E-16	0.04556	0.00205	< 2.2E-16

Focusing now on the variables associated with the foreigner group (Table 12), it can be observed that all the tested categories are statistically very significant and that they all have an inflationary effect on the rental price, with the exception of the citizens coming from Southern/Eastern Schengen countries (slight deflationary effect of -0.19% per 1% point change of the population). Comparing the estimated effect of the foreigner group and the Schengen group together, it can be noticed that the citizens of the Schengen countries would lead to an almost two times greater percentage change of the rents than the aggregated group. Nevertheless, the greater inflationary effect is shown by the category Northwestern Schengen, with a 2.61% increase of the rental price in relation to a 1% point increase of this population. Taking into account the spatial distribution of this demographic group (mainly located in the expensive Lake of Zurich area), this fact is not surprising (Figure 8).

Models 4 to 6 (RentPerSQM)

In this subsection we mainly focus on the differences that exist between the previous models group (models 1 to 3) and this one. According to the results of the SAR*error* model 5 (Table 13), the building age category *Age3* is statistically insignificant. Nevertheless, the other categories are highly significant and show estimates signs that are consistent with the results of the SAR*error* model 2. The *Dist_Highway* variable shows for this model group a slightly improved significance and a positive estimate's sign, which is consistent with the results of the SAR*error* model 1 (Table 32). Like for the previous group, the *Lake_dummy* variable seems to have a quite high inflationary effect on the rental prices (an increase of 2.9 CHF/(m^2·month) for a view on a lake). In contrast to the model 1 to 3, the population density variable *Pop_300m* is, in this case, related with a rental price augmentation. However, this seems to be consistent with the spatial distribution of the average monthly rent per m^2 and per municipality in Canton Zurich (Figure 22). Indeed, the highest rent prices per m^2 are found in the city of Zurich and in its close vicinity (along the lake), which are densely populated zones. Finally, the variable that shows a completely different pattern than in the models 1 to 3 is the number of rooms. In fact, *Room* has a negative sign in the models 4 to 6. Nevertheless, it makes sense that, even if the gross rent is higher, the rental price per m^2 becomes smaller with a greater number of rooms, at least till a certain apartment size (Figure 39). This fact can be presented as a kind of *Economies of scale*.

The coefficient estimates of the variables that describe the foreigner categories show similar results, in terms of relative magnitude and sign, as the ones of the models 1 to 3, with the exception of the residents coming from outside of the Schengen zone (Table 14). Indeed, this variable shows, in the models 4 to 6, a slight negative effect of -0.02 CHF per month and per m^2 for a 1% point increase of this population. In the models 1 to 3, citizens coming from outside of Schengen have a slight positive effect of 0.1%. It is questionable, which of the two models group catches the effective relation. However, the higher R^2-value of the first group as well as the higher significance of the coefficient by using this type of model leads to a higher reliability of the positive coefficient estimate. However, the category Northwestern Schengen remains, in the model 4 to 6, by far the foreigner group related with the highest inflationary effect (0.61 CHF per m^2 and per month).

6.2 Knowledge gained

For both model groups that are estimated in the context of this thesis, the use of SAR methodology leads to a quality improvement. Furthermore, the k-nearest method, combined with an influence reduction based on the distance to the observation point, seems to be a suitable approach for constructing the neighboring weighting matrix that is used to estimate the SAR models. Hence, the SAR*error* model with 10 nearest neighbors seems to be the most accurate and stable regression model for describing the dependent variables *Ln(Rent)* and *RentPerSQM*.

The differentiation of the foreigners into several groups, in order to estimate the effect of the foreigner proportion per municipality on the rental prices level, leads to very interesting results. Indeed, this approach indicates that different effects can be observed up to which category is analyzed, confirming the former assumption that the different foreigner groups do not influence the rents in the same extent. The group Northwestern Schengen is identified as being the category that shows, by far, the highest inflationary effect on both *Ln(Rent)* and *RentPerSQM*, e.g. +2.61% respectively +0.61 CHF/(month·m^2) for a 1% point increase of this population. Hence, it is the only foreigner group, which has been tested, that shows an inflationary value close to the 2.7% housing price increase stated by Degen and Fischer (2010, p. 4) for the Swiss real estate market. In fact, the other tested categories seem to affect the rents only very slightly. However, the citizens coming from the aggregated Schengen zone show an about two times higher inflationary effect than the aggregate foreigners category, e.g. +0.63% against +0.35%, respectively +0.14 against +0.06 CHF/(month·m^2). Nevertheless, the group Southern/Eastern Schengen is related with a negative coefficient estimate. Indeed, a 1% point increase of this population would lead to a rents decrease of 0.19% respectively of 0.10 CHF/(month·m^2). Finally, the effect of the immigrants coming from outside of the Schengen Zone is ambiguous. In fact, this foreigners category would lead to a slight increase of the monthly gross rent (+0.10% for a 1% point increase) but to a tiny reduction of the gross rental price per m^2 (-0.02 CHF/(month·m^2)). Nevertheless, the better fitting of the models describing the monthly gross rent variable (models 1 to 3) gives support to the thesis of the slight inflationary effect.

6.3 Restrictions and further research

The aim of this thesis, to quantify the effect of immigration on the rental prices, is only partially achieved because of the nature of the demographic data that are used. Indeed, only data that describe the percentages of foreigners per municipality, year and nationality were used. However, it is very likely that a certain proportion of this population actually concerns foreigners of the second or even third generation, which are born on the Swiss territory. Nevertheless, the Swiss Federal Statistical Office computes some data that allow the separation of the immigrants from the rest of the foreigners. Unfortunately, these data do not cover all the years of the present study.

Furthermore, demographic data covering a smaller scale than the municipal one (for instance Quarter or smaller) would be desirable to model more accurately the effects of the foreigner groups on the rents level. Indeed, it is not really ideal to only have a foreigner percentage for a whole municipality, e.g. a great city like Zurich. In fact, the rental prices may vary over the municipality’s territory, like the foreigner proportion as well. Some data could have been used for the city of Zurich in order to get the foreigner proportion per nationality and per Quarter, but these also do not cover the whole time period described by the present study.

In addition, rental data that are used in this study are only asking prices of the open market. These values may differ from the effective transaction rents and take into account only new rentals, as mentioned in Section 4.2.2. Thus, it would be desirable to rather use effective rental data in the context of this study, in order to describe properly the effect of immigration on rents. Nevertheless, the availability of such data may be an issue.

The estimation of GWR models would also be of great interest to account for the spatial heterogeneity of the data that are used. Indeed, as mentioned in Section 3.4, this issue may lead to the estimation of biased coefficients. Thus, computing GWR models could potentially lead to better model quality and to more reliable coefficient estimates.

Finally, it would make sense to study the motivation of the location choice for the different foreigner groups. Indeed, it would be interesting to know, which factors attract the most the citizens from, for instance, the Northwestern Schengen countries, so that these ones are living in majority along the Lake of Zurich. Furthermore, the average income level of each foreigner category that is tested should be estimated and taken into account. This enhanced approach may actually help a lot when building the regression model (choice of the variables) and also when interpreting the coefficient estimates.

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A 1 Demographic data

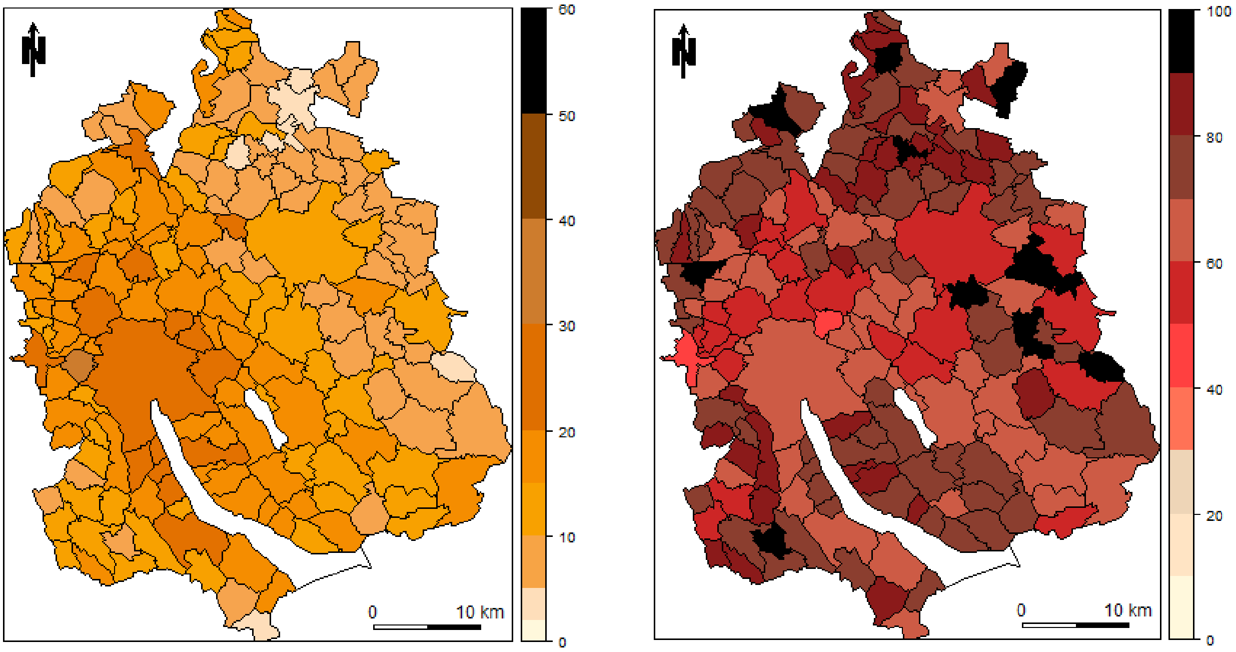
Foreigners groups

Table 16 Foreigner groups formed for the hedonic modeling with the respective nationalities they include

Country	Demographic Group Schengen (S.)	Northwestern S.	Southern/Eastern S.	Outside Schengen
Austria	X	X		
Belgium	X	X		
Cyprus	X		X	
Czech Republic	X		X	
Denmark	X	X		
Estland	X		X	
Finland	X	X		
France	X	X		
Germany	X	X		
Greece	X		X	
Hungary	X		X	
Iceland	X	X		
Ireland	X	X		
Italy	X		X	
Latvia	X		X	
Liechtenstein	X	X		
Lithuania	X		X	
Luxembourg	X	X		
Malta	X		X	
Norway	X	X		
Poland	X		X	
Portugal	X		X	
Slovakia	X		X	
Slovenia	X		X	
Spain	X		X	
Sweden	X	X		
The Netherlands	X	X		
United Kingdom	X	X		
Other countries				X

Constitution of the foreign population in 2013

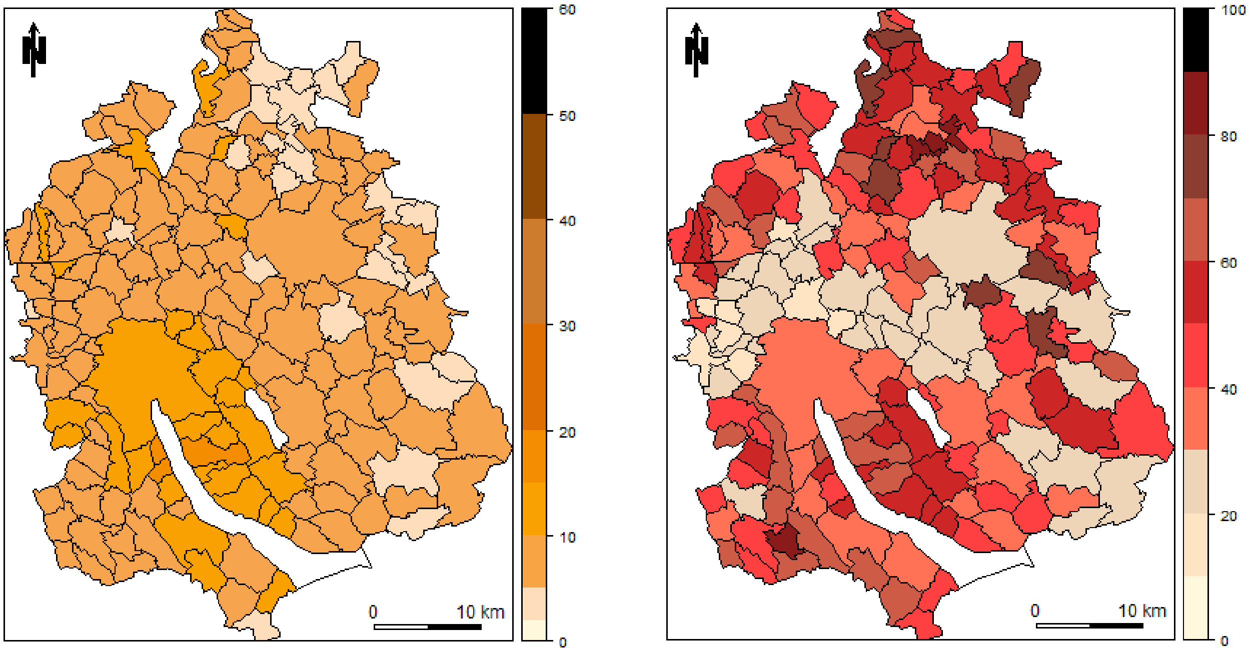
Figure 23 Percentage of Schengen countries citizens in relation to whole population (left picture) and to foreigners population (right picture) per municipality in Canton Zurich 2013



Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

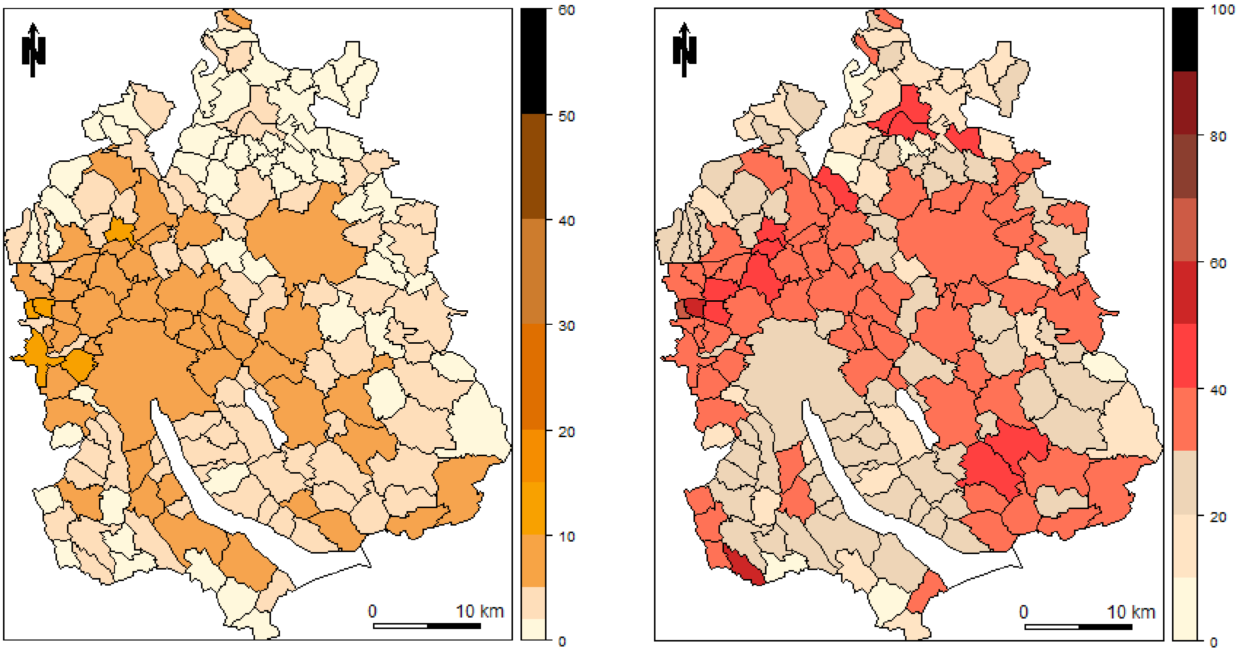
Figure 24 Percentage of Northwestern Schengen countries citizens in relation to whole population (left picture) and to foreigners population (right picture) per municipality in Canton Zurich 2013



Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

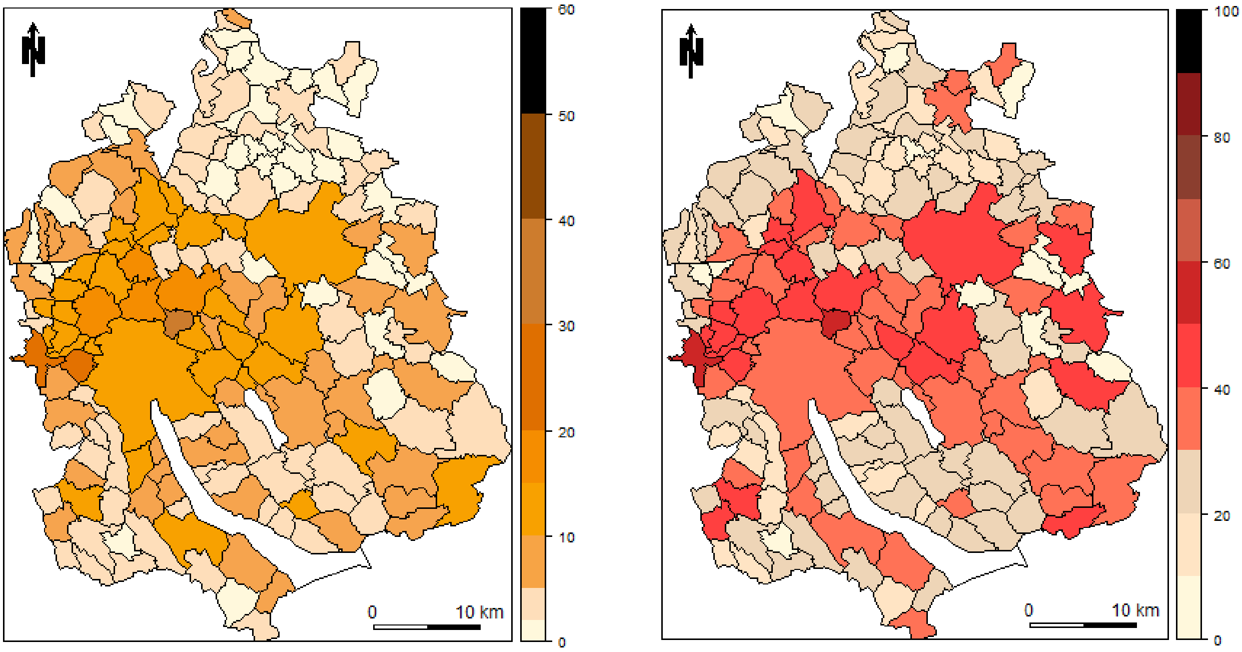
Figure 25 Percentage of Southern/Eastern Schengen countries citizens in relation to whole population (left picture) and to foreigners population (right picture) per municipality in Canton Zurich 2013



Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

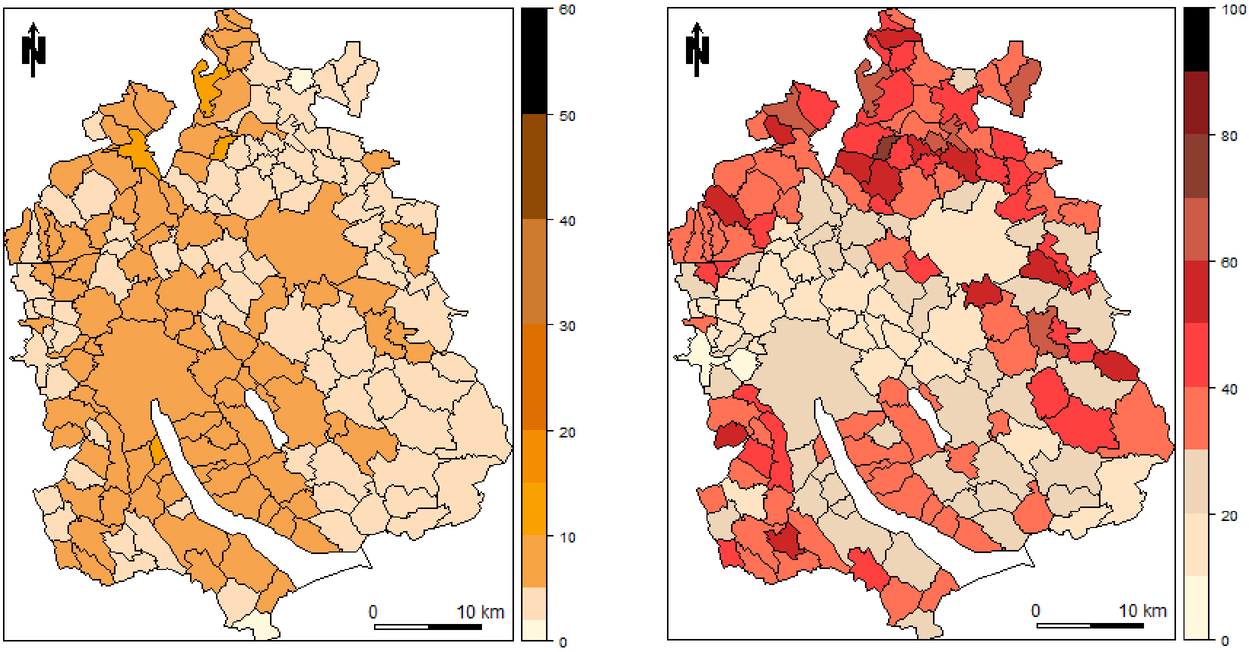
Figure 26	Percentage of outside of Schengen countries citizens in relation to whole population (left picture) and to foreigners population (right picture) per municipality in Canton Zurich 2013



Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

Figure 27 Percentage of German citizens in relation to whole population (left picture) and to foreigners population (right picture) per municipality in Canton Zurich 2013

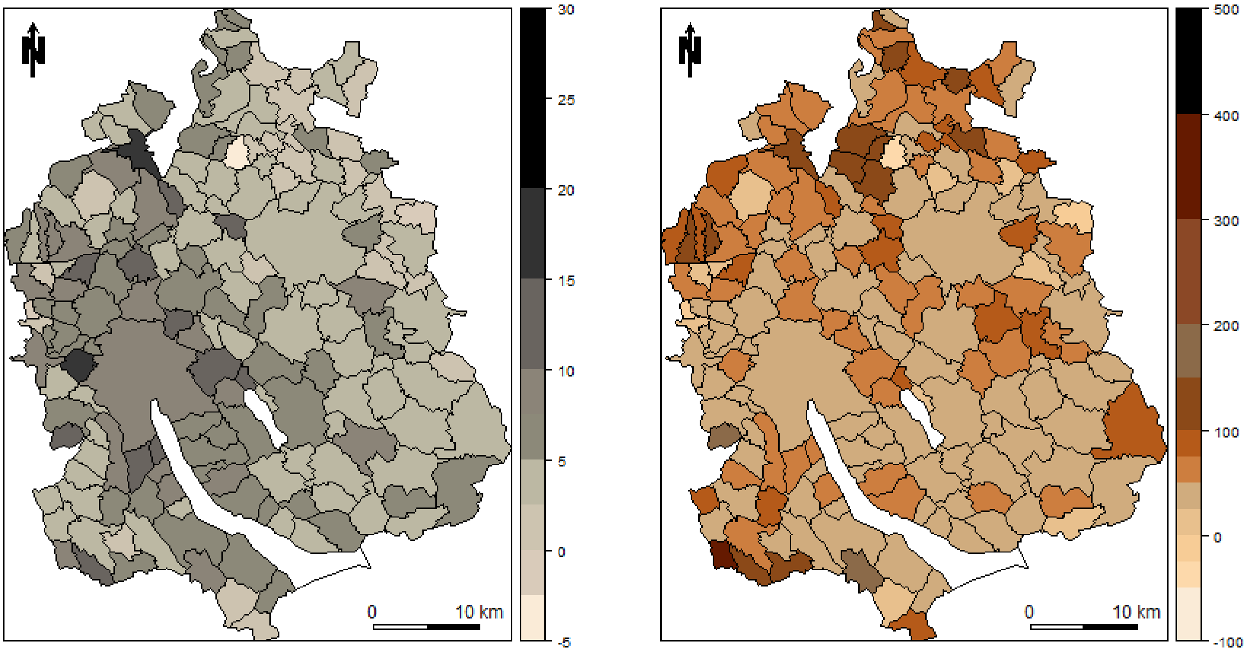


Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

Change of the population of the foreigner groups between 2006 and 2013

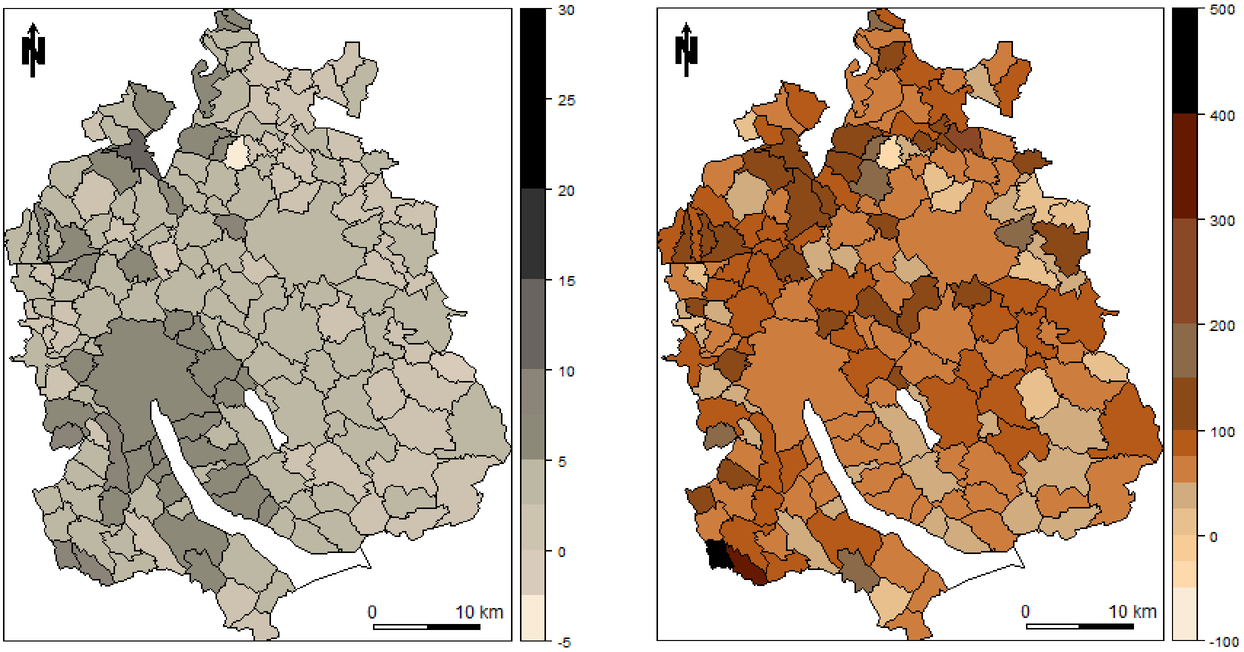
Figure 28 Percentage change of the population of citizens from Schengen countries compared to the whole population (left picture) and to the analyzed population itself (right picture) per municipality in Canton Zurich between 2006 and 2013



Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

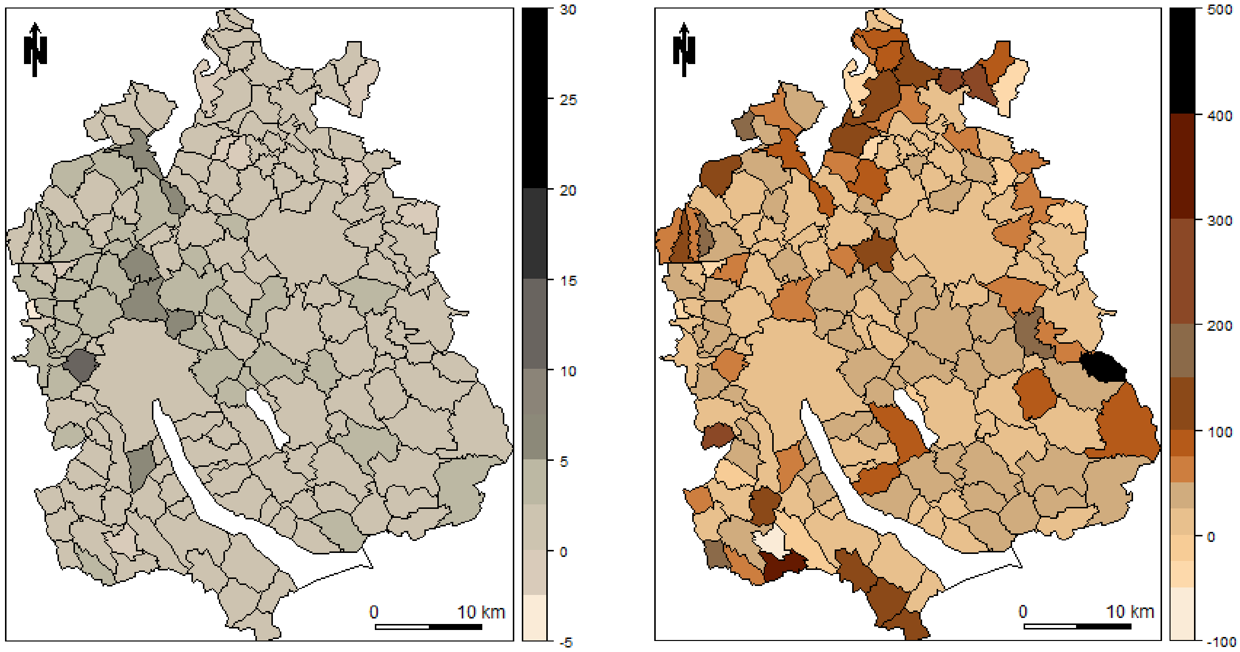
Figure 29 Percentage change of the population of citizens from Northwestern Schengen countries compared to the whole population (left picture) and to the analyzed population itself (right picture) per municipality in Canton Zurich between 2006 and 2013



Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

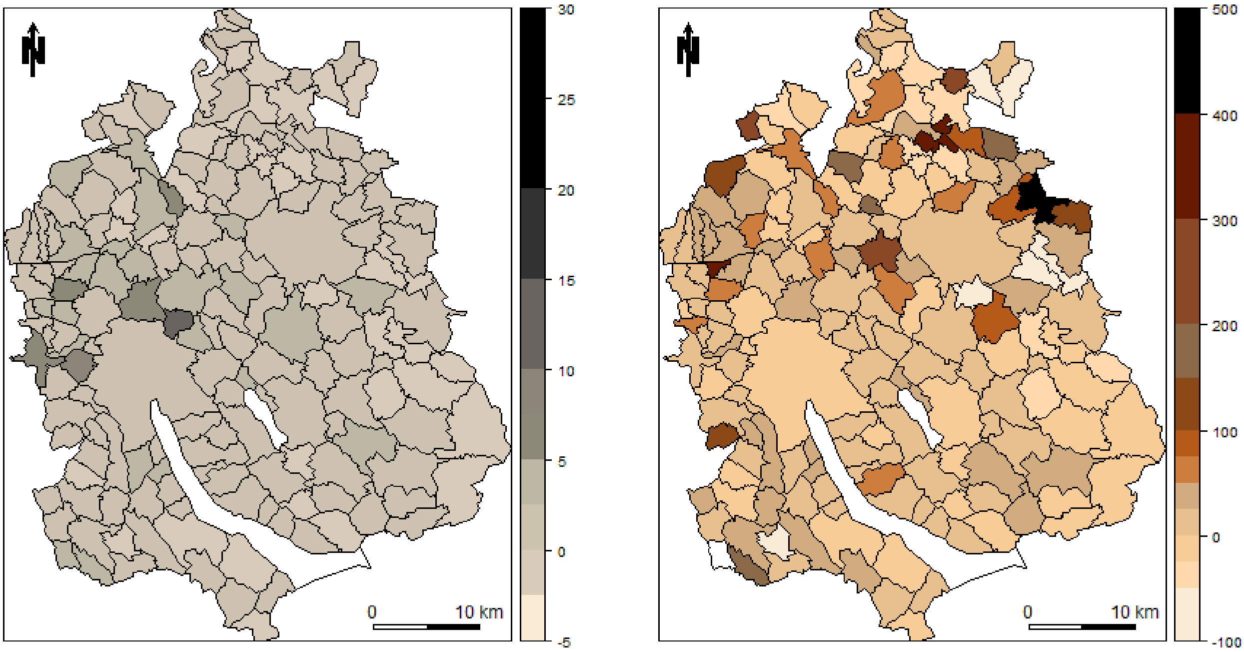
Figure 30 Percentage change of the population of citizens from Southern/Eastern Schengen countries compared to the whole population (left picture) and to the analyzed population itself (right picture) per municipality in Canton Zurich between 2006 and 2013



Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

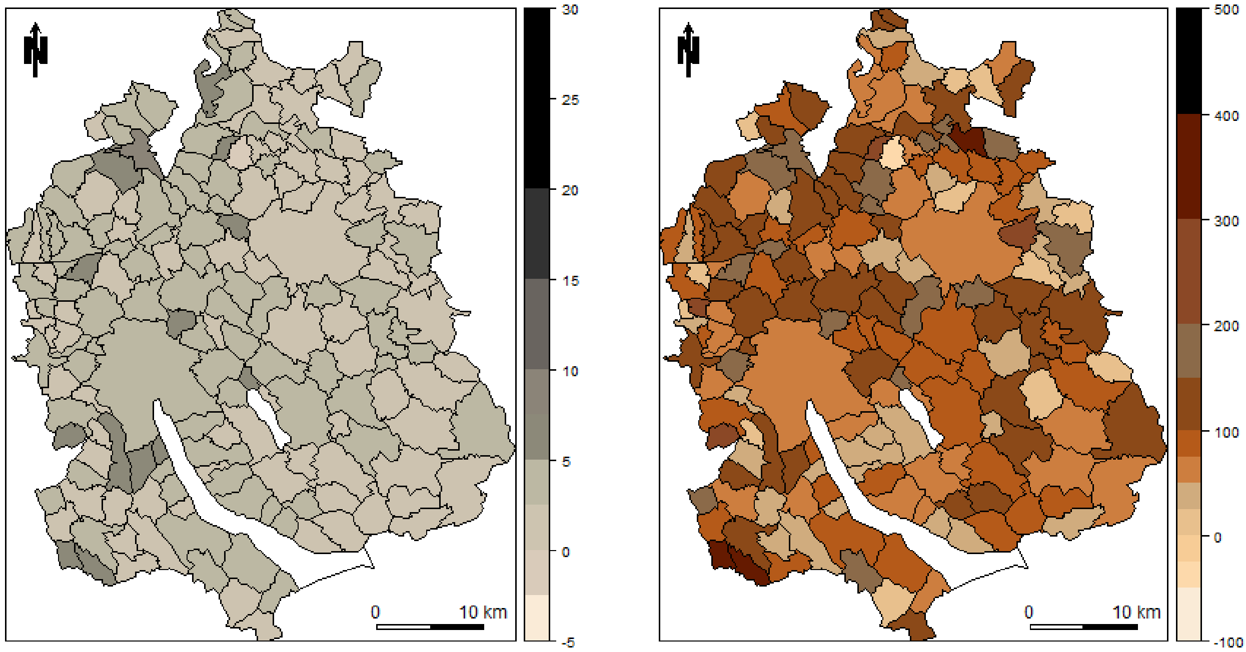
Figure 31 Percentage change of the population of citizens from countries outside of Schengen compared to the whole population (left picture) and to the analyzed population itself (right picture) per municipality in Canton Zurich between 2006 and 2013



Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

Figure 32 Percentage change of the population of citizens from Germany compared to the whole population (left picture) and to the analyzed population itself (right picture) per municipality in Canton Zurich between 2006 and 2013

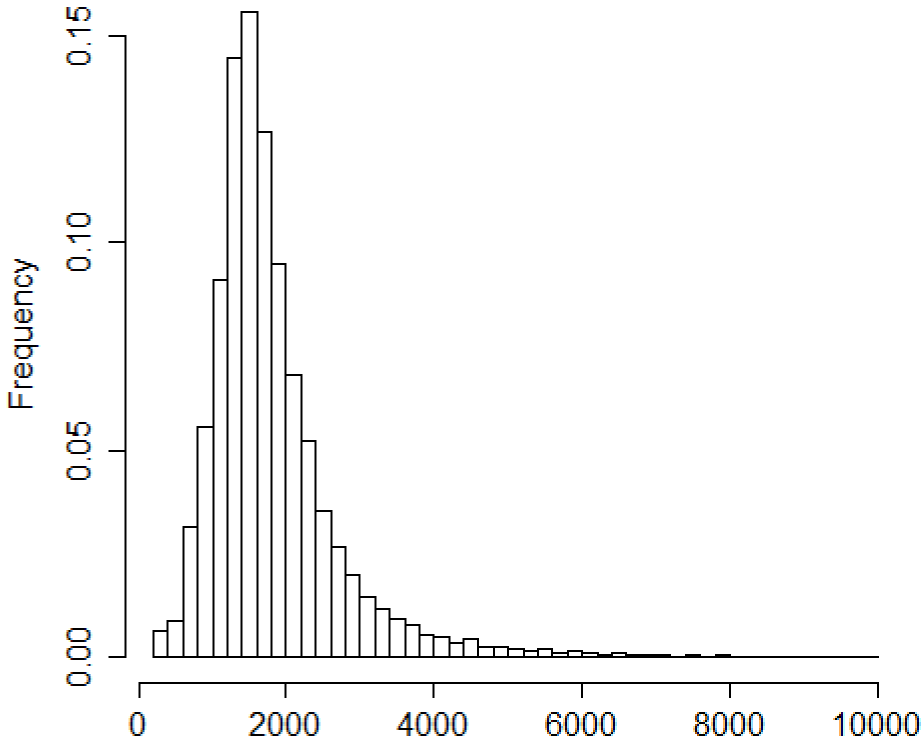


Data: Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Boundaries: Swiss Federal Statistical Office (2013).

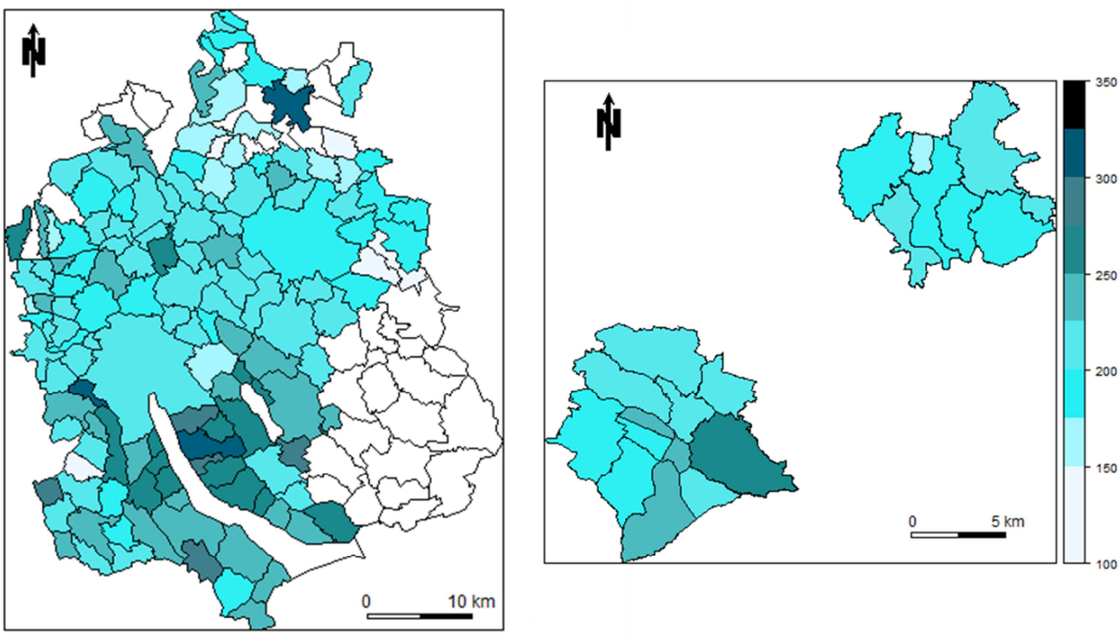
A 2 Housing data

Figure 33 Distribution of the monthly extra rent [CHF] per dwelling unit



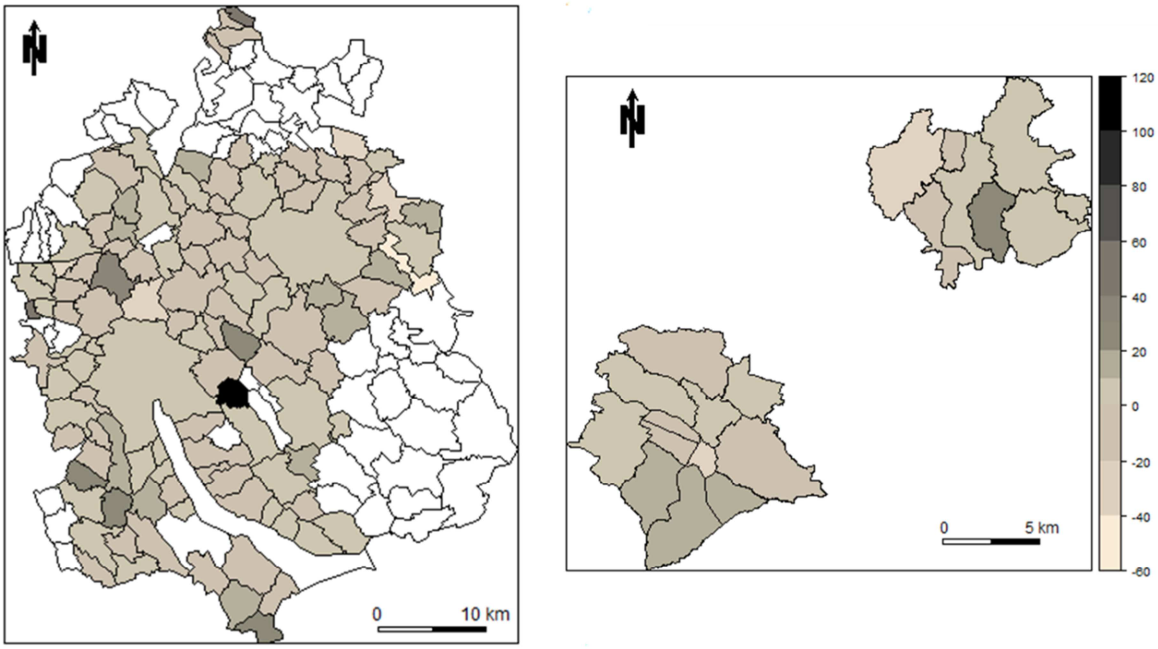
Data source: web based housing advertisements (2009-2013)

Figure 34 Average rental extra price per dwelling unit and per municipality (left picture) respectively per Quarter (right picture)



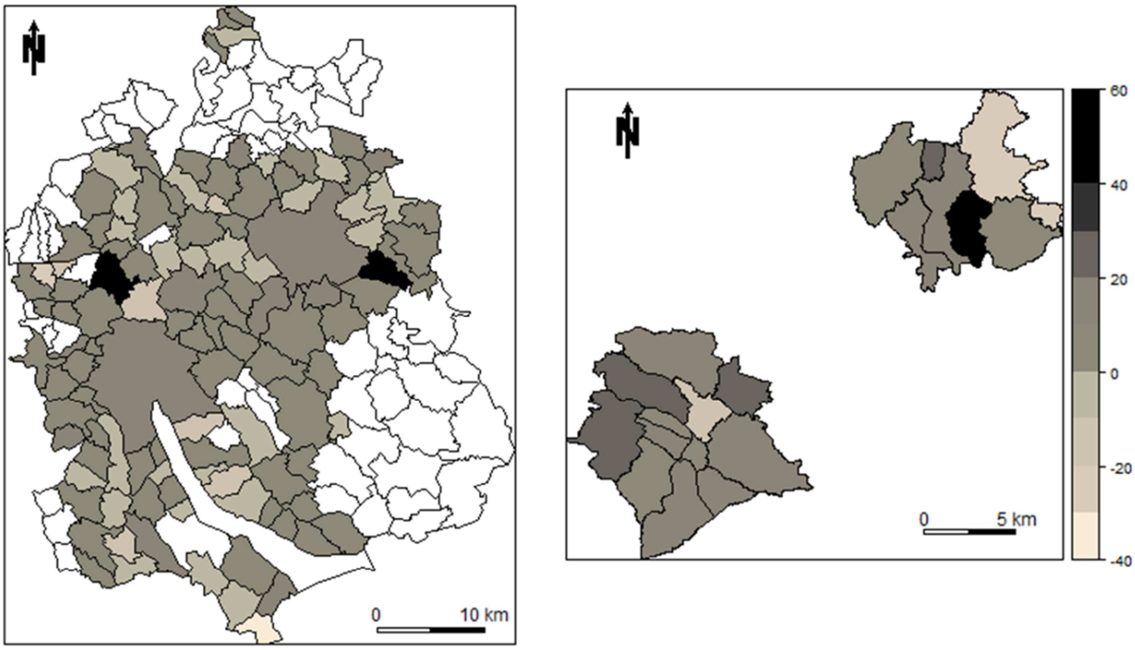
Data source: web based housing advertisements (2009-2013)

Figure 35 Percentage change of the average monthly gross rent per dwelling unit and per municipality (left picture) respectively per Quarter (right picture) between 2009 and 2013



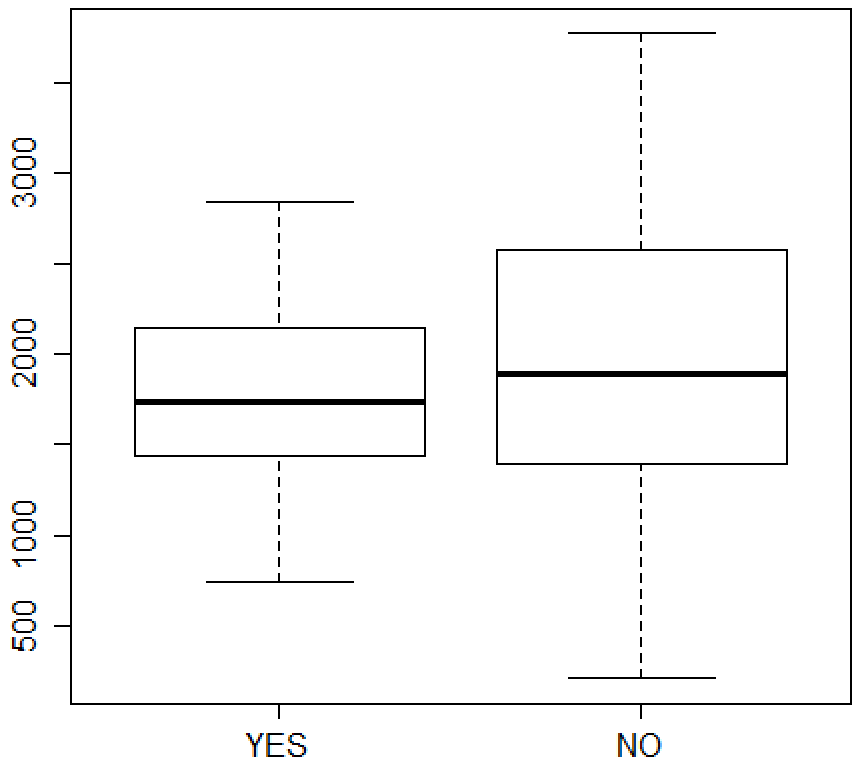
Data source: web based housing advertisements (2009-2013)

Figure 36 Percentage change of the average monthly gross rent per m², per dwelling unit and per municipality (left picture) respectively per Quarter (right picture) between 2009 and 2013



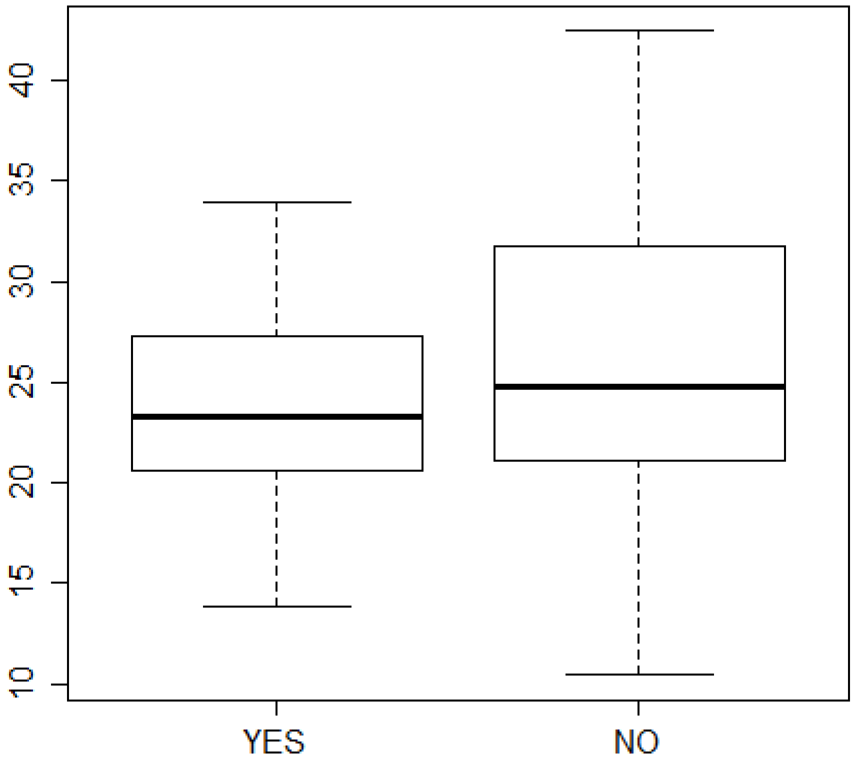
Data source: web based housing advertisements (2009-2013)

Figure 37 Boxplots of the monthly gross rent [CHF/month] with (YES) and without (NO) balcony



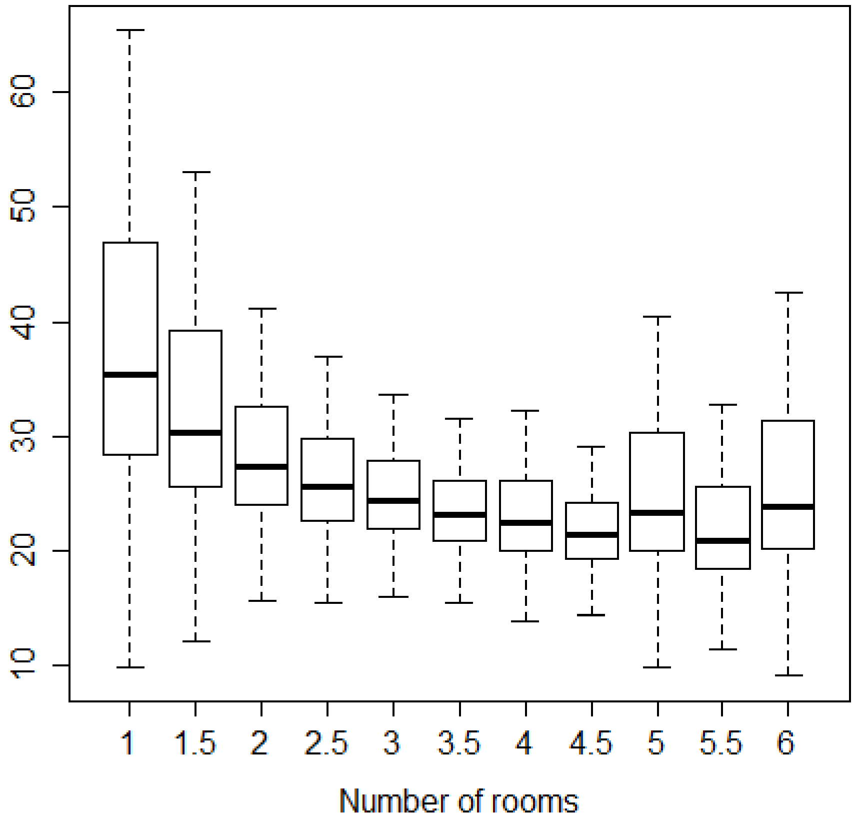
Data source: web based housing advertisements (2009-2013)

Figure 38 Boxplots of the monthly gross rent per m^2 [CHF/(month·m^2)] with (YES) and without (NO) balcony



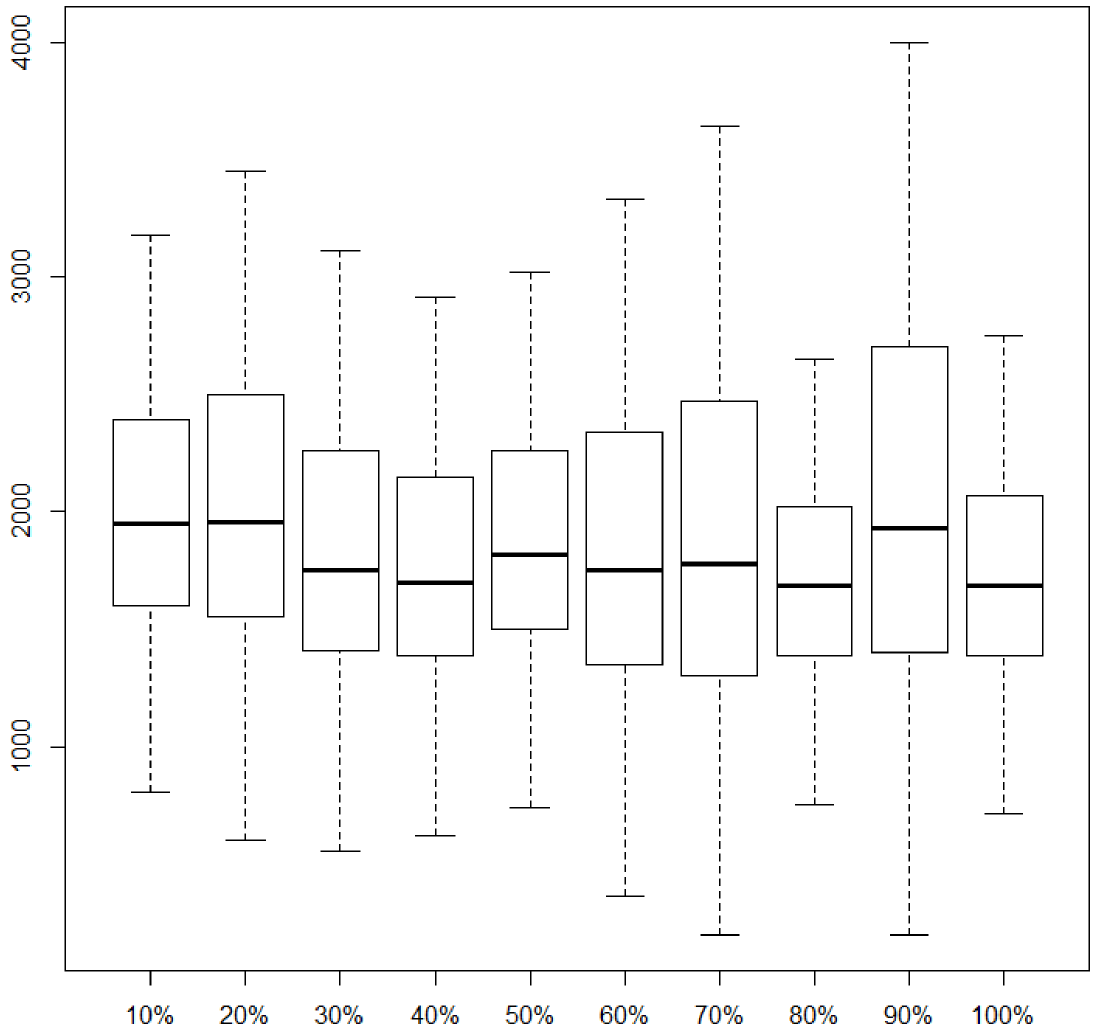
Data source: web based housing advertisements (2009-2013)

Figure 39 Boxplots of the monthly gross rent per m^2 [CHF/(month·m^2)] in relation to the number of rooms of the rental unit



Data source: web based housing advertisements (2009-2013)

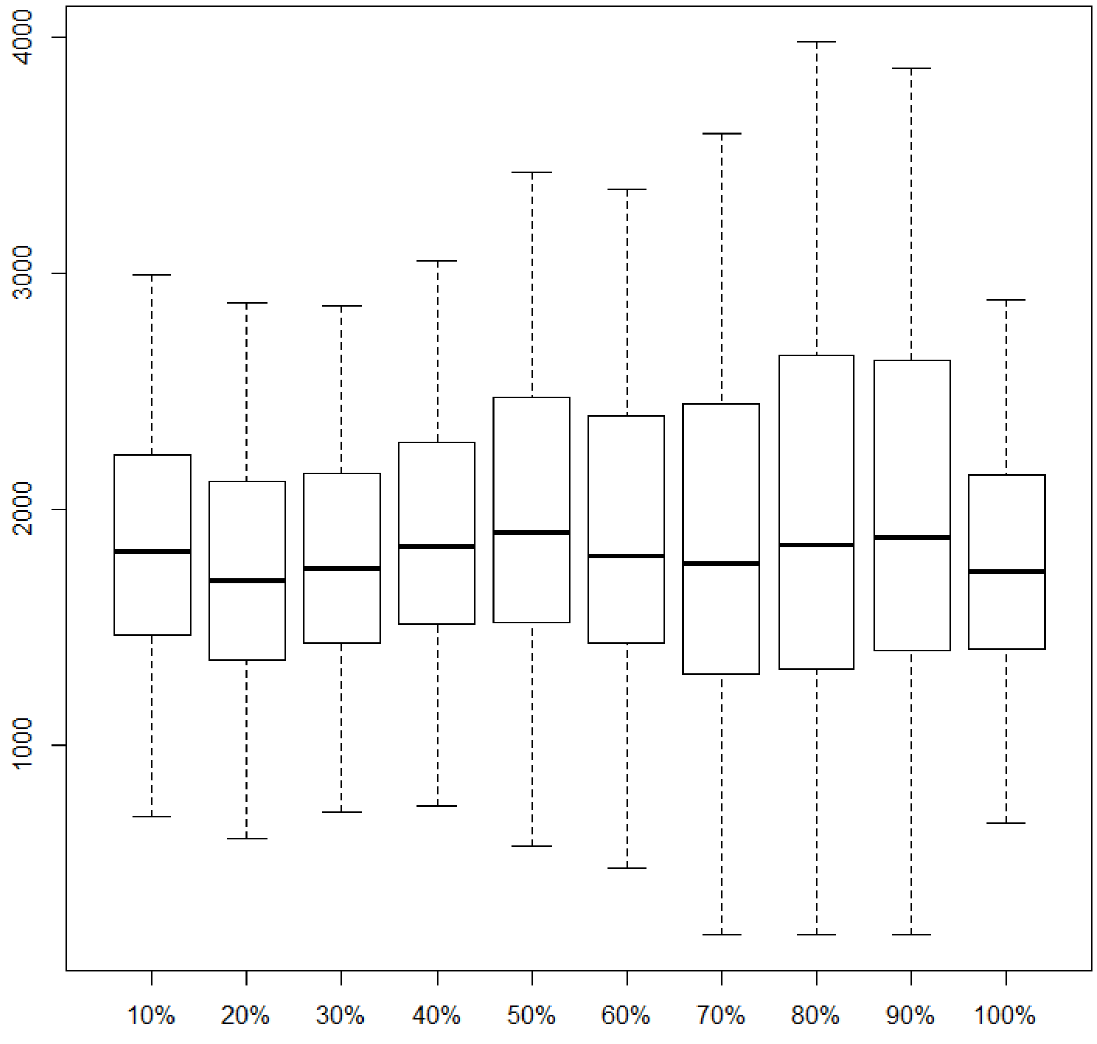
Figure 40 Boxplots of the monthly gross rent [CHF/month] according to the deciles of the proportion of foreigners in relation to whole municipal population



Data source: web based housing advertisements (2009-2013)

Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

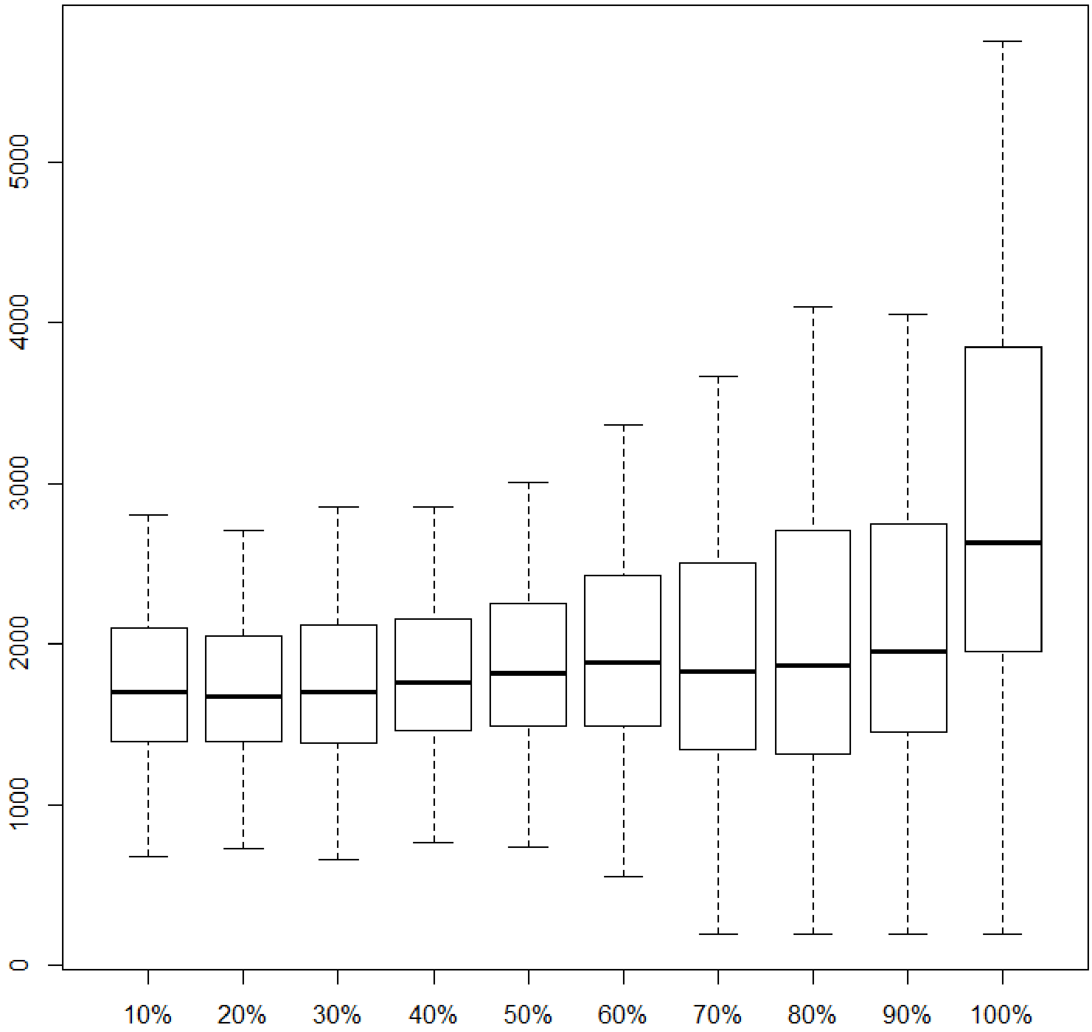
Figure 41 Boxplots of the monthly gross rent [CHF/month] according to the deciles of the proportion of Schengen countries citizens in relation to whole municipal population



Data source: web based housing advertisements (2009-2013)

Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

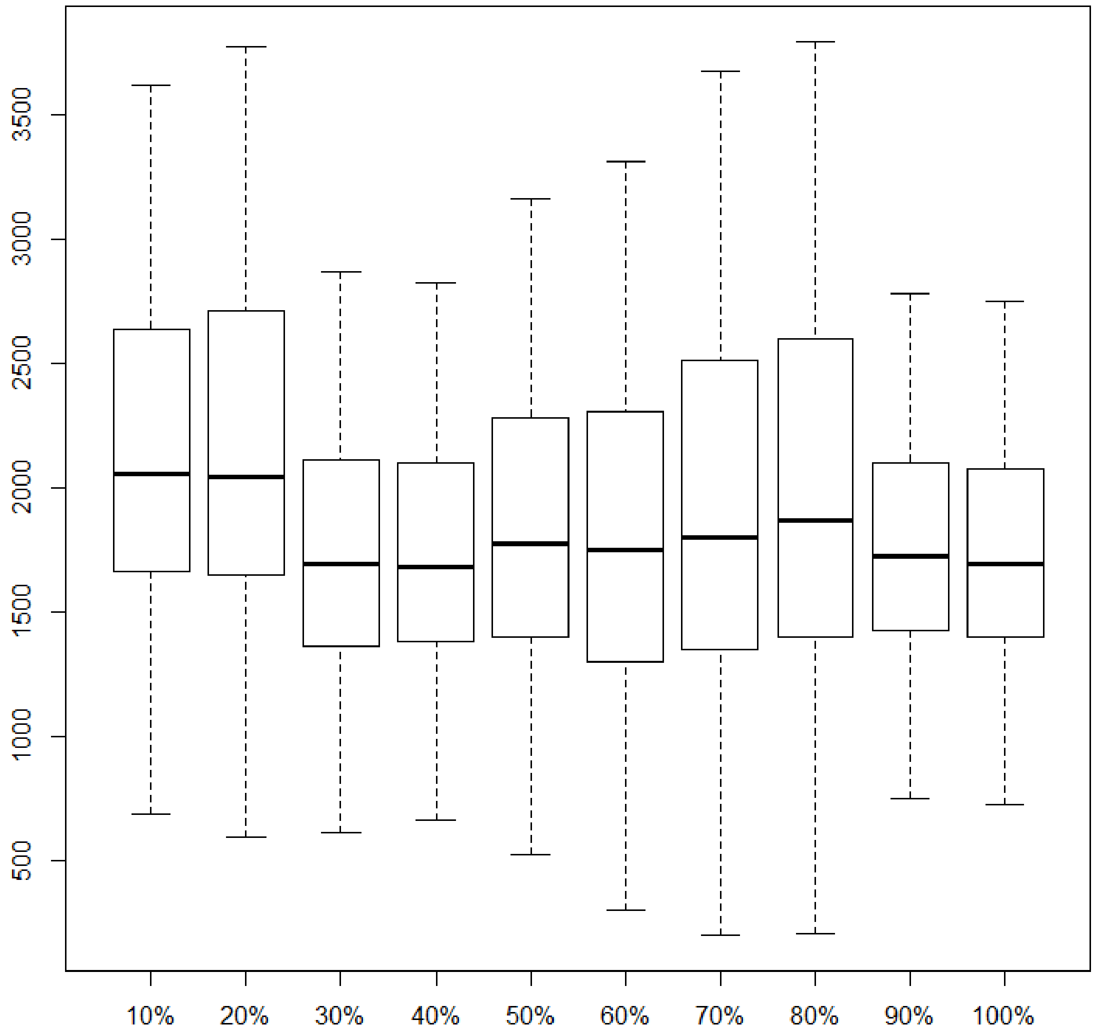
Figure 42 Boxplots of the monthly gross rent [CHF/month] according to the deciles of the proportion of Northwestern Schengen countries citizens in relation to whole municipal population



Data source: web based housing advertisements (2009-2013)

Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

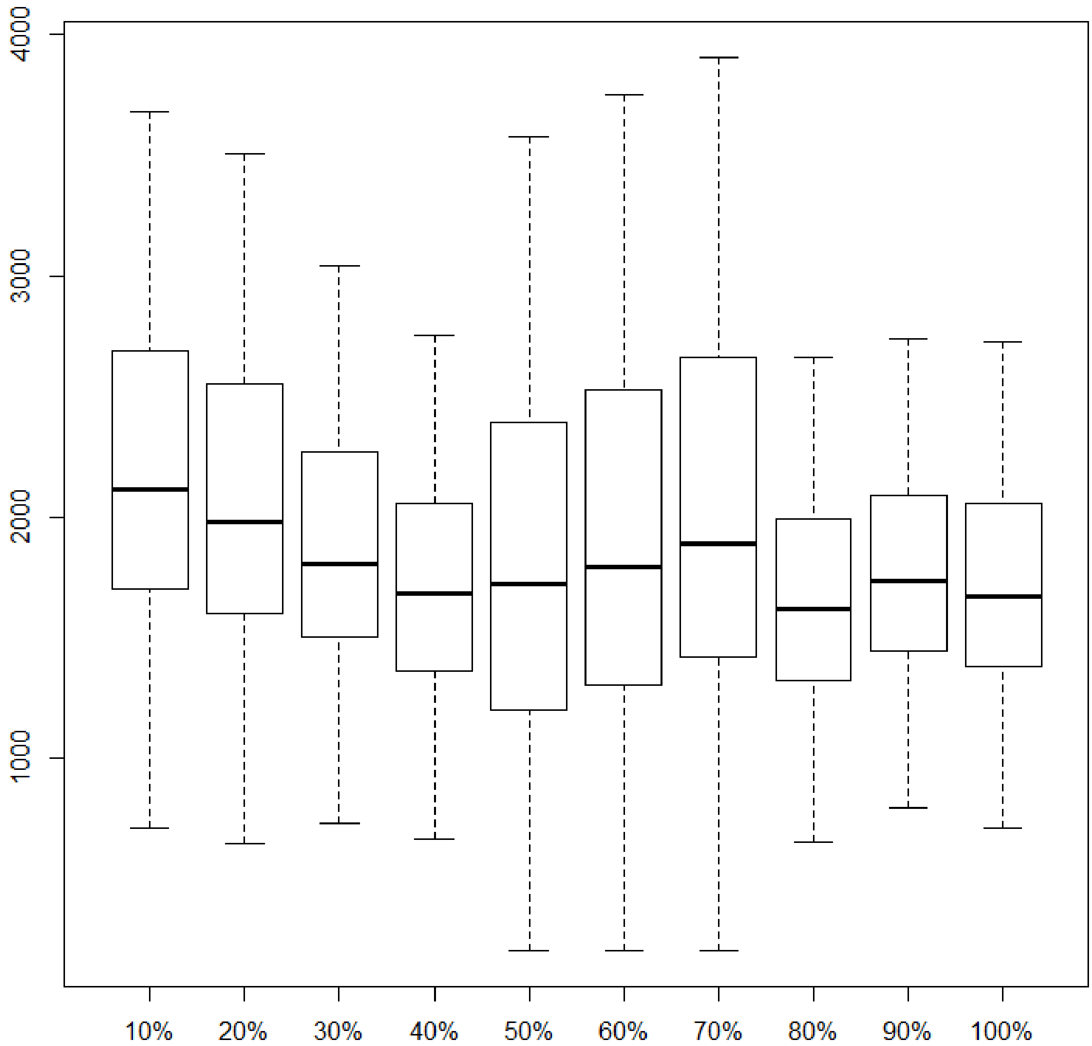
Figure 43 Boxplots of the monthly gross rent [CHF/month] according to the deciles of the proportion of Southern/Eastern Schengen countries citizens in relation to whole municipal population



Data source: web based housing advertisements (2009-2013)

Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

Figure 44 Boxplots of the monthly gross rent [CHF/month] according to the deciles of the proportion of outside of Schengen countries citizens in relation to whole municipal population



Data source: web based housing advertisements (2009-2013)

Swiss Federal Office for Migration / Statistical Office of Canton Zurich (2014).

A 3 Hedonic models

Correlation among the potential relevant variables

The following tables present correlation values among the potentially relevant variables. Values ranging between 0.50 and 0.69, respectively -0.50 and -0.69, are underlined in orange (high correlation). Values of red color describe cases of severe correlation, which excludes a common use of the concerned variables into the same model (values ≥ 0.7 respectively ≤ -0.7).

Table 17 Correlation among potentially relevant variables (Part 1 of 8)

	Room	Living_Area	Story	Land_Value	Dist_Highway	Dist_Station	Acc_Car	Acc_PT	Univ
Room	1.00	0.83	0.00	-0.18	0.16	0.10	-0.22	-0.18	-0.13
Living_Area		1.00	0.06	-0.10	0.15	0.10	-0.20	-0.17	-0.04
Story			1.00	0.06	-0.10	-0.08	0.11	0.09	0.02
Land_Value				1.00	-0.26	-0.11	0.42	0.49	0.91
Dist_Highway					1.00	0.11	-0.55	-0.40	-0.16
Dist_Station						1.00	-0.04	-0.19	-0.09
Acc_Car							1.00	0.47	0.29
Acc_PT								1.00	0.41
Univ									1.00
Owner									
Highway									
Slope									
Lake_View									
Stories									
Res_Units									
H_05km									
H_01km									
Pop_300m									
Attic									
Balcony									
Fire									
Garden									
Terrace									
Acc_Tot									
Parcel_Size									
Resi_Perc									
Retail_Perc									
Office_Prop									
Indus_prop									
H1_300m									
H2_300m									
H3_300m									
H4_300m									
H5_300m									
H6_300m									
H_300m									
H_500m									
H1_500m									
H2_500m									
H3_500m									
H4_500m									
H5_500m									
H6_500m									
Children_500m									
Pop_500m									
Foreigners_500m									
Swiss_500m									
Dis_School									
Dis_Kindergarten									
Dis_CBD_ZH									
Dis_CBD_Winterthur									
Retail_300m									
Retail_1000m									
Hotel_300m									
Hotel_1000m									
Perc_Foreigners									
Perc_Schengen									
Perc_NW									
Perc_SE									
Perc_OutSchengen									
Sun_Eve									
year_2010									
year_2011									
year_2012									
year_2013									
Lake_dummy									
Age1									
Age2									
Age3									
Age4									

Data source: web based housing advertisements (2009-2013)

Table 18 Correlation among potentially relevant variables (Part 2 of 8)

	Owner	Highway	Slope	Lake_View	Stories	Res_Units	H_05km	H_01km	Pop_300m
Room	0.28	-0.04	0.08	0.08	-0.17	-0.17	-0.30	-0.31	-0.27
Living_Area	0.26	-0.03	0.10	0.10	-0.11	-0.13	-0.28	-0.27	-0.28
Story	-0.14	0.00	-0.14	-0.05	0.38	0.33	0.14	0.17	0.14
Land_Value	-0.61	0.07	0.14	0.21	0.41	0.07	0.49	0.56	0.40
Dist_Highway	0.43	-0.14	0.09	0.09	-0.23	-0.14	-0.33	-0.37	-0.30
Dist_Station	0.25	0.02	0.13	-0.03	-0.11	-0.10	-0.25	-0.26	-0.22
Acc_Car	-0.64	0.09	-0.14	-0.30	0.37	0.16	0.53	0.59	0.49
Acc_PT	-0.56	0.05	-0.03	-0.02	0.29	0.13	0.42	0.45	0.37
Univ	-0.39	0.07	0.18	0.18	0.32	0.03	0.36	0.43	0.27
Owner	1.00	-0.05	0.05	0.03	-0.44	-0.19	-0.61	-0.67	-0.57
Highway		1.00	0.00	-0.03	0.03	0.01	0.01	0.04	0.00
Slope			1.00	0.36	-0.14	-0.18	-0.21	-0.20	-0.24
Lake_View				1.00	-0.07	-0.09	-0.09	-0.10	-0.11
Stories					1.00	0.48	0.42	0.47	0.38
Res_Units						1.00	0.18	0.22	0.16
H_05km							1.00	0.93	0.93
H_01km								1.00	0.81
Pop_300m									1.00
Attic									
Balcony									
Fire									
Garden									
Terrace									
Acc_Tot									
Parcel_Size									
Resi_Perc									
Retail_Perc									
Office_Prop									
Indus_prop									
H1_300m									
H2_300m									
H3_300m									
H4_300m									
H5_300m									
H6_300m									
H_300m									
H_500m									
H1_500m									
H2_500m									
H3_500m									
H4_500m									
H5_500m									
H6_500m									
Children_500m									
Pop_500m									
Foreigners_500m									
Swiss_500m									
Dis_School									
Dis_Kindergarten									
Dis_CBD_ZH									
Dis_CBD_Winterthur									
Retail_300m									
Retail_1000m									
Hotel_300m									
Hotel_1000m									
Perc_Foreigners									
Perc_Schengen									
Perc_NW									
Perc_SE									
Perc_OutSchengen									
Sun_Eve									
year_2010									
year_2011									
year_2012									
year_2013									
Lake_dummy									
Age1									
Age2									
Age3									
Age4									

Data source: web based housing advertisements (2009-2013)

Table 19 Correlation among potentially relevant variables (Part 3 of 8)

	Attic	Balcony	Fire	Garden	Terrace	Acc_Tot	Parcel_Size	Resi_Perc	Retail_Perc	Office_Prop	Indus_prop
Room	0.10	-0.04	0.15	0.05	0.08	-0.27	0.08	0.08	-0.02	-0.07	-0.04
Living_Area	0.14	-0.12	0.16	0.05	0.13	-0.23	0.06	-0.03	0.03	0.02	-0.01
Story	0.19	0.05	0.01	-0.22	0.14	0.12	0.10	-0.11	0.06	0.08	0.03
Land_Value	0.00	-0.08	-0.02	-0.02	0.02	0.70	-0.09	-0.16	0.03	0.18	0.02
Dist_Highway	0.02	-0.02	0.06	0.04	0.01	-0.50	-0.01	0.08	-0.02	-0.09	-0.03
Dist_Station	0.02	-0.02	0.06	0.05	0.01	-0.22	0.00	0.12	-0.06	-0.10	-0.02
Acc_Car	-0.02	0.01	-0.06	-0.05	-0.01	0.70	-0.01	-0.12	0.03	0.12	0.05
Acc_PT	-0.01	0.01	-0.05	-0.04	0.00	0.78	-0.02	-0.11	0.03	0.12	0.02
Univ	0.00	-0.09	0.01	0.00	0.03	0.58	-0.08	-0.11	0.01	0.15	0.00
Owner	0.02	-0.01	0.10	0.07	0.01	-0.79	0.05	0.17	-0.04	-0.16	-0.05
Highway	-0.01	-0.01	0.00	-0.01	-0.01	0.07	-0.01	-0.01	0.01	0.02	0.00
Slope	0.03	-0.06	0.06	0.07	0.05	-0.05	-0.05	0.09	-0.08	-0.03	-0.04
Lake_View	0.04	-0.04	0.05	0.04	0.05	-0.08	-0.04	0.00	-0.01	0.02	-0.02
Stories	-0.01	0.01	-0.08	-0.09	0.00	0.43	0.03	-0.11	0.03	0.12	0.02
Res_Units	0.00	0.05	-0.08	-0.09	-0.02	0.17	0.09	0.06	-0.04	-0.03	-0.03
H_05km	-0.04	0.00	-0.10	-0.08	-0.03	0.60	-0.09	-0.13	0.04	0.13	0.03
H_01km	-0.04	-0.02	-0.10	-0.08	-0.02	0.66	-0.11	-0.19	0.06	0.19	0.06
Pop_300m	-0.03	0.03	-0.10	-0.08	-0.03	0.53	-0.07	-0.08	0.04	0.08	0.01
Attic	1.00	-0.07	0.08	-0.04	0.30	-0.02	0.04	-0.01	0.00	0.00	0.01
Balcony		1.00	0.04	-0.12	-0.10	-0.01	0.04	0.12	-0.05	-0.09	-0.05
Fire			1.00	0.04	0.11	-0.08	-0.01	0.05	-0.02	-0.02	-0.03
Garden				1.00	-0.01	-0.06	0.00	0.06	-0.03	-0.04	-0.02
Terrace					1.00	0.00	0.03	-0.04	0.02	0.02	0.01
Acc_Tot						1.00	-0.05	-0.17	0.04	0.18	0.03
Parcel_Size							1.00	0.03	-0.02	-0.04	0.00
Resi_Perc								1.00	-0.51	-0.60	-0.51
Retail_Perc									1.00	-0.01	-0.03
Office_Prop										1.00	-0.02
Indus_prop											1.00
H1_300m											
H2_300m											
H3_300m											
H4_300m											
H5_300m											
H6_300m											
H_300m											
H_500m											
H1_500m											
H2_500m											
H3_500m											
H4_500m											
H5_500m											
H6_500m											
Children_500m											
Pop_500m											
Foreigners_500m											
Swiss_500m											
Dis_School											
Dis_Kindergarten											
Dis_CBD_ZH											
Dis_CBD_Winterthur											
Retail_300m											
Retail_1000m											
Hotel_300m											
Hotel_1000m											
Perc_Foreigners											
Perc_Schengen											
Perc_NW											
Perc_SE											
Perc_OutSchengen											
Sun_Eve											
year_2010											
year_2011											
year_2012											
year_2013											
Lake_dummy											
Age1											
Age2											
Age3											
Age4											

Data source: web based housing advertisements (2009-2013)

Table 20 Correlation among potentially relevant variables (Part 4 of 8)

	H1_300m	H2_300m	H3_300m	H4_300m	H5_300m	H6_300m	H_300m	H_500m
Room	-0.31	-0.26	-0.23	-0.14	-0.14	-0.18	-0.29	-0.30
Living_Area	-0.30	-0.27	-0.25	-0.19	-0.20	-0.22	-0.29	-0.29
Story	0.14	0.14	0.13	0.06	0.04	0.10	0.14	0.14
Land_Value	0.49	0.41	0.36	0.19	0.11	0.11	0.45	0.48
Dist_Highway	-0.31	-0.30	-0.29	-0.17	-0.15	-0.22	-0.30	-0.32
Dist_Station	-0.22	-0.22	-0.20	-0.13	-0.17	-0.21	-0.22	-0.24
Acc_Car	0.49	0.48	0.48	0.32	0.23	0.31	0.49	0.51
Acc_PT	0.40	0.37	0.34	0.23	0.19	0.22	0.39	0.41
Univ	0.38	0.30	0.23	0.09	0.01	-0.01	0.33	0.36
Owner	-0.58	-0.55	-0.53	-0.36	-0.33	-0.43	-0.57	-0.60
Highway	0.01	-0.01	-0.01	-0.01	-0.02	0.01	0.00	0.01
Slope	-0.19	-0.21	-0.22	-0.19	-0.19	-0.26	-0.21	-0.20
Lake_View	-0.08	-0.08	-0.10	-0.09	-0.09	-0.19	-0.09	-0.08
Stories	0.42	0.38	0.34	0.18	0.10	0.20	0.40	0.41
Res_Units	0.16	0.16	0.16	0.09	0.06	0.13	0.16	0.17
H_05km	0.94	0.93	0.87	0.66	0.58	0.62	0.95	0.98
H_01km	0.87	0.82	0.74	0.48	0.40	0.53	0.85	0.90
Pop_300m	0.93	0.98	0.96	0.81	0.74	0.73	0.98	0.96
Attic	-0.04	-0.03	-0.02	-0.01	-0.02	-0.02	-0.04	-0.04
Balcony	0.00	0.02	0.05	0.08	0.09	0.06	0.02	0.01
Fire	-0.10	-0.09	-0.09	-0.06	-0.07	-0.09	-0.10	-0.10
Garden	-0.08	-0.07	-0.07	-0.05	-0.05	-0.07	-0.08	-0.08
Terrace	-0.03	-0.03	-0.03	-0.03	-0.04	-0.04	-0.03	-0.03
Acc_Tot	0.59	0.53	0.49	0.31	0.25	0.31	0.56	0.59
Parcel_Size	-0.11	-0.07	-0.04	-0.01	-0.03	-0.05	-0.08	-0.10
Resi_Perc	-0.14	-0.09	-0.04	0.06	0.07	-0.01	-0.10	-0.12
Retail_Perc	0.05	0.04	0.01	-0.02	-0.02	0.00	0.04	0.05
Office_Prop	0.14	0.09	0.05	-0.04	-0.05	0.02	0.10	0.12
Indus_prop	0.03	0.01	0.00	-0.03	-0.05	0.00	0.01	0.02
H1_300m	1.00	0.94	0.85	0.60	0.53	0.58	0.98	0.98
H2_300m		1.00	0.94	0.76	0.66	0.65	0.99	0.96
H3_300m			1.00	0.87	0.78	0.71	0.94	0.90
H4_300m				1.00	0.86	0.68	0.75	0.68
H5_300m					1.00	0.73	0.67	0.61
H6_300m						1.00	0.67	0.64
H_300m							1.00	0.99
H_500m								1.00
H1_500m								
H2_500m								
H3_500m								
H4_500m								
H5_500m								
H6_500m								
Children_500m								
Pop_500m								
Foreigners_500m								
Swiss_500m								
Dis_School								
Dis_Kindergarten								
Dis_CBD_ZH								
Dis_CBD_Winterthur								
Retail_300m								
Retail_1000m								
Hotel_300m								
Hotel_1000m								
Perc_Foreigners								
Perc_Schengen								
Perc_NW								
Perc_SE								
Perc_OutSchengen								
Sun_Eve								
year_2010								
year_2011								
year_2012								
year_2013								
Lake_dummy								
Age1								
Age2								
Age3								
Age4								

Data source: web based housing advertisements (2009-2013)

Table 21 Correlation among potentially relevant variables (Part 5 of 8)

	Foreigners_500m	Swiss_500m	Dis_School	Dis_Kindergarten	Dis_CBD_ZH
Room	-0.29	-0.27	0.15	0.05	0.20
Living_Area	-0.29	-0.27	0.16	0.11	0.15
Story	0.16	0.12	-0.04	-0.02	-0.08
Land_Value	0.44	0.45	-0.15	0.06	-0.70
Dist_Highway	-0.38	-0.28	0.13	0.10	0.40
Dist_Station	-0.26	-0.24	0.25	0.16	0.09
Acc_Car	0.56	0.48	-0.15	-0.01	-0.73
Acc_PT	0.41	0.40	-0.20	-0.11	-0.51
Univ	0.28	0.34	-0.12	0.11	-0.60
Owner	-0.63	-0.57	0.26	0.10	0.66
Highway	0.04	0.00	0.01	0.01	-0.07
Slope	-0.26	-0.19	0.15	0.08	-0.04
Lake_View	-0.15	-0.07	0.05	-0.04	0.09
Stories	0.42	0.38	-0.12	0.03	-0.39
Res_Units	0.21	0.16	-0.06	-0.04	-0.08
H_05km	0.94	0.97	-0.38	-0.12	-0.50
H_01km	0.87	0.88	-0.32	-0.05	-0.56
Pop_300m	0.89	0.91	-0.38	-0.18	-0.43
Attic	-0.03	-0.03	0.04	0.00	0.01
Balcony	0.01	0.01	-0.04	-0.09	0.05
Fire	-0.11	-0.09	0.05	0.02	0.03
Garden	-0.08	-0.07	0.04	0.02	0.03
Terrace	-0.03	-0.03	0.03	0.02	-0.01
Acc_Tot	0.59	0.56	-0.24	-0.08	-0.73
Parcel_Size	-0.08	-0.09	0.10	-0.01	0.04
Resi_Perc	-0.13	-0.11	0.02	-0.08	0.16
Retail_Perc	0.04	0.04	-0.01	0.01	-0.03
Office_Prop	0.13	0.12	-0.04	0.05	-0.18
Indus_prop	0.04	0.02	0.02	0.06	-0.02
H1_300m	0.87	0.90	-0.35	-0.07	-0.50
H2_300m	0.86	0.92	-0.37	-0.15	-0.43
H3_300m	0.84	0.87	-0.38	-0.21	-0.40
H4_300m	0.64	0.70	-0.34	-0.28	-0.22
H5_300m	0.61	0.62	-0.34	-0.31	-0.14
H6_300m	0.68	0.62	-0.30	-0.21	-0.18
H_300m	0.89	0.92	-0.37	-0.14	-0.46
H_500m	0.92	0.96	-0.38	-0.13	-0.49
H1_500m	0.74	0.80	-0.28	0.00	-0.52
H2_500m	0.82	0.90	-0.36	-0.14	-0.49
H3_500m	0.79	0.84	-0.34	-0.20	-0.37
H4_500m	0.65	0.73	-0.36	-0.27	-0.22
H5_500m	0.61	0.69	-0.34	-0.21	-0.14
H6_500m	0.66	0.66	-0.21	-0.09	-0.23
Children_500m	0.81	0.89	-0.43	-0.27	-0.33
Pop_500m	0.95	0.98	-0.40	-0.16	-0.48
Foreigners_500m	1.00	0.87	-0.35	-0.15	-0.52
Swiss_500m		1.00	-0.41	-0.16	-0.43
Dis_School			1.00	0.23	0.13
Dis_Kindergarten				1.00	-0.08
Dis_CBD_ZH					1.00
Dis_CBD_Winterthur					
Retail_300m					
Retail_1000m					
Hotel_300m					
Hotel_1000m					
Perc_Foreigners					
Perc_Schengen					
Perc_NW					
Perc_SE					
Perc_OutSchengen					
Sun_Eve					
year_2010					
year_2011					
year_2012					
year_2013					
Lake_dummy					
Age1					
Age2					
Age3					
Age4					

Data source: web based housing advertisements (2009-2013)

Table 22 Correlation among potentially relevant variables (Part 6 of 8)

	Dis_CBD_Winterthur	Retail_300m	Retail_1000m	Hotel_300m	Hotel_1000m
Room	0.03	-0.10	-0.18	-0.14	-0.19
Living_Area	0.05	-0.03	-0.12	-0.07	-0.13
Story	-0.03	0.12	0.16	0.17	0.16
Land_Value	0.31	0.15	0.29	0.25	0.35
Dist_Highway	0.06	-0.09	-0.20	-0.15	-0.22
Dist_Station	0.00	-0.15	-0.21	-0.18	-0.20
Acc_Car	-0.12	0.06	0.22	0.13	0.27
Acc_PT	0.05	0.13	0.24	0.19	0.26
Univ	0.26	0.12	0.23	0.21	0.28
Owner	-0.05	-0.17	-0.33	-0.26	-0.36
Highway	-0.01	-0.02	-0.01	-0.01	-0.01
Slope	0.30	-0.12	-0.16	-0.13	-0.13
Lake_View	0.41	-0.02	-0.06	-0.03	-0.04
Stories	0.02	0.18	0.32	0.29	0.35
Res_Units	-0.11	0.04	0.15	0.09	0.13
H_05km	0.02	0.13	0.30	0.20	0.37
H_01km	0.02	0.20	0.43	0.30	0.50
Pop_300m	0.00	0.12	0.24	0.17	0.30
Attic	0.02	-0.02	-0.03	-0.02	-0.03
Balcony	-0.04	-0.08	-0.09	-0.12	-0.10
Fire	0.05	-0.04	-0.06	-0.04	-0.06
Garden	0.04	-0.05	-0.07	-0.07	-0.07
Terrace	0.03	0.01	0.00	0.02	0.00
Acc_Tot	0.05	0.19	0.36	0.30	0.39
Parcel_Size	-0.03	-0.05	-0.08	-0.10	-0.11
Resi_Perc	-0.02	-0.27	-0.27	-0.29	-0.28
Retail_Perc	0.00	0.20	0.12	0.18	0.12
Office_Prop	0.03	0.21	0.28	0.25	0.29
Indus_prop	-0.01	0.02	0.02	0.02	0.03
H1_300m	0.04	0.17	0.33	0.26	0.40
H2_300m	0.01	0.09	0.22	0.15	0.29
H3_300m	0.00	0.03	0.14	0.06	0.20
H4_300m	-0.01	-0.10	-0.05	-0.13	-0.02
H5_300m	-0.06	-0.10	-0.04	-0.14	-0.02
H6_300m	-0.14	0.03	0.13	0.03	0.15
H_300m	0.02	0.11	0.26	0.18	0.32
H_500m	0.02	0.13	0.29	0.20	0.36
H1_500m	0.05	0.38	0.53	0.48	0.60
H2_500m	0.05	0.23	0.36	0.30	0.42
H3_500m	0.03	0.23	0.33	0.28	0.38
H4_500m	0.00	0.12	0.14	0.09	0.16
H5_500m	0.03	0.14	0.18	0.13	0.21
H6_500m	0.04	0.21	0.33	0.27	0.38
Children_500m	-0.01	-0.01	0.08	-0.05	0.11
Pop_500m	0.01	0.15	0.30	0.20	0.36
Foreigners_500m	0.05	0.14	0.32	0.22	0.39
Swiss_500m	-0.01	0.14	0.28	0.18	0.33
Dis_School	0.01	-0.05	-0.13	-0.06	-0.12
Dis_Kindergarten	0.00	0.05	0.02	0.10	0.06
Dis_CBD_ZH	-0.30	-0.16	-0.32	-0.28	-0.39
Dis_CBD_Winterthur	1.00	-0.01	-0.02	0.01	0.02
Retail_300m		1.00	0.57	0.76	0.56
Retail_1000m			1.00	0.81	0.95
Hotel_300m				1.00	0.82
Hotel_1000m					1.00
Perc_Foreigners					
Perc_Schengen					
Perc_NW					
Perc_SE					
Perc_OutSchengen					
Sun_Eve					
year_2010					
year_2011					
year_2012					
year_2013					
Lake_dummy					
Age1					
Age2					
Age3					
Age4					

Data source: web based housing advertisements (2009-2013)

Table 23 Correlation among potentially relevant variables (Part 7 of 8)

	Perc_Foreigners	Perc_Schengen	Perc_NW	Perc_SE	Perc_OutSchengen	Sun_Eve
Room	-0.19	-0.21	-0.16	-0.14	-0.14	0.05
Living_Area	-0.18	-0.17	-0.09	-0.16	-0.15	0.07
Story	0.14	0.11	0.04	0.12	0.13	-0.04
Land_Value	0.29	0.59	0.84	0.02	-0.06	0.00
Dist_Highway	-0.38	-0.38	-0.26	-0.29	-0.30	0.03
Dist_Station	-0.21	-0.19	-0.12	-0.16	-0.18	0.12
Acc_Car	0.57	0.57	0.34	0.48	0.44	-0.01
Acc_PT	0.39	0.47	0.41	0.27	0.23	-0.03
Univ	0.06	0.41	0.83	-0.23	-0.31	0.04
Owner	-0.74	-0.76	-0.53	-0.58	-0.56	0.06
Highway	0.07	0.06	0.06	0.03	0.06	0.00
Slope	-0.09	0.03	0.18	-0.14	-0.18	0.29
Lake_View	-0.12	0.00	0.22	-0.21	-0.22	0.01
Stories	0.30	0.36	0.34	0.19	0.16	-0.04
Res_Units	0.15	0.11	0.04	0.12	0.15	-0.05
H_05km	0.39	0.46	0.41	0.27	0.23	-0.09
H_01km	0.43	0.52	0.48	0.28	0.24	-0.07
Pop_300m	0.39	0.42	0.32	0.29	0.28	-0.10
Attic	0.00	0.00	0.00	-0.01	0.00	0.01
Balcony	0.01	-0.04	-0.09	0.03	0.05	-0.04
Fire	-0.09	-0.07	-0.02	-0.08	-0.08	0.02
Garden	-0.06	-0.05	-0.02	-0.05	-0.06	0.03
Terrace	-0.01	0.00	0.02	-0.02	-0.02	0.03
Acc_Tot	0.55	0.65	0.57	0.38	0.32	-0.03
Parcel_Size	-0.02	-0.06	-0.08	-0.01	0.02	-0.01
Resi_Perc	-0.11	-0.14	-0.13	-0.08	-0.06	0.01
Retail_Perc	0.03	0.03	0.02	0.03	0.01	-0.01
Office_Prop	0.10	0.15	0.16	0.06	0.04	0.00
Indus_prop	0.05	0.04	0.01	0.04	0.04	-0.02
H1_300m	0.37	0.45	0.42	0.23	0.20	-0.08
H2_300m	0.35	0.40	0.34	0.24	0.22	-0.09
H3_300m	0.38	0.40	0.28	0.29	0.28	-0.10
H4_300m	0.27	0.25	0.13	0.24	0.23	-0.10
H5_300m	0.26	0.20	0.04	0.25	0.27	-0.08
H6_300m	0.38	0.28	0.06	0.36	0.39	-0.09
H_300m	0.38	0.43	0.37	0.26	0.24	-0.09
H_500m	0.39	0.45	0.40	0.26	0.23	-0.09
H1_500m	0.33	0.44	0.44	0.19	0.14	-0.05
H2_500m	0.34	0.43	0.42	0.21	0.18	-0.07
H3_500m	0.25	0.31	0.29	0.17	0.14	-0.07
H4_500m	0.16	0.18	0.14	0.13	0.11	-0.09
H5_500m	0.09	0.13	0.12	0.07	0.03	-0.09
H6_500m	0.11	0.18	0.22	0.04	0.01	-0.06
Children_500m	0.32	0.33	0.22	0.26	0.24	-0.11
Pop_500m	0.41	0.47	0.38	0.30	0.27	-0.10
Foreigners_500m	0.54	0.55	0.38	0.42	0.39	-0.10
Swiss_500m	0.32	0.39	0.36	0.21	0.18	-0.10
Dis_School	-0.16	-0.19	-0.16	-0.12	-0.09	0.14
Dis_Kindergarten	-0.07	0.00	0.09	-0.09	-0.11	0.13
Dis_CBD_ZH	-0.57	-0.73	-0.68	-0.39	-0.28	-0.04
Dis_CBD_Winterthur	0.10	0.29	0.37	0.06	-0.11	0.01
Retail_300m	0.10	0.13	0.13	0.06	0.04	-0.03
Retail_1000m	0.20	0.26	0.26	0.12	0.09	-0.04
Hotel_300m	0.16	0.23	0.24	0.09	0.06	-0.02
Hotel_1000m	0.23	0.31	0.32	0.13	0.10	-0.03
Perc_Foreigners	1.00	0.88	0.38	0.90	0.89	-0.06
Perc_Schengen		1.00	0.73	0.73	0.56	-0.05
Perc_NW			1.00	0.06	-0.05	0.00
Perc_SE				1.00	0.86	-0.07
Perc_OutSchengen					1.00	-0.06
Sun_Eve						1.00
year_2010						
year_2011						
year_2012						
year_2013						
Lake_dummy						
Age1						
Age2						
Age3						
Age4						

Data source: web based housing advertisements (2009-2013)

Table 24 Correlation among potentially relevant variables (Part 8 of 8)

	year_2010	year_2011	year_2012	year_2013	Lake_dummy	Age1	Age2	Age3	Age4
Room	0.01	0.00	-0.02	-0.02	0.05	-0.08	-0.10	0.07	0.24
Living_Area	0.01	0.00	-0.01	-0.02	0.10	-0.03	-0.09	0.04	0.34
Story	-0.03	-0.01	0.02	0.03	-0.06	0.04	-0.02	0.00	0.03
Land_Value	-0.05	-0.03	0.04	0.06	0.37	0.13	0.27	-0.11	-0.15
Dist_Highway	0.03	0.01	-0.02	-0.03	0.12	-0.02	-0.10	0.08	0.08
Dist_Station	0.01	0.00	-0.01	-0.02	0.02	-0.05	-0.08	0.08	0.05
Acc_Car	-0.03	-0.01	0.02	0.02	-0.17	0.02	0.18	-0.09	-0.10
Acc_PT	-0.03	-0.03	0.02	0.04	0.11	0.04	0.16	-0.08	-0.14
Univ	-0.04	-0.03	0.03	0.05	0.39	0.12	0.24	-0.10	-0.13
Owner	0.05	0.02	-0.03	-0.05	-0.03	-0.08	-0.23	0.13	0.20
Highway	0.00	0.00	0.00	0.00	-0.04	0.00	0.03	-0.01	-0.02
Slope	0.00	-0.01	-0.01	0.01	0.39	-0.01	0.01	0.04	-0.09
Lake_View	-0.03	-0.01	0.00	0.04	**0.65**	0.05	0.01	0.03	-0.05
Stories	-0.03	-0.02	0.03	0.03	0.00	0.07	0.10	-0.04	-0.01
Res_Units	-0.01	-0.01	0.02	0.00	-0.12	-0.13	-0.10	0.01	0.09
H_05km	-0.04	-0.01	0.03	0.04	-0.05	0.18	0.24	-0.16	-0.18
H_01km	-0.05	-0.01	0.03	0.05	-0.06	0.21	0.28	-0.18	-0.16
Pop_300m	-0.03	0.00	0.02	0.03	-0.09	0.15	0.20	-0.14	-0.17
Attic	-0.01	0.01	0.00	0.00	0.03	-0.04	-0.03	0.02	0.10
Balcony	0.04	0.03	-0.02	-0.07	-0.06	-0.14	-0.03	0.07	-0.09
Fire	0.02	0.01	-0.01	-0.03	0.04	-0.03	-0.05	0.15	-0.03
Garden	0.02	0.00	-0.01	-0.02	0.04	0.00	0.01	0.02	0.03
Terrace	0.00	0.01	0.00	-0.01	0.04	0.00	-0.02	0.03	0.06
Acc_Tot	-0.04	-0.03	0.04	0.05	0.12	0.10	0.25	-0.14	-0.20
Parcel_Size	0.01	0.01	0.01	-0.02	-0.02	-0.07	-0.10	0.06	0.09
Resi_Perc	0.01	0.01	-0.03	-0.02	-0.04	-0.17	-0.07	0.06	-0.04
Retail_Perc	0.00	0.00	0.01	0.01	0.00	0.06	0.04	-0.03	0.02
Office_Prop	-0.02	-0.01	0.02	0.02	0.06	0.15	0.07	-0.05	-0.01
Indus_prop	0.00	0.00	0.01	0.00	-0.03	0.04	0.01	-0.02	0.05
H1_300m	-0.04	-0.01	0.03	0.04	-0.01	0.21	0.26	-0.16	-0.21
H2_300m	-0.03	0.00	0.02	0.03	-0.06	0.15	0.20	-0.14	-0.16
H3_300m	-0.02	0.00	0.01	0.02	-0.09	0.10	0.17	-0.13	-0.14
H4_300m	-0.01	0.01	0.01	0.01	-0.10	-0.01	0.09	-0.08	-0.10
H5_300m	0.00	0.01	0.00	0.00	-0.13	-0.01	0.07	-0.08	-0.14
H6_300m	-0.01	0.01	0.00	0.00	-0.25	0.05	0.11	-0.08	-0.13
H_300m	-0.03	-0.01	0.02	0.04	-0.05	0.17	0.23	-0.15	-0.19
H_500m	-0.04	-0.01	0.02	0.04	-0.04	0.19	0.24	-0.16	-0.20
H1_500m	-0.04	-0.02	0.03	0.04	0.08	0.25	0.25	-0.16	-0.18
H2_500m	-0.03	-0.01	0.02	0.04	0.04	0.19	0.24	-0.14	-0.26
H3_500m	-0.01	0.00	0.01	0.01	-0.02	0.18	0.18	-0.10	-0.25
H4_500m	0.00	0.01	-0.01	0.00	-0.07	0.09	0.11	-0.05	-0.23
H5_500m	0.00	0.01	0.00	-0.01	-0.07	0.14	0.15	-0.09	-0.18
H6_500m	-0.02	0.01	0.02	0.01	-0.10	0.22	0.14	-0.09	-0.13
Children_500m	0.02	0.06	-0.02	-0.06	-0.08	0.06	0.17	-0.13	-0.15
Pop_500m	-0.05	-0.01	0.03	0.05	-0.07	0.17	0.23	-0.15	-0.18
Foreigners_500m	-0.06	-0.01	0.04	0.06	-0.16	0.15	0.20	-0.14	-0.17
Swiss_500m	-0.04	-0.01	0.02	0.04	-0.02	0.17	0.23	-0.15	-0.17
Dis_School	0.01	0.01	0.00	-0.02	0.01	-0.07	-0.07	0.07	0.10
Dis_Kindergarten	-0.01	0.00	0.01	0.00	0.04	0.04	0.04	0.01	0.07
Dis_CBD_ZH	0.04	0.04	-0.03	-0.05	-0.10	-0.08	-0.23	0.08	0.15
Dis_CBD_Winterthur	-0.02	-0.03	0.01	0.03	0.38	0.02	0.04	0.08	-0.06
Retail_300m	-0.04	-0.04	0.04	0.05	0.02	0.19	0.05	-0.06	-0.04
Retail_1000m	-0.06	-0.03	0.05	0.07	0.01	0.28	0.11	-0.11	-0.09
Hotel_300m	-0.07	-0.06	0.07	0.09	0.04	0.27	0.06	-0.08	-0.08
Hotel_1000m	-0.08	-0.04	0.06	0.09	0.04	0.31	0.12	-0.11	-0.11
Perc_Foreigners	-0.14	-0.06	0.06	0.20	-0.12	0.01	0.13	-0.07	-0.10
Perc_Schengen	-0.19	-0.08	0.08	0.28	0.08	0.06	0.20	-0.09	-0.14
Perc_NW	-0.15	-0.06	0.08	0.23	0.35	0.11	0.24	-0.10	-0.15
Perc_SE	-0.12	-0.06	0.04	0.18	-0.23	-0.03	0.06	-0.03	-0.06
Perc_OutSchengen	-0.06	-0.02	0.02	0.07	-0.29	-0.05	0.03	-0.04	-0.04
Sun_Eve	0.01	0.00	-0.01	0.00	0.04	0.00	-0.01	0.00	-0.01
year_2010	1.00	-0.21	-0.25	-0.27	-0.02	-0.03	-0.03	0.02	0.01
year_2011		1.00	-0.29	-0.32	-0.03	0.00	-0.02	0.01	0.01
year_2012			1.00	-0.38	0.01	0.01	0.01	-0.01	-0.01
year_2013				1.00	0.05	0.03	0.04	-0.03	-0.03
Lake_dummy					1.00	0.09	0.10	-0.03	-0.09
Age1						1.00	-0.12	-0.21	-0.18
Age2							1.00	-0.20	-0.17
Age3								1.00	-0.31
Age4									1.00

Data source: web based housing advertisements (2009-2013)

OLS models

Table 25 Description of the global OLS model 1

Variable	Coefficient	SE	p-value
Intercept	5.34500	0.01506	< 2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22890	0.00047	< 2E-16
Story	0.01661	0.00040	< 2E-16
Stories	0.00156	0.00029	5.02E-08
Attic	0.16330	0.00360	< 2E-16
Garden	0.02935	0.00236	< 2E-16
Terrace	0.11540	0.00274	< 2E-16
Age1	0.15030	0.00189	< 2E-16
Age2	0.09171	0.00185	< 2E-16
Age3	0.05394	0.00142	< 2E-16
Age4	0.20480	0.00160	< 2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.00045	0.00005	< 2E-16
Highway	-0.06235	0.00437	< 2E-16
Dist_Station	-0.00182	0.00010	< 2E-16
Acc_Tot	0.08734	0.00135	< 2E-16
Slope	0.00428	0.00019	< 2E-16
Lake_dummy	0.12300	0.00142	< 2E-16
Log(Sun_Eve)	0.00804	0.00023	< 2E-16
Spatial explanatory variables: socio-economic			
Pop_300m	-0.00026	0.00002	< 2E-16
Hotel_300m	0.02554	0.00034	< 2E-16
Perc_NW	0.02641	0.00027	< 2E-16
Perc_SE	-0.00172	0.00020	< 2E-16
Year_10	-0.01388	0.00212	5.41E-11
Year_11	-0.00966	0.00200	1.32E-06
Year_12	0.00858	0.00199	1.66E-05
Year_13	0.00155	0.00205	0.45000

Adjusted R^2 = 0.6533

AIC = 429.7

Table 26 Description of the global OLS model 3

Variable	Coefficient	SE	p-value
Intercept	5.79600	0.01628	< 2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22890	0.00046	< 2E-16
Story	0.01606	0.00040	< 2E-16
Stories	0.00084	0.00029	0.003
Attic	0.16500	0.00358	< 2E-16
Garden	0.02755	0.00234	< 2E-16
Terrace	0.11560	0.00272	< 2E-16
Age1	0.14890	0.00189	< 2E-16
Age2	0.08695	0.00185	< 2E-16
Age3	0.05183	0.00141	< 2E-16
Age4	0.20140	0.00160	< 2E-16
Spatial explanatory variables: structural			
Dist_Highway	-0.00015	0.00005	0.004
Highway	-0.07350	0.00436	< 2E-16
Dist_Station	-0.00148	0.00010	< 2E-16
Acc_Tot	0.04283	0.00150	< 2E-16
Slope	0.00375	0.00019	< 2E-16
Lake_dummy	0.12600	0.00139	< 2E-16
Log(Sun_Eve)	0.00475	0.00022	< 2E-16
Spatial explanatory variables: socio-economic			
Univ	0.02273	0.00020	< 2E-16
Pop_300m	-0.00025	0.00002	< 2E-16
Hotel_300m	0.02654	0.00034	< 2E-16
Perc_Foreigners	0.00362	0.00009	< 2E-16
Year_10	-0.00184	0.00210	0.382
Year_11	0.01127	0.00196	8.7E-09
Year_12	0.03516	0.00193	< 2E-16
Year_13	0.03743	0.00194	< 2E-16

Adjusted R^2 = 0.6533

AIC = -1947.5

Table 27 Description of the global OLS model 4

Variable	Coefficient	SE	p-value
Intercept	1.73222	0.54196	0.001
Dependent variable			
RentPerSQM			
Building related explanatory variables: structural			
Room	-2.76205	0.01697	< 2E-16
Story	0.18923	0.01338	< 2E-16
Attic	3.11919	0.12623	< 2E-16
Terrace	1.04003	0.09670	< 2E-16
Age1	5.27509	0.06986	< 2E-16
Age2	0.81754	0.06781	< 2E-16
Age3	0.05835	0.05103	0.253
Age4	1.49797	0.05660	< 2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.01773	0.00184	< 2E-16
Highway	-2.55562	0.16305	< 2E-16
Dist_Station	-0.04339	0.00360	< 2E-16
Acc_Tot	2.02930	0.04834	< 2E-16
Slope	0.12550	0.00680	< 2E-16
Lake_dummy	2.96065	0.05106	< 2E-16
Log(Sun_Eve)	0.19500	0.00830	< 2E-16
Spatial explanatory variables: socio-economic			
Pop_300m	0.02321	0.00065	< 2E-16
Hotel_300m	1.33720	0.01259	< 2E-16
Perc_NW	0.61154	0.00955	< 2E-16
Perc_SE	-0.08762	0.00720	< 2E-16
Year_10	-0.34429	0.07724	8.31E-06
Year_11	-0.05502	0.07257	0.448
Year_12	0.57419	0.07209	1.66E-15
Year_13	0.07580	0.07391	0.305

Adjusted R^2 = 0.4337

AIC = 1'352'000.0

Table 28 Description of the global OLS model 6

Variable	Coefficient	SE	p-value
Intercept	11.76268	0.59103	<2E-16
Dependent variable			
RentPerSQM			
Building related explanatory variables: structural			
Room	-2.76577	0.01694	<2E-16
Story	0.16864	0.01335	<2E-16
Attic	3.18475	0.12602	<2E-16
Terrace	1.05083	0.09652	<2E-16
Age1	5.22326	0.06980	<2E-16
Age2	0.70611	0.06780	<2E-16
Age3	-0.01944	0.05094	0.703
Age4	1.39108	0.05654	<2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.00350	0.00185	0.059
Highway	-2.77599	0.16307	<2E-16
Dist_Station	-0.03568	0.00359	<2E-16
Acc_Tot	1.05698	0.05424	<2E-16
Slope	0.11780	0.00679	<2E-16
Lake_dummy	3.05392	0.05034	<2E-16
Log(Sun_Eve)	0.11506	0.00806	<2E-16
Spatial explanatory variables: socio-economic			
Univ	0.52002	0.00700	<2E-16
Pop_300m	0.02364	0.00065	<2E-16
Hotel_300m	1.36161	0.01255	<2E-16
Perc_Foreigners	0.05907	0.00333	<2E-16
Year_10	-0.04274	0.07691	0.578
Year_11	0.46218	0.07147	1.00E-10
Year_12	1.22970	0.07023	<2E-16
Year_13	0.95799	0.07042	<2E-16

Adjusted R^2 = 0.4357

AIC = 1'351'300.0

SAR models

Table 29 Description of the SAR*lag* model 1

Variable	Coefficient	SE	p-value
Intercept	4.57580	0.02421	< 2.2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22730	0.00047	< 2.2E-16
Story	0.01656	0.00040	< 2.2E-16
Stories	0.00162	0.00028	6.3E-09
Attic	0.16337	0.00359	< 2.2E-16
Garden	0.02922	0.00235	< 2.2E-16
Terrace	0.11410	0.00272	< 2.2E-16
Age1	0.14852	0.00189	< 2.2E-16
Age2	0.08997	0.00185	< 2.2E-16
Age3	0.05269	0.00142	< 2.2E-16
Age4	0.20135	0.00160	< 2.2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.00047	0.00005	< 2.2E-16
Highway	-0.06122	0.00436	< 2.2E-16
Dist_Station	-0.00171	0.00010	< 2.2E-16
Acc_Tot	0.08764	0.00133	< 2.2E-16
Slope	0.00427	0.00019	< 2.2E-16
Lake_dummy	0.11946	0.00141	< 2.2E-16
Log(Sun_Eve)	0.00787	0.00023	< 2.2E-16
Spatial explanatory variables: socio-economic			
Pop_300m	-0.00025	0.00002	< 2.2E-16
Hotel_300m	0.02524	0.00034	< 2.2E-16
Perc_NW	0.02544	0.00027	< 2.2E-16
Perc_SE	-0.00176	0.00020	< 2.2E-16
Year_10	-0.01260	0.00193	7.0E-11
Year_11	-0.00778	0.00181	1.7E-05
Year_12	0.01147	0.00183	3.6E-10
Year_13	0.00541	0.00196	0.006

Rho = 0.10407 (p-value = <2.22E-16)

AIC_{Lag} = -1175.4

AIC_{OLS} = 429.7

ΔAIC = 1605.1

Table 30 Description of the SAR*lag* model 2

Variable	Coefficient	SE	p-value
Intercept	5.03990	0.02464	< 2.2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22742	0.00046	< 2.2E-16
Story	0.01621	0.00039	< 2.2E-16
Stories	0.00073	0.00026	0.004
Attic	0.16511	0.00357	< 2.2E-16
Garden	0.02730	0.00238	< 2.2E-16
Terrace	0.11405	0.00271	< 2.2E-16
Age1	0.14651	0.00188	< 2.2E-16
Age2	0.08465	0.00184	< 2.2E-16
Age3	0.05027	0.00140	< 2.2E-16
Age4	0.19760	0.00159	< 2.2E-16
Spatial explanatory variables: structural			
Dist_Highway	-0.00010	0.00004	0.020
Highway	-0.06907	0.00438	< 2.2E-16
Dist_Station	-0.00151	0.00010	< 2.2E-16
Acc_Tot	0.04569	0.00142	< 2.2E-16
Slope	0.00367	0.00019	< 2.2E-16
Lake_dummy	0.12114	0.00139	< 2.2E-16
Log(Sun_Eve)	0.00530	0.00023	< 2.2E-16
Spatial explanatory variables: socio-economic			
Univ	0.02011	0.00025	< 2.2E-16
Pop_300m	-0.00024	0.00002	< 2.2E-16
Hotel_300m	0.02616	0.00034	< 2.2E-16
Perc_Schengen	0.00597	0.00025	< 2.2E-16
Perc_OutSchengen	0.00123	0.00022	3.0E-08
Year_10	-0.00253	0.00200	0.205
Year_11	0.00911	0.00174	1.7E-07
Year_12	0.03208	0.00183	< 2.2E-16
Year_13	0.03251	0.00187	< 2.2E-16

Rho = 0.098776 (p-value = <2.22E-16)

AIC_{Lag} = -3543.4

AIC_{OLS} = -2084.6

ΔAIC = 1458.8

Table 31 Description of the SAR*lag* model 3

Variable	Coefficient	SE	p-value
Intercept	5.04620	0.02508	< 2.2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22738	0.00046	< 2.2E-16
Story	0.01603	0.00039	< 2.2E-16
Stories	0.00090	0.00022	4.9E-05
Attic	0.16498	0.00357	< 2.2E-16
Garden	0.02748	0.00230	< 2.2E-16
Terrace	0.11436	0.00270	< 2.2E-16
Age1	0.14722	0.00188	< 2.2E-16
Age2	0.08541	0.00184	< 2.2E-16
Age3	0.05069	0.00141	< 2.2E-16
Age4	0.19812	0.00159	< 2.2E-16
Spatial explanatory variables: structural			
Dist_Highway	-0.00012	0.00004	0.005
Highway	-0.07207	0.00434	< 2.2E-16
Dist_Station	-0.00139	0.00010	< 2.2E-16
Acc_Tot	0.04438	0.00146	< 2.2E-16
Slope	0.00375	0.00019	< 2.2E-16
Lake_dummy	0.12258	0.00139	< 2.2E-16
Log(Sun_Eve)	0.00471	0.00022	< 2.2E-16
Spatial explanatory variables: socio-economic			
Univ	0.02199	0.00020	< 2.2E-16
Pop_300m	-0.00024	0.00002	< 2.2E-16
Hotel_300m	0.02622	0.00034	< 2.2E-16
Perc_Foreigners	0.00349	0.00009	< 2.2E-16
Year_10	-0.00104	NA	NA
Year_11	0.01229	0.00142	< 2.2E-16
Year_12	0.03690	0.00133	< 2.2E-16
Year_13	0.03970	0.00128	< 2.2E-16

Rho = 0.099660 (p-value = <2.22E-16)

AIC_{Lag} = -3433.0

AIC_{OLS} = -1947.5

ΔAIC = 1485.5

Table 32 Description of the SAR*error* model 1

Variable	Coefficient	SE	p-value
Intercept	5.32840	0.01550	< 2.2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22831	0.00047	< 2.2E-16
Story	0.01668	0.00040	< 2.2E-16
Stories	0.00152	0.00029	1.4E-07
Attic	0.16526	0.00358	< 2.2E-16
Garden	0.02978	0.00235	< 2.2E-16
Terrace	0.11439	0.00273	< 2.2E-16
Age1	0.14819	0.00190	< 2.2E-16
Age2	0.08899	0.00186	< 2.2E-16
Age3	0.05340	0.00144	< 2.2E-16
Age4	0.20257	0.00162	< 2.2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.00053	0.00005	< 2.2E-16
Highway	-0.06415	0.00442	< 2.2E-16
Dist_Station	-0.00172	0.00010	< 2.2E-16
Acc_Tot	0.08854	0.00138	< 2.2E-16
Slope	0.00414	0.00019	< 2.2E-16
Lake_dummy	0.12143	0.00145	< 2.2E-16
Log(Sun_Eve)	0.00795	0.00024	< 2.2E-16
Spatial explanatory variables: socio-economic			
Pop_300m	-0.00025	0.00002	< 2.2E-16
Hotel_300m	0.02511	0.00034	< 2.2E-16
Perc_NW	0.02613	0.00028	< 2.2E-16
Perc_SE	-0.00191	0.00021	< 2.2E-16
Year_10	-0.00603	0.00209	0.004
Year_11	-0.00286	0.00207	0.167
Year_12	0.01620	0.00209	9.1E-15
Year_13	0.00936	0.00216	1.5E-05

Lambda = 0.26030 (p-value = <2.22E-16)

AIC_{Error} = -2935.4

AIC_{OLS} = 429.7

ΔAIC = 3365.1

Table 33 Description of the SAR*error* model 3

Variable	Coefficient	SE	p-value
Intercept	5.76780	0.01671	< 2.2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22829	0.00046	< 2.2E-16
Story	0.01613	0.00040	< 2.2E-16
Stories	0.00092	0.00029	0.001
Attic	0.16672	0.00357	< 2.2E-16
Garden	0.02785	0.00233	< 2.2E-16
Terrace	0.11488	0.00272	< 2.2E-16
Age1	0.14741	0.00189	< 2.2E-16
Age2	0.08536	0.00185	< 2.2E-16
Age3	0.05171	0.00143	< 2.2E-16
Age4	0.19950	0.00161	< 2.2E-16
Spatial explanatory variables: structural			
Dist_Highway	-0.00006	0.00005	0.272
Highway	-0.07483	0.00440	< 2.2E-16
Dist_Station	-0.00138	0.00010	< 2.2E-16
Acc_Tot	0.04485	0.00153	< 2.2E-16
Slope	0.00371	0.00019	< 2.2E-16
Lake_dummy	0.12462	0.00143	< 2.2E-16
Log(Sun_Eve)	0.00464	0.00023	< 2.2E-16
Spatial explanatory variables: socio-economic			
Univ	0.02252	0.00020	< 2.2E-16
Pop_300m	-0.00024	0.00002	< 2.2E-16
Hotel_300m	0.02613	0.00034	< 2.2E-16
Perc_Foreigners	0.00353	0.00010	< 2.2E-16
Year_10	0.00727	0.00208	4.67E-04
Year_11	0.01888	0.00203	< 2.2E-16
Year_12	0.04332	0.00203	< 2.2E-16
Year_13	0.04556	0.00205	< 2.2E-16

Lambda = 0.25132 (p-value = <2.22E-16)

AIC_{Error} = -5093.3

AIC_{OLS} = -1947.5

ΔAIC = 3145.8

Table 34 Description of the SAR*mix* model 1

Variable	Coefficient	NA	p-value
Intercept	4.10760	3.80E-02	< 2.2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22846	0.00047	< 2.2E-16
Story	0.01660	0.00040	< 2.2E-16
Stories	0.00140	0.00027	2.88E-07
Attic	0.16445	0.00358	< 2.2E-16
Garden	0.02982	0.00233	< 2.2E-16
Terrace	0.11453	0.00273	< 2.2E-16
Age1	0.14769	0.00190	< 2.2E-16
Age2	0.08811	0.00184	< 2.2E-16
Age3	0.05283	0.00142	< 2.2E-16
Age4	0.20157	0.00161	< 2.2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.00059	0.00005	< 2.2E-16
Highway	-0.06297	0.00438	< 2.2E-16
Dist_Station	-0.00167	0.00010	< 2.2E-16
Acc_Tot	0.08937	0.00140	< 2.2E-16
Slope	0.00405	0.00019	< 2.2E-16
Lake_dummy	0.11939	0.00148	< 2.2E-16
Log(Sun_Eve)	0.00798	0.00024	< 2.2E-16
Spatial explanatory variables: socio-economic			
Pop_300m	-0.00026	0.00002	< 2.2E-16
Hotel_300m	0.02491	0.00034	< 2.2E-16
Perc_NW	0.02549	0.00029	< 2.2E-16
Perc_SE	-0.00219	0.00021	< 2.2E-16
Year_10	-0.01064	0.00164	9.89E-11
Year_11	-0.00194	0.00064	0.002
Year_12	0.01908	0.00145	< 2.2E-16
Year_13	0.01616	0.00154	< 2.2E-16
Lagged variables			
Lag.Room	-0.05755	0.00142	< 2.2E-16
Lag.Story	-0.00304	0.00078	9.34E-05
Lag.Stories	-0.00053	0.00031	0.087
Lag.Attic	-0.08873	0.00894	< 2.2E-16
Lag.Garden	-0.00216	NA	NA
Lag.Terrace	-0.02704	0.00548	7.95E-07
Lag.Age1	-0.01325	0.00360	2.28E-04
Lag.Age2	-0.00097	NA	NA
Lag.Age3	-0.00517	0.00126	3.98E-05
Lag.Age4	-0.04363	0.00293	< 2.2E-16
Lag.Dist_Highway	-0.00063	0.00012	4.30E-08
Lag.Highway	0.01520	0.00694	0.028
Lag.Dist_Station	-0.00011	NA	NA
Lag.Acc_Tot	-0.03907	0.00285	< 2.2E-16
Lag.Slope	0.00011	0.00002	4.80E-08
Lag.Lake_dummy	-0.01736	0.00283	8.97E-10
Lag.Log(Sun_Eve)	-0.00166	0.00044	1.3E-04
Lag.Pop_300m	0.00004	NA	NA
Lag.Hotel_300m	0.00458	0.00118	1.0E-04
Lag.Perc_NW	-0.00391	0.00068	9.47E-09
Lag.Perc_SE	0.00335	0.00050	2.53E-11
Lag.Year_10	-0.01620	0.00164	< 2.2E-16
Lag.Year_11	-0.05917	0.00654	< 2.2E-16
Lag.Year_12	NA	NA	NA
Lag.Year_13	NA	NA	NA

Rho = 0.25612 (p-value = <2.22E-16)

AIC_{Mix} = -3055.5

AIC_{OLS} = 429.7

ΔAIC = 3485.2

Table 35 Description of the SAR*mix* model 2

Variable	Coefficient	SE	p-value
Intercept	4.51650	0.05019	< 2.2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22848	0.00046	< 2.2E-16
Story	0.01622	0.00043	< 2.2E-16
Stories	0.00063	0.00035	0.069
Attic	0.16598	0.00356	< 2.2E-16
Garden	0.02784	0.00241	< 2.2E-16
Terrace	0.11476	0.00275	< 2.2E-16
Age1	0.14639	0.00190	< 2.2E-16
Age2	0.08379	0.00183	< 2.2E-16
Age3	0.05092	0.00161	< 2.2E-16
Age4	0.19804	0.00165	< 2.2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.00003	NA	NA
Highway	-0.07021	0.00464	< 2.2E-16
Dist_Station	-0.00142	0.00011	< 2.2E-16
Acc_Tot	0.04766	0.00156	< 2.2E-16
Slope	0.00356	0.00019	< 2.2E-16
Lake_dummy	0.12112	0.00145	< 2.2E-16
Log(Sun_Eve)	0.00534	0.00025	< 2.2E-16
Spatial explanatory variables: socio-economic			
Univ	0.02034	0.00033	< 2.2E-16
Pop_300m	-0.00025	0.00002	< 2.2E-16
Hotel_300m	0.02585	0.00034	< 2.2E-16
Perc_Schengen	0.00587	0.00036	< 2.2E-16
Perc_OutSchengen	0.00115	0.00040	0.004
Year_10	0.00080	0.00072	0.267
Year_11	0.01687	0.00161	< 2.2E-16
Year_12	0.04163	0.00179	< 2.2E-16
Year_13	0.04536	0.00210	< 2.2E-16
Lagged variables			
Lag.Room	-0.05563	0.00149	< 2.2E-16
Lag.Story	-0.00270	NA	NA
Lag.Stories	-0.00138	NA	NA
Lag.Attic	-0.08781	0.00834	< 2.2E-16
Lag.Garden	-0.00145	NA	NA
Lag.Terrace	-0.02639	0.00861	0.002
Lag.Age1	-0.01402	0.00427	0.001
Lag.Age2	-0.00388	NA	NA
Lag.Age3	-0.00749	0.00468	0.110
Lag.Age4	-0.04253	0.00336	< 2.2E-16
Lag.Dist_Highway	-0.00054	0.00011	3.22E-07
Lag.Highway	0.01602	0.00693	0.021
Lag.Dist_Station	-0.00040	NA	NA
Lag.Acc_Tot	-0.03127	0.00391	1.33E-15
Lag.Slope	-0.00018	0.00010	0.069
Lag.Lake_dummy	-0.01929	0.00353	4.84E-08
Lag.Log(Sun_Eve)	-0.00071	0.00134	0.593
Lag.Univ	-0.00458	0.00054	< 2.2E-16
Lag.Pop_300m	0.00000	NA	NA
Lag.Hotel_300m	0.00492	0.00094	1.53E-07
Lag.Perc_Schengen	0.00151	0.00046	0.001
Lag.Perc_OutSchengen	-0.00054	0.00032	0.089
Lag.Year_10	-0.02236	0.00169	< 2.2E-16
Lag.Year_11	-0.06923	0.00628	< 2.2E-16
Lag.Year_12	NA	NA	NA
Lag.Year_13	NA	NA	NA

Rho = 0.24732 (p-value = <2.22E-16)

AIC_{Mix} = -5075.8

AIC_{OLS} = -2084.6

ΔAIC = 2991.2

Table 36 Description of the SAR*mix* model 3

Variable	Coefficient	SE	p-value
Intercept	4.52720	0.03937	< 2.2E-16
Dependent variable			
Ln(Rent)			
Building related explanatory variables: structural			
Room	0.22844	0.00046	< 2.2E-16
Story	0.01603	0.00038	< 2.2E-16
Stories	0.00082	0.00022	2.3E-04
Attic	0.16596	0.00353	< 2.2E-16
Garden	0.02800	0.00231	< 2.2E-16
Terrace	0.11503	0.00270	< 2.2E-16
Age1	0.14715	0.00188	< 2.2E-16
Age2	0.08452	0.00182	< 2.2E-16
Age3	0.05132	0.00140	< 2.2E-16
Age4	0.19861	0.00160	< 2.2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.00002	NA	NA
Highway	-0.07325	0.00423	< 2.2E-16
Dist_Station	-0.00131	0.00008	< 2.2E-16
Acc_Tot	0.04634	0.00141	< 2.2E-16
Slope	0.00362	0.00018	< 2.2E-16
Lake_dummy	0.12252	0.00137	< 2.2E-16
Log(Sun_Eve)	0.00478	0.00023	< 2.2E-16
Spatial explanatory variables: socio-economic			
Univ	0.02217	0.00021	< 2.2E-16
Pop_300m	-0.00024	0.00001	< 2.2E-16
Hotel_300m	0.02591	0.00034	< 2.2E-16
Perc_Foreigners	0.00339	0.00009	< 2.2E-16
Year_10	0.00213	0.00156	0.171
Year_11	0.01985	0.00177	< 2.2E-16
Year_12	0.04624	0.00181	< 2.2E-16
Year_13	0.05232	0.00188	< 2.2E-16
Lagged variables			
Lag.Room	-0.05562	0.00130	< 2.2E-16
Lag.Story	-0.00281	NA	NA
Lag.Stories	-0.00144	NA	NA
Lag.Attic	-0.08913	0.00831	< 2.2E-16
Lag.Garden	-0.00031	NA	NA
Lag.Terrace	-0.02528	0.00480	1.41E-07
Lag.Age1	-0.01476	0.00327	6.27E-06
Lag.Age2	-0.00421	NA	NA
Lag.Age3	-0.00697	0.00164	2.07E-05
Lag.Age4	-0.04227	0.00212	< 2.2E-16
Lag.Dist_Highway	-0.00060	0.00009	9.74E-12
Lag.Highway	0.01509	0.00738	0.041
Lag.Dist_Station	-0.00026	NA	NA
Lag.Acc_Tot	-0.03131	0.00218	< 2.2E-16
Lag.Slope	-0.00010	NA	NA
Lag.Lake_dummy	-0.01752	0.00256	7.29E-12
Lag.Log(Sun_Eve)	-0.00110	NA	NA
Lag.Univ	-0.00376	0.00034	< 2.2E-16
Lag.Pop_300m	0.00002	NA	NA
Lag.Hotel_300m	0.00427	0.00097	1.01E-05
Lag.Perc_Foreigners	0.00031	NA	NA
Lag.Year_10	-0.02131	0.00168	< 2.2E-16
Lag.Year_11	-0.06682	0.00567	< 2.2E-16
Lag.Year_12	NA	NA	NA
Lag.Year_13	NA	NA	NA

Rho = 0.24797 (p-value = <2.22E-16)

AIC_{Mix} = -4953.7

AIC_{OLS} = -1947.5

ΔAIC = 3006.2

Table 37 Description of the SAR*error* model 4

Variable	Coefficient	SE	p-value
Intercept	0.69487	0.55790	0.213
Dependent variable			
RentPerSQM			
Building related explanatory variables: structural			
Room	-2.79441	0.01696	< 2.2E-16
Story	0.18169	0.01335	< 2.2E-16
Attic	3.14707	0.12542	< 2.2E-16
Terrace	1.09021	0.09637	< 2.2E-16
Age1	5.31523	0.07020	< 2.2E-16
Age2	0.83440	0.06822	< 2.2E-16
Age3	0.06184	0.05153	0.230
Age4	1.48693	0.05721	< 2.2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.01710	0.00189	< 2.2E-16
Highway	-2.54504	0.16472	< 2.2E-16
Dist_Station	-0.04220	0.00367	< 2.2E-16
Acc_Tot	2.08606	0.04954	< 2.2E-16
Slope	0.10649	0.00690	< 2.2E-16
Lake_dummy	2.82945	0.05225	< 2.2E-16
Log(Sun_Eve)	0.18913	0.00850	< 2.2E-16
Spatial explanatory variables: socio-economic			
Pop_300m	0.02288	0.00066	< 2.2E-16
Hotel_300m	1.29690	0.01257	< 2.2E-16
Perc_NW	0.60755	0.00983	< 2.2E-16
Perc_SE	-0.09913	0.00739	< 2.2E-16
Year_10	0.59017	0.07591	7.55E-15
Year_11	0.65854	0.07512	< 2.2E-16
Year_12	1.27479	0.07574	< 2.2E-16
Year_13	0.80450	0.07829	< 2.2E-16

Lambda = 0.25854 (p-value = <2.22E-16)

AIC_{Error} = 1'349'100.0

AIC_{OLS} = 1'352'000.0

ΔAIC = 2900.0

Table 38 Description of the SAR*error* model 6

Variable	Coefficient	SE	p-value
Intercept	10.78064	0.60641	< 2E-16
Dependent variable			
RentPerSQM			
Building related explanatory variables: structural			
Room	-2.79923	0.01692	< 2E-16
Story	0.16337	0.01332	< 2E-16
Attic	3.19005	0.12518	< 2E-16
Terrace	1.11026	0.09617	< 2E-16
Age1	5.27446	0.07011	< 2E-16
Age2	0.74327	0.06816	< 2E-16
Age3	-0.01395	0.05144	0.786
Age4	1.38248	0.05714	< 2E-16
Spatial explanatory variables: structural			
Dist_Highway	0.00317	0.00190	0.096
Highway	-2.76568	0.16471	< 2E-16
Dist_Station	-0.03450	0.00366	< 2E-16
Acc_Tot	1.09605	0.05549	< 2E-16
Slope	0.10050	0.00689	< 2E-16
Lake_dummy	2.90903	0.05158	< 2E-16
Log(Sun_Eve)	0.10871	0.00827	< 2E-16
Spatial explanatory variables: socio-economic			
Univ	0.52500	0.00721	< 2E-16
Pop_300m	0.02347	0.00066	< 2E-16
Hotel_300m	1.32093	0.01252	< 2E-16
Perc_Foreigners	0.05674	0.00343	< 2E-16
Year_10	0.92791	0.07552	< 2E-16
Year_11	1.20166	0.07398	< 2E-16
Year_12	1.94914	0.07387	< 2E-16
Year_13	1.69752	0.07482	< 2E-16

Lambda = 0.26042 (p-value =<2.22E-16)

AIC_{Error} = 1'348'300.0

AIC_{OLS} = 1'351'300.0

ΔAIC = 3000.0