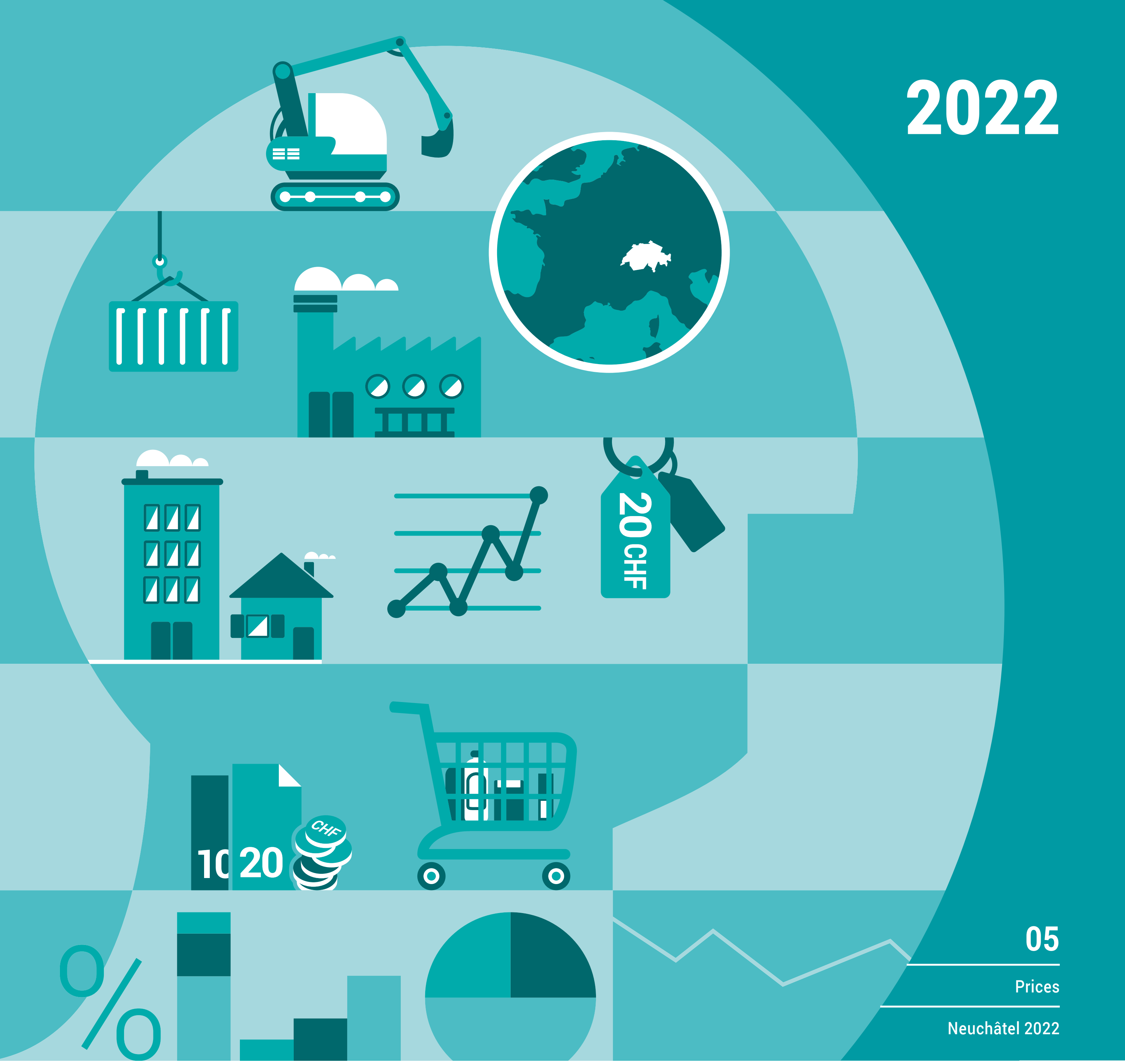


2022

05

Prices

Neuchâtel 2022

Rental price index: methodological report

New hedonic rental price model

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Statistical Office FSO

Topic of Prices

Current publications linked with this topic

Almost all publications published by the FSO are available in electronic form on the website www.statistics.admin.ch free of charge. Print publications can be ordered by telephone on 058 463 60 60 or by emailing order@bfs.admin.ch.

Swiss residential property price index, Quality Adjustment Procedure, Neuchâtel 2020, FSO number 2074-2002

Swiss residential property price index (Q4 2019 = 100), Methodological principles, Neuchâtel 2020, 44 pages, FSO number 2074-2001

Services Producer Price Indices (SPPI), Methodological foundations, Neuchâtel 2020, 113 pages, FSO number 2026-2000

Harmonised Index of Consumer Prices (HICP), Overview of methods and weightings 2018, Neuchâtel 2018, 28 pages, FSO number 953-1800-05

Schweizerische Baupreisstatistik. Oktober 2015 = 100, Methodische Grundlagen, Neuchâtel 2016, 60 Seiten, BFS-Nummer 622-1501

Producer and import price index December 2015 = 100, Fundamental principles, Neuchâtel 2016, 76 pages, FSO number 1198-1501

Consumer Price Index (December 2015 = 100), Methodological foundations, Neuchâtel 2016, 64 pages, FSO number 855-1500

Topic of prices online

www.statistics.ch → Topics → 05 – Prices

Rental price index: methodological report

New hedonic rental price model

Editor Laetitia Fourcade, FSO

Published by Federal Statistical Office (FSO)

Neuchâtel 2022

Published by: Federal Statistical Office (FSO)
Information: LIK@bfs.admin.ch, tel. +41 58 463 69 00
Editor: Laetitia Fourcade, FSO
Series: Swiss Statistics
Topic: 05 Prices
Original text: French
Translation: FSO language services
Layout: DIAM Section, Prepress / Print
Graphics: PREIS Section, FSO
Maps: DIAM Section, ThemaKart
Online: www.statistics.admin.ch
Print: www.statistics.admin.ch
Federal Statistical Office, CH-2010 Neuchâtel,
order@bfs.admin.ch, tel. +41 58 463 60 60
Printed in Switzerland

FSO number: 2121-2200
ISBN: 978-3-303-05774-2

Table of contents

Introduction

The housing rental price index makes up the largest share of the basket underlying the consumer price index (CPI). Since 2011, an adjustment has been made in the housing rental price index to account for differences in the characteristics of dwellings entering and leaving the sample. This quality adjustment is based on a hedonic model that expresses the rental price as a function of the different characteristics of the dwelling. The model that was used from 2011 to 2020 is based on data from the survey of the structure of rental prices from 2003. As part of the 2020 revision of the CPI, a new model was prepared using more recent data from the rental price index from 2014 to 2018, supplemented with housing geolocation variables. Following a brief review of the quality adjustment process applied in the rental price index, this article describes the data, methodology and final form of the new hedonic rental price model.

1 Quality adjustment in the rental price index

The rental price index measures the change in rental prices for dwellings in Switzerland. Each quarter, 12% of the sample (representing approximately 1500 dwellings) is replaced in order to keep track of the state of the rental housing market. To allow calculation of the change in rental prices, properties entering the sample should have exactly the same characteristics in terms of structure and location as properties leaving the sample. Due to the unique nature and to the random sampling of every dwelling, however, this is not possible, and an adjustment is necessary in order to keep track of these quality differences (Matthey, Becker Vermeulen, & Corti, 2014). The quality adjustment in the rental price index is based on stratification in terms of age group and number of rooms along with usage of *hedonic repricing* (Eurostat, 2017).

Stratification makes it possible to replace dwellings leaving the sample with incoming units that are equivalent in terms of the number of rooms and age category. The *hedonic repricing* method involves calculating a quality adjustment factor which neutralises differences in characteristics not taken into account by the stratification. This adjustment factor is based on the estimation by quarter t of dwellings entering and leaving the sample using a hedonic model. It is equal to the quotient of the weighted average of the estimated rental prices of dwellings entering the sample by that of dwellings leaving the sample within each cell. Thus, we have for a cell i in quarter t:

$$\text{adjustment factor}_{i,t} = \frac{\left(\prod_j \hat{y}_j\right)^{\frac{1}{\sum_j p_j}}}{\left(\prod_k \hat{y}_k\right)^{\frac{1}{\sum_k p_k}}}$$

where $\hat{y}_j$ is the estimated rental price of dwelling j entering sample in quarter *t*,
p_j is the survey weight of dwelling j entering sample in quarter *t*,
$\hat{y}_k$ is the estimated rental price of dwelling k leaving sample in quarter *t*,
p_k is the survey weight of dwelling k leaving sample in quarter *t*.

This adjustment factor is multiplied with the index of the cell calculated on the basis of the actually surveyed rental prices for dwellings entering and leaving the sample. The adjusted index obtained in this manner and the index calculated on the basis of dwellings remaining in the sample from one period to the next are aggregated in each cell using a weighted average.

The hedonic model that was used from 2011 to 2020 is based on 91 243 observations from the 2003 survey of the structure of rental prices (Federal Statistical Office, 2007). It includes an extensive set of variables, especially variables related to the housing structure (age, living area, number of rooms, etc.), the age of the current lease agreement and ten geolocation variables (Lüscher, Salvi, Bröhl, & Horehájová, 2010). Nevertheless, the model needs to be updated due to the age of the database. One question that is relevant for the future is how often the model should be updated. An update every five years in connection with the revision of the CPI may possibly be considered.

2 Data

Choice of the database

Data from the 2015 structural survey (SE) on one hand and data from the rental price index (RPI) from 2010 to 2018 on the other were analysed in order to determine which data source would be most suitable for use in our modelling. Besides the net rents, the two databases also indicate the precise location of the dwellings based on their federal building identification number (EGID). This makes it possible to supplement the information with data from the Buildings and Dwellings Statistics and the Federal Register of Buildings and Dwellings (BDS, RBD) as well as other geolocation data furnished by the Federal Administration. The SE provides a snapshot of the housing stock at a given moment, whereas the RPI represents a survey of a rotating panel that is carried out each quarter. A single dwelling can be taken into account for up to eight consecutive quarters. This structure requires special treatment (see Selection of the observations on page 9).

Each database has specific advantages for calculation of a hedonic model. The SE contains a large number of observations (approximately 122 000), and a single year of the survey is thus adequate to calculate a model. In contrast, several years of the RPI survey must be combined in order to obtain a sufficient number of observations, which can lead to undesirable differences between the observations. However, the RPI provides key variables that are missing from the SE, including the age of the current lease agreement, the landlord type and a detailed categorisation of the rental status.

In order to choose the database, the correlation of each variable with the rent was examined and several thousand models involving various transformations, categorisations and combinations of variables were compared on the basis of their predictive power and the quality of their residuals.[1] Since the RPI contains variables that are missing from the SE, this step was repeated with models that included only the common structural variables between the two databases.[2]

The best models obtained with the SE provide a less accurate prediction of the variance observed in the rental prices compared to the best models using the RPI (Federal Statistical Office, 2019). For models including all of the variables, the data from the SE exhibit 20% worse predictive power compared to the RPI data. For models including only the structural variables common to both databases and the cantons, there is already a difference of over 15%. On the basis of these analyses, the RPI database was chosen for hedonic modelling of rental prices.

Variables

The variable that the hedonic rental price model seeks to predict is the monthly rent net of additional charges. This is the information that is surveyed in the RPI survey. For approximately 10% of the dwellings, the rent that is collected represents a lump sum, i.e. the additional charges are included but the amount is unknown. A net rent is thus imputed for the index calculation. Our model uses the surveyed net rents as well as the imputed net rents. Moreover, 1% of the dwellings surveyed for the RPI exhibit extreme rents. Although these rents were excluded from the index calculation, they were retained for modelling purposes.

Different variables were tested for use in predicting the net rent of the dwellings. These variables are listed along with their source in Table T1 (page 8). They are split into three categories: structural variables describing the physical characteristics of the dwelling, variables related to the lease agreement, and geolocation variables describing the geographical location of the dwelling.

[1] The adjusted R^2 (R^2 adj.), the Akaike information criterion (AIC), the Anderson-Darling normality test and the Fligner-Killeen heteroscedasticity test were used. For definitions of R^2 adj. and AIC, see Annex 1 on page 52.

[2] The predictor variables common to both databases are the construction period, the number of rooms, the living area, the floor, the dwelling type and the number of garages.

Source of the tested predictor variables T1

	Tested predictor variables	Source
Structural variables	Year of construction; number of rooms; living area; floor; building type; parking spaces; penthouse; duplex; loft; number of bathrooms; number of separate toilets; type of exterior space; lift; Minergie® certificate; renovation	Rental price index
Variables related to the lease agreement	Year of signing of lease agreement; rental status; landlord type; year of survey	Rental price index
Geolocation variables	Tax burden	Federal Tax Administration
	Travel time to centres and agglomerations; quality of available public transport service; rate of second homes	Federal Office for Spatial Development
	Slope; exposure; distance to lakes, waterways, high-voltage power lines	Federal Office of Topography
	Canton; municipality type; potential view of mountains or lakes	Federal Statistical Office
	Daytime and night-time road noise; daytime and night-time train noise	Federal Office for the Environment
	Daytime and night-time aircraft noise	Federal Office of Civil Aviation

Source: FSO – Consumer Price Index (CPI)

Structural variables

The structural variables are gathered directly through the RPI survey that landlords are requested to complete. If any of the values are missing, data from the RBD can be used to fill in the year of construction of the building, the number of rooms, the living area and the floor on which the dwelling is located. The number of rooms surveyed does not include kitchens, half-rooms or extra rooms with living space located outside of the dwelling. The building type distinguishes detached houses from buildings with multiple dwellings. Parking spaces are divided into two categories: individual or shared garages, and exterior parking spaces, including covered spaces. For modelling purposes, parking spaces are considered only if the corresponding rent is included in the net rent of the dwelling.

The RPI survey also asks landlords whether the rented flat is a duplex (on two floors), a penthouse (with a roof terrace) or a loft (e.g. in a former factory). The survey asks for the number of bathrooms and separate toilets as well as about the presence of exterior space in four different categories: balcony less than 4 square metres, balcony greater than 4 square metres, garden access and terrace. The RPI also asks for information about the presence of a lift or Minergie® certification as well as the year in which a complete renovation of the dwelling was carried out, if relevant.

Variables related to the lease agreement

Variables related to the lease agreement are included in the RPI survey of landlords. The year when the lease agreement was signed indicates when the current lease agreement began. The rental status of the dwelling distinguishes four types of tenancy agreements: a lease agreement for cooperative or subsidised housing; a lease agreement with reduced rent due to a family relationship or friendship between the tenant and landlord; a lease agreement with reduced rent due to caretaker work; or none of the above-mentioned categories.

The type of owner of the housing is divided into six categories: private individuals; pension, insurance or investment funds; cooperatives; government authorities; real estate or building companies; owners not belonging to any of the above types. Finally, the survey year indicates when the RPI survey took place.

Geolocation variables

The geolocation variables that were studied during development of the hedonic model come from different sources (see Table T1). The relationship between a dwelling surveyed in the RPI and its precise location in Switzerland is determined using the building's EGID number.[3] The geolocation variables that are applied for modelling rental prices are also used in the hedonic model of the Swiss residential property price index (Federal Statistical Office, 2020). Thus, the rental price index and the property price index enjoy a certain degree of synergy in the processing of these variables for their respective purposes. There are two types of geolocation: the “macro location” represents the characteristics of the municipality in which the housing is located, whereas the “micro location” reflects the characteristics of the location of the building within the municipality.

Macro location

The classification scheme for municipalities developed by the Federal Statistical Office distinguishes urban, peri-urban and rural municipalities based on nine categories: urban municipality of a large agglomeration, of a medium-sized agglomeration, of a small or outside agglomeration; peri-urban municipality of high density, of medium density or of low density; municipality of a rural centre, centrally located rural municipality and lastly, peripheral rural municipality. This categorisation is based on criteria related to density, size and accessibility (Federal Statistical Office, 2017). Moreover, the travel time from each municipality in Switzerland to the most easily accessible core city or regional centre is calculated by the Federal Office for Spatial Development. Basel, Bern, Geneva, Lausanne, Lugano and Zurich are considered as core cities, whereas some 50 agglomerations or municipality centres outside agglomerations are considered as

[3] Prior to modification of the survey framework of the RPI survey in November 2016, the EGID was obtained by matching the address of the housing in the RBD. The EGID was taken directly from the framework of the survey thereafter.

regional centres. Data is available on the travel time in minutes via public transport or via private motorised transport (Federal Office for Spatial Development, 2021). The Federal Office for Spatial Development also has data on the percentage of second homes in every municipality in Switzerland (Federal Office for Spatial Development, 2017).

Finally, one variable that was tested in the modelling work as a macro location variable is the tax burden. Although this variable does not represent a quality of the housing as such, it does serve as a proxy variable for the quality of the location. The Federal Tax Administration publishes the tax burden in each municipality for different types of households and different income levels on an annual basis. This burden corresponds to the cantonal, communal and parish taxes and is expressed as a percentage of the gross labour income (Federal Tax Administration, 2021). Several combinations of household type and gross labour income were tested for modelling purposes.[4]

Micro location

A value in decibels for road, train (Federal Office for the Environment, 2021) and aircraft noise (Federal Office of Civil Aviation, 2021) during the day and night (10pm to 6am) was attributed to each building in our sample based on the geographical coordinates. Moreover, the quality of public transport service as calculated by the Federal Office for Spatial Development is expressed by a letter from A to D. This is determined based on the distance to transit stops, the type of public transport service at the stop and the frequency of service at the stop (Federal Office for Spatial Development, 2010). No accessibility score is given to dwellings which are further than 1 kilometre away from stops. The location of lakes, waterways and high-voltage power lines is available from the Federal Office of Topography. We used this information to attribute the distance from such elements to each building in our sample. Only lakes with an area greater than 1 square kilometre and waterways with a minimum width of 5 metres and length of 500 metres were considered in the analysis.

The potential view of mountains and lakes, expressed in terms of the number of potentially visible peaks or hectares of lake surface, is calculated by the Federal Statistical Office based on the elevation models swissALTI3D from swisstopo and EU-DEM from the European Environment Agency (European Environment Agency, 2021). For each building, the 300 most dominant peaks[5] within a radius of 125 kilometres in Switzerland and 30 kilometres outside Switzerland are taken into account along with the surface area of lakes within a radius of 20 kilometres from the building. A potential view as used here does not take into account any buildings or vegetation that might obstruct the view.[6] Finally, the slope of the land and the exposure in degrees were tested in the hedonic model.

Selection of the observations

The RPI survey takes place each quarter. On average 10 000 dwellings are surveyed each quarter. 8500 of these dwellings were already present in the sample in the previous quarter; they are re-surveyed in a follow-up survey. 1500 dwellings enter the sample for the first time (the same number of dwellings also leaves the sample each quarter). A single dwelling may be surveyed for up to eight consecutive quarters. Landlords have the opportunity in the follow-up survey each quarter to correct any details related to the lease agreement or the structure of the dwelling. As part of our modelling of the RPI data, we first corrected any non-plausible changes in values and then deleted duplicate observations from the database. These operations are illustrated in Table T2 (page 10).

It would be unrealistic for the geographical coordinates, the canton[7], the year of construction, the floor or the type (penthouse, duplex or home) to change over the course of the survey for a single dwelling. In cases where this did occur nevertheless, we only took into account the last value that was surveyed. In contrast, it is possible for the rent, the number of garages or parking spaces included in the rent, the year the lease agreement began, the owner type or the rental status to actually change over the course of the survey. In very rare cases, it is also possible for the number of rooms and the living area of the dwelling to actually change over the course of the survey.[8] Lastly, the number of bathrooms, the number of separate toilets, the type of exterior space, the presence of a lift or a Minergie® certificate, and the existence of a renovation are only surveyed once during the initial survey. These values may not be corrected thereafter.

By deleting redundant observations from the database, we are able to obtain a maximum degree of heterogeneity between the observations while also increasing the precision of the estimators (Wooldridge, 2012). The database formed in this manner includes all unique observations present in the RPI data collected between December 2010 and February 2018 for a total of 72 757 observations.

---

4 Testing involved the household types "single", "married person without child", "married person with two children", and "both spouses in paid employment with two children" along with gross labour income of CHF 50 000, 100 000, 150 000 and 200 000.

5 The dominance of a peak is calculated as a function of the distance to the nearest summit.

6 However, natural obstacles such as hills and mountains are considered. The estimate is calculated based on a height of 2 metres above the ground.

7 We should note that a change in municipality number could possibly occur due to a merger of municipalities or a change of canton. However, this specific case has not occurred in our database.

8 If the change in the number of rooms or the living area is confirmed by the RBD or if the surveyed rent changes simultaneously in the expected direction, then only the change in living area or number of rooms is considered to have actually taken place. Such cases only concern 0.2% of the dwellings in the sample.

Correction and selection of observations for a fictional dwelling in the RPI surveyed over three quarters T2

	Quarter	Rent	Surveyed floor	Corrected floor for modelling	Observation selected for modelling
A single dwelling surveyed 3 times	1/3	CHF 1 500	~~3~~	2	✓
	2/3	CHF 1 750	2		**x**
	3/3	CHF 1 750	2		✓

Source: FSO – Consumer Price Index (CPI)

3 Methodology

Initial estimates

Following our descriptive analysis of the data, different categorisations and transformations (e.g. square or logarithmic) of the variables were carried out. Thousands of models combining the different available variables were generated in this process. These models were ranked according to several performance criteria, using the three following indicators: adjusted R^2 (R^2 adj.) describing the share of the variance present in the rents predicted by the model and adjusted to penalise for the addition of predictor variables in the model; the Akaike information criterion (AIC) based on the likelihood function of the model and also penalising each additional predictor variable; the Bayesian information criterion (BIC), which is a variation on AIC with a larger penalty for additional variables. For algebraic definitions of the measures that were applied, see Annex 1 on page 52.

Modelling

Cross-validation was then used to evaluate the ten best candidate models: the coefficient values were estimated using 90% of the observations (training set) and the model's predictive capacity was evaluated with the remaining 10% (validation set). The process was then repeated until all of the observations in the database have passed through the validation set. In addition to the indicators mentioned in the Initial estimates section, the predictive capacity was estimated based on the mean absolute error (MAE) between rents estimated by the model and rents in the validation set, as well as the root mean square error (RMSE), which puts more weight on extreme errors compared to the MAE. For algebraic definitions of these measures, see Annex 1 on page 52.

Following this step, the most promising models were reworked manually focusing on the choice of variables to be included in the model and their form. This part of the modelling process is described in the Optimisation of the variables and Interaction variables sections. Cross-validation and the performance indicators were used again during the whole phase in which we manually refined the model. Supplemental tests were also carried out focussing on the handling of influential observations and the estimation period of the model.

Optimisation of the variables

The structural variables number of separate toilets, lift and Minergie® certificate, which are collected solely during the initial landlord survey, contain too many missing values and were not retained.[1] The variables loft, number of covered or non-covered exterior parking spaces, number of bathrooms, type of exterior space, renovation, distance to waterways and exposure were also eliminated because their presence does not increase the adjusted R^2 of the models, nor does it reduce the MAE and RMSE of the cross-validation.

The tax burden, which is not considered directly as a quality characteristic, is used as a proxy variable for the quality of the dwelling's location. In view of the nature of this variable, special attention was given to the question of whether to include it in the model. Because this variable makes it possible to increase the predictive power of model 1%, the decision was made to retain it.

The objective of the model is not related to analysis of the implicit prices of each characteristic, but rather to its general predictive capacity. However, the economic significance of the coefficients and their statistical significance were still subject to careful evaluation, and the elimination of certain variables was tested along with other transformations and categorisations until the best results were obtained regarding the implicit prices of each variable as well as the general performance of the model.

Interaction variables

The interaction between two predictor variables can be used to adjust the effect of one variable on the rent according to the value of another variable. For example, by introducing an interaction between the living area and the municipality type, it is possible to model an implicit price of the living area that varies according to whether the dwelling is located in a rural municipality or an agglomeration. As part of the modelling process, different interactions between variables were tested. Interactions between the municipality type and the living area, age, rate of second homes and slope, as well as interactions between the living area and age with the dwelling types penthouse and duplex, proved to be significant. Moreover, joint hypothesis tests with an F-test confirm that the model benefits from including the interactions. In contrast, they have little influence on the coefficients of the

[1] The missing values are as follows: number of separate toilets 41%, presence of a lift 35% and Minergie® certification 61%.

variables and the global adjustment of the model. Furthermore, the number of available observations is sufficiently large to include these 40 additional coefficients in the model. This allows more precise modelling of certain particularly important variables such as the living area and municipality type.

Influential observations

Cook's distance (Cook, 1977) was used in order to determine which observations have an especially large influence on the model's estimation. This value (see formula in Annex 1 on page 52) allows evaluation of the impact on the residuals (the share of the rent that is not predicted by the model's variables) if an observation is omitted when estimating the model's parameters. This operation is repeated for each observation in the database. An observation was deemed to be especially influential if it surpassed the threshold $4/(n-k)$, where n is the number of dwellings in the database and k is the number of parameters in the estimated model. The impact of retaining especially influential observations in the model was evaluated in terms of the structure of the residuals and the general performance of the model (see Performance of the model on page 48). The analysis was repeated with different models while adjusting the variables included in the model, the interaction variables or the estimation period.

For example, the final model (see detailed discussion in the Model section on page 13), which is estimated based on the period 2014 – 2018 and includes interaction variables, was evaluated before and after excluding approximately 2500 especially influential observations exhibiting a Cook's distance greater than the above-mentioned threshold. Based on our analysis, we were able to verify that these influential observations do not exhibit any particular structure. Excluding these observations has little influence on the value of the model's coefficients and helps to improve certain characteristics related to graphical analysis of the residuals (see Annex 2 on page 53 compared with the Residuals section on page 46). In contrast, the conclusions from the tests on the residuals presented in the Residuals section were not altered. Finally, excluding the observations violating Cook's distance increases the model's R^2 adj. by 7%.

Estimation period

The observations in the database range from 2010 to 2018. Modelling tests were carried out with the whole database as well as with databases covering periods of two years, three years and five years. The general conclusion from these tests is that the performance of models estimated based on the last five years is virtually identical to that of models estimated using the whole database. The significance of certain rare coefficients is impacted. However, the structure of the residuals and the results of tests on the residuals (see the Performance of the model section on page 48) exhibit practically no variation. In contrast, estimation periods of two years and three years do not permit attainment of a sufficient number of observations in certain constellations of variables and were not retained. Since models estimated based on the last five years of data and the entire database are equivalent, modelling over five years with the most recent data was preferred.

Assessment

Following these modelling steps, the results of the hedonic model were assessed. Mick Silver, Professor Emeritus of Economic Statistics at Cardiff University and Senior Economist at the International Monetary Fund, carried out this assessment in 2020 on the basis of detailed documentation of the process and the results of the modelling as well as many discussions with the staff of the Prices Section. The conclusions from the analysis report are available on the site of the Federal Statistical Office (Silver, 2020).

4 Model

Form of the model

Rosen was the first to theorise the concept of hedonic price regression in 1974 in his article "Hedonic Prices and Implicit Markets" (Rosen, 1974). Regression of this type is used to attribute an implicit price to different characteristics of a property. The hedonic model of rental prices is an equation that expresses the rent as the sum of predictor variables, multiplied by coefficients representing their significance in the prediction, plus the intercept and an error term, also known as a residual, which represents the share of the rent that is not predicted by the other terms. Thus:

$$y_i = \beta_1 x_{i,1} + \cdots + \beta_k x_{i,k} + \beta_0 + \varepsilon_i$$

where y_i is the rental price of dwelling i,
$x_{i,1}$ to $x_{i,k}$ are predictor variables 1 to k of dwelling i,
β_1 to β_k are the coefficients of the variables,
β_0 is the model intercept,
ε_i is the error term of dwelling i.

The model contains 41 559 observations and uses the natural logarithm of the rental price. Table T3 on page 14 lists the coefficient of each variable in the model ("Estimate") along with its standard error ("Std. Error"), which is used to calculate a confidence interval for the coefficient. The value of each coefficient is discussed in the Detailed description of the variables section. Table T3 on page 14 also lists the t-value for each coefficient resulting from Student's t-test, as well as the p-value from the t-test (Pr(>|t|)), which expresses the probability of obtaining the indicated estimate if the true coefficient of the model were zero. The asterisks next to the p-values are intended to aid interpretation of the values. The meaning of the asterisks is given at the end of the table. We can see that most of the coefficients are significant. The rare exceptions arise in connection with certain modalities of categorical variables whose presence in the model is important. The meaning of the variable names used in the model can be found in Annex 3 on page 55.

The last three lines of Table T3 on page 14 provide information about the general fit of the model. The residual standard error provides an estimate of the standard deviation of the share of the rental price that is not explained by the model's variables. The degrees of freedom used to calculate the standard error correspond to the number of observations less the number of parameters in the model. The multiple R-squared (R^2) and adjusted R-squared (R^2 adj.) indicate the share of the variance in the observed rental prices explained by the model before and after adjustment penalising the addition of predictor variables to the model. In our case we can see that 79% of the variance in the rental prices is explained by the model. Finally, the F-statistic and the associated p-value are used to evaluate the null hypothesis that all of the coefficients are zero compared to the alternative that at least one of them is not zero.

Detailed description of the variables

The variables in the model are detailed below. The graphical representation of the marginal effects of each variable is calculated by keeping the other variables in the model fixed, for the continuous variables at their mean value and for the discrete variables at their baseline level (i.e. the level integrated with the intercept of the model). The maps of the macro location and micro location data represent the most current data at the beginning of the year 2021.

Model coefficients T 3

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	6,799247582	0,023565868	288,52	<0,0000000000000002	***
BuildingAge	– 0,003183670	0,000057370	– 55,49	<0,0000000000000002	***
BuildingAge^2	0,000008088	0,000000171	47,24	<0,0000000000000002	***
NumberOfRooms2	0,142908423	0,005938702	24,06	<0,0000000000000002	***
NumberOfRooms3	0,188118395	0,006577732	28,60	<0,0000000000000002	***
NumberOfRooms4	0,205183354	0,007378405	27,81	<0,0000000000000002	***
NumberOfRooms5	0,233290752	0,008420438	27,71	<0,0000000000000002	***
NumberOfRooms6	0,276181015	0,010852567	25,45	<0,0000000000000002	***
NumberOfRooms7 or more	0,296428521	0,017895770	16,56	<0,0000000000000002	***
LivingArea	0,012972673	0,000167577	77,41	<0,0000000000000002	***
LivingArea^2	– 0,000023669	0,000000704	– 33,62	<0,0000000000000002	***
Floor2nd floor	0,007588436	0,002315541	3,28	0,00105	**
Floor3rd floor	0,016383633	0,002812359	5,83	0,00000000573332513	***
Floor4th floor	0,020058578	0,003820907	5,25	0,00000015310551690	***
Floor5th floor or above	0,019145940	0,003784991	5,06	0,00000042462473002	***
FloorHouse	0,026070614	0,005100393	5,11	0,00000032104381965	***
NumberOfParkingSpaces1	0,042666665	0,004335416	9,84	<0,0000000000000002	***
NumberOfParkingSpaces2 or more	0,063894379	0,008445804	7,57	0,00000000000003952	***
PenthouseYes	0,266049025	0,018768779	14,18	<0,0000000000000002	***
DuplexYes	0,127961507	0,016043047	7,98	0,00000000000000155	***
AgeOfLeaseAgreement	– 0,009718195	0,000093536	– 103,90	<0,0000000000000002	***
RentalStatusConcierge	– 0,115220112	0,013102803	– 8,79	<0,0000000000000002	***
RentalStatusRelative or friend	– 0,248340659	0,005842583	– 42,51	<0,0000000000000002	***
RentalStatusSubsidized or cooperative housing	– 0,148866880	0,004287452	– 34,72	<0,0000000000000002	***
TypeOfOwnerGovernment	– 0,156692396	0,004940572	– 31,72	<0,0000000000000002	***
TypeOfOwnerCooperative	– 0,100197536	0,005119673	– 19,57	<0,0000000000000002	***
TypeOfOwnerReal estate or building company	– 0,013306330	0,003264319	– 4,08	0,00004584406829510	***
TypeOfOwnerPension, insurance or investment fund	– 0,037388486	0,002370870	– 15,77	<0,0000000000000002	***
TypeOfOwnerUnknown	– 0,039555133	0,003545931	– 11,16	<0,0000000000000002	***
Year2017	– 0,001431759	0,002705446	– 0,53	0,59666	
Year2016	– 0,011507505	0,002849856	– 4,04	0,00005402306759245	***
Year2015	– 0,021588173	0,002754738	– 7,84	0,00000000000000473	***
Year2014	– 0,032362074	0,002824667	– 11,46	<0,0000000000000002	***
CantonAI	0,079423969	0,039723226	2,00	0,04557	*
CantonAR	0,028210752	0,014766892	1,91	0,05609	.
CantonBasel	0,092374772	0,009476308	9,75	<0,0000000000000002	***
CantonBE	0,090660180	0,007402965	12,25	<0,0000000000000002	***
CantonBern	0,048303591	0,012371153	3,90	0,00009455650222521	***
CantonBL	0,133770778	0,007531278	17,76	<0,0000000000000002	***
CantonBS	0,148097620	0,017548790	8,44	<0,0000000000000002	***
CantonFR	0,042882644	0,006937646	6,18	0,00000000064227299	***
CantonGE	0,129138004	0,007082047	18,23	<0,0000000000000002	***
CantonGenève	0,086176898	0,009444550	9,12	<0,0000000000000002	***

Source: FSO – Consumer Price Index (CPI)

Model coefficients (Continued) T3

	Estimate	Std. Error	t value	Pr(>|t|)	
CantonGL	– 0,058035265	0,019987632	– 2,90	0,00369	**
CantonGR	0,199632670	0,010248784	19,48	<0,0000000000000002	***
CantonJU	0,019866005	0,016004047	1,24	0,21450	
CantonLausanne	0,112104783	0,011236569	9,98	<0,0000000000000002	***
CantonLU	0,061132553	0,005493236	11,13	<0,0000000000000002	***
CantonNE	0,090031395	0,011869033	7,59	0,00000000000003384	***
CantonNW	0,025480521	0,015451579	1,65	0,09914	.
CantonOW	0,039510911	0,018245864	2,17	0,03036	*
CantonSG	0,088759998	0,006500159	13,66	<0,0000000000000002	***
CantonSH	0,011466915	0,012512481	0,92	0,35944	
CantonSO	0,065579515	0,008950670	7,33	0,00000000000024005	***
CantonSZ	– 0,063720475	0,009319003	– 6,84	0,00000000000815923	***
CantonTG	– 0,028298230	0,007016612	– 4,03	0,00005516000329833	***
CantonTI	– 0,201580603	0,007881577	– 25,58	<0,0000000000000002	***
CantonUR	– 0,008146176	0,019991830	– 0,41	0,68366	
CantonVD	0,172147289	0,007401660	23,26	<0,0000000000000002	***
CantonVS	– 0,021231547	0,009236812	– 2,30	0,02153	*
CantonZG	– 0,141823313	0,013992872	– 10,14	<0,0000000000000002	***
CantonZH	0,028661363	0,005035874	5,69	0,00000001268228505	***
CantonZürich	0,040524481	0,006681327	6,07	0,00000000132817264	***
MunicipalityType2	0,171261460	0,012178084	14,06	<0,0000000000000002	***
MunicipalityType3	0,214355707	0,014630845	14,65	<0,0000000000000002	***
MunicipalityType4	0,204903505	0,019357435	10,59	<0,0000000000000002	***
MunicipalityType5	0,204788982	0,016330361	12,54	<0,0000000000000002	***
MunicipalityType6	0,176176784	0,023595989	7,47	0,00000000000008404	***
MunicipalityType7	0,274937580	0,022019693	12,49	<0,0000000000000002	***
MunicipalityType8	0,261746761	0,019112999	13,69	<0,0000000000000002	***
MunicipalityType9	0,196410725	0,040548619	4,84	0,00000127817421907	***
TravelTimeToCenters	– 0,004350578	0,000152982	– 28,44	<0,0000000000000002	***
RateOfSecondHomes	0,009539316	0,000782142	12,20	<0,0000000000000002	***
TaxBurden	– 0,053030103	0,001784296	– 29,72	<0,0000000000000002	***
NighttimeRoadNoise	– 0,000550025	0,000106841	– 5,15	0,00000026437790994	***
DaytimeTrainNoise	– 0,000128167	0,000062009	– 2,07	0,03875	*
DaytimeAircraftNoiseFrom 50 to 55 dB	– 0,020623865	0,007275742	– 2,83	0,00459	**
DaytimeAircraftNoiseOver 55 dB	– 0,027652283	0,005073746	– 5,45	0,00000005063587858	***
PublicTransportQualityA	0,060109009	0,004927815	12,20	<0,0000000000000002	***
PublicTransportQualityB	0,039779766	0,004604339	8,64	<0,0000000000000002	***
PublicTransportQualityC	0,026264996	0,004373630	6,01	0,00000000192555625	***
PublicTransportQualityD	0,019371030	0,004235033	4,57	0,00000479890884528	***
DistanceToLakes100 m or less	0,086221610	0,010008298	8,62	<0,0000000000000002	***
DistanceToLakesFrom 100 to 150 m	0,066210417	0,009505289	6,97	0,00000000000331781	***
DistanceToLakesFrom 150 to 200 m	0,040581043	0,008495146	4,78	0,00000178566028120	***
DistanceToHighVoltagePowerLines200 m or less	– 0,020784916	0,005737504	– 3,62	0,00029	***

Source: FSO – Consumer Price Index (CPI)

Model coefficients (End) T 3

	Estimate	Std. Error	t value	Pr(>|t|)	
PotentialMountainView	0,000758991	0,000098326	7,72	0,00000000000001198	***
PotentialLakeViewFrom 1 to 5000 ha	0,028539880	0,002111109	13,52	<0,0000000000000002	***
PotentialLakeViewOver 5000 ha	0,062284661	0,004648386	13,40	<0,0000000000000002	***
Slope	0,005092455	0,000445523	11,43	<0,0000000000000002	***
LivingArea:MunicipalityType2	– 0,001133458	0,000077939	– 14,54	<0,0000000000000002	***
LivingArea:MunicipalityType3	– 0,001954809	0,000108335	– 18,04	<0,0000000000000002	***
LivingArea:MunicipalityType4	– 0,001675451	0,000139846	– 11,98	<0,0000000000000002	***
LivingArea:MunicipalityType5	– 0,001728509	0,000116204	– 14,87	<0,0000000000000002	***
LivingArea:MunicipalityType6	– 0,001089368	0,000175324	– 6,21	0,00000000052327602	***
LivingArea:MunicipalityType7	– 0,002324242	0,000181770	– 12,79	<0,0000000000000002	***
LivingArea:MunicipalityType8	– 0,002136262	0,000135198	– 15,80	<0,0000000000000002	***
LivingArea:MunicipalityType9	– 0,002720261	0,000337402	– 8,06	0,00000000000000077	***
LivingArea:PenthouseYes	– 0,000991735	0,000157154	– 6,31	0,00000000028073069	***
LivingArea:DuplexYes	– 0,001007887	0,000123011	– 8,19	0,00000000000000026	***
BuildingAge:MunicipalityType2	– 0,000488723	0,000062943	– 7,76	0,00000000000000838	***
BuildingAge:MunicipalityType3	– 0,001021737	0,000085906	– 11,89	<0,0000000000000002	***
BuildingAge:MunicipalityType4	– 0,000636243	0,000113328	– 5,61	0,00000001987380844	***
BuildingAge:MunicipalityType5	– 0,000637927	0,000087393	– 7,30	0,00000000000029390	***
BuildingAge:MunicipalityType6	– 0,000116314	0,000110538	– 1,05	0,29269	
BuildingAge:MunicipalityType7	– 0,001148569	0,000122464	– 9,38	<0,0000000000000002	***
BuildingAge:MunicipalityType8	– 0,000716872	0,000097559	– 7,35	0,00000000000020477	***
BuildingAge:MunicipalityType9	– 0,001026301	0,000187572	– 5,47	0,00000004488416265	***
BuildingAge:PenthouseYes	– 0,000550108	0,000205679	– 2,67	0,00748	**
BuildingAge:DuplexYes	0,000276961	0,000069298	4,00	0,00006434915329198	***
MunicipalityType2:Slope	– 0,002758833	0,000584009	– 4,72	0,00000232056261797	***
MunicipalityType3:Slope	– 0,006479238	0,001060564	– 6,11	0,00000000100997981	***
MunicipalityType4:Slope	– 0,004388927	0,001176149	– 3,73	0,00019	***
MunicipalityType5:Slope	– 0,003873924	0,001016146	– 3,81	0,00014	***
MunicipalityType6:Slope	– 0,012508815	0,001603274	– 7,80	0,00000000000000623	***
MunicipalityType7:Slope	– 0,008911424	0,001365690	– 6,53	0,00000000006868423	***
MunicipalityType8:Slope	– 0,006776600	0,001189313	– 5,70	0,00000001221032865	***
MunicipalityType9:Slope	– 0,008663940	0,001962215	– 4,42	0,00001010838565821	***
MunicipalityType2:RateOfSecondHomes	– 0,005618719	0,000893193	– 6,29	0,00000000031939904	***
MunicipalityType3:RateOfSecondHomes	– 0,003557454	0,000886616	– 4,01	0,00006021165630504	***
MunicipalityType4:RateOfSecondHomes	– 0,004021456	0,001369704	– 2,94	0,00333	**
MunicipalityType5:RateOfSecondHomes	– 0,006023657	0,001037661	– 5,81	0,00000000648219135	***
MunicipalityType6:RateOfSecondHomes	– 0,006906398	0,001128579	– 6,12	0,00000000094676964	***
MunicipalityType7:RateOfSecondHomes	– 0,006509622	0,000890959	– 7,31	0,00000000000027952	***
MunicipalityType8:RateOfSecondHomes	– 0,010573717	0,001043746	– 10,13	<0,0000000000000002	***
MunicipalityType9:RateOfSecondHomes	– 0,006146662	0,000937162	– 6,56	0,00000000005487888	***

Signif. codes: 0 '***' 0,001 '**' 0,01 '*' 0,05 '.' 0,1 ' ' 1
Residual standard error: 0,182 on 41433 degrees of freedom
Multiple R-squared: 0,79, Adjusted R-squared: 0,789
F-statistic: 1,24e+03 on 125 and 41433 DF, p-value: <0,0000000000000002

Source: FSO – Consumer Price Index (CPI)

Rent

The average net rent in our sample is CHF 1438. The average net rent is highest in high-density peri-urban municipalities (type 4) with a value of CHF 1531, followed by urban municipalities of a large agglomeration (type 1) with a value of CHF 1520. The lowest average net rent is found in peripheral rural municipalities (type 9) with a value of CHF 1114.

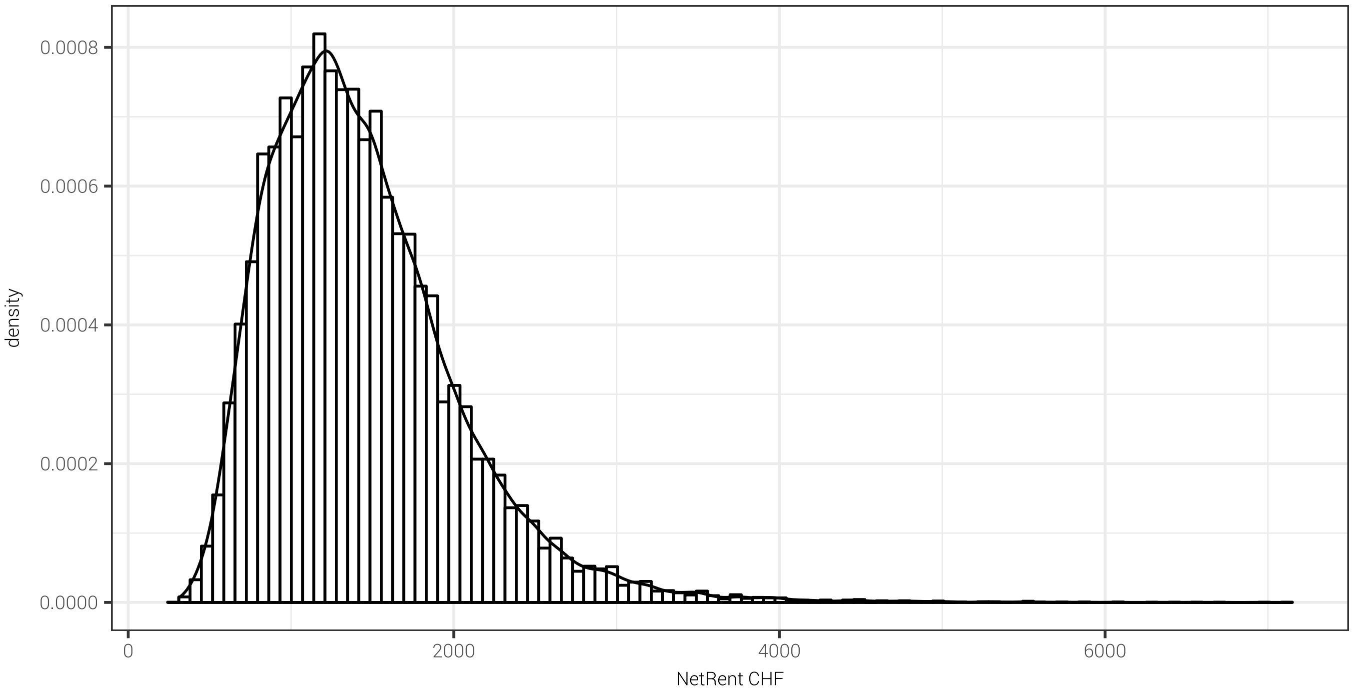
Structural variables

The structural variables describe the physical characteristics of the dwelling. Our model includes the age of the dwelling, the number of rooms, the living area, the floor on which it is located, whether it is a house, duplex or penthouse flat, and whether it includes a garage in the net rent. The interaction between the age, municipality type and status as a penthouse or duplex, as well as the interaction between the living area, municipality type and status as a penthouse or duplex also figure in our model. The structural characteristics of the dwelling are the most important predictive factor for the observed rent. Taken as a set, they describe 57% of the observed variation in the rental prices.

Age of the dwelling

Half of the dwellings in our sample are less than 40 years old. Dwellings in urban and rural municipalities have an average age of 43 years compared with 36 years for dwellings in peri-urban municipalities. 7% of our sample is older than 100 years. In our model, the age exhibits a quadratic relationship with the rental price: the rental price decreases for each additional year up to an age of about 200 years, and then this tendency reverses. The impact of age on the rental price varies depending on whether the dwelling is located in a city centre or a rural area. The same dwelling located in an urban municipality of a large agglomeration (type 1) would thus have rent that is lower by –8% on average depending on whether it is new or thirty years old, all other things being equal. In a municipality of a rural centre (type 7), this value is equal to –12%. There is also an interaction between the age and the duplex or penthouse status of a dwelling. In our model, the age of the dwelling thus has in general greater impact on the rental price if the dwelling is a penthouse or a duplex.

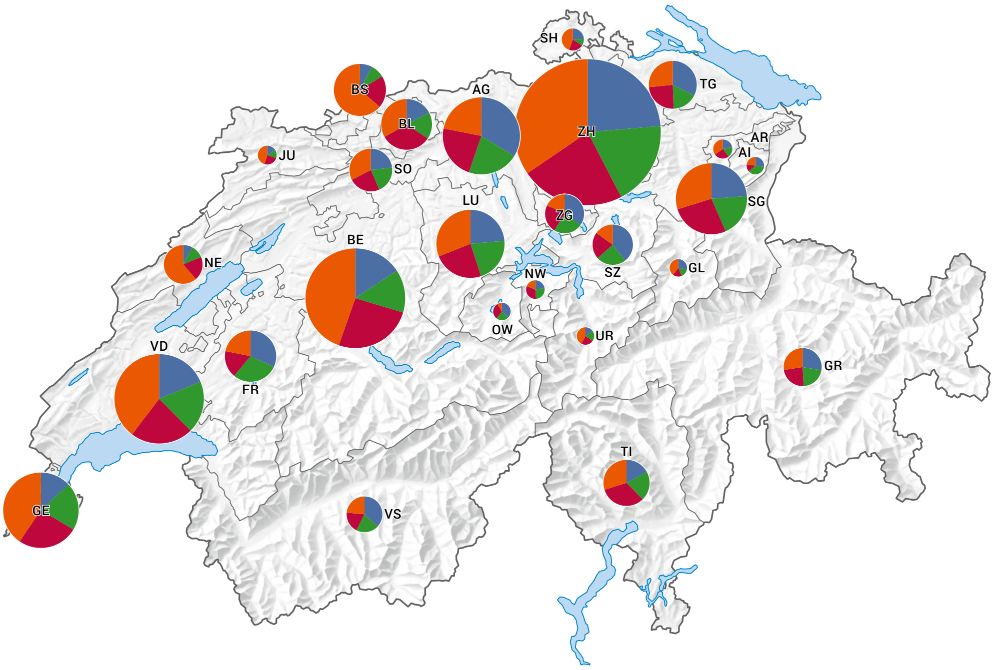
Distribution of rental prices **G 1**



Source: FSO – Consumer Price Index (CPI) © FSO 2022

Age of dwellings in the sample, 2014 – 2018[1]

G 2



Dwellings in the sample

10 515
5 000
1 000
150

For easier readability, the size of symbols with a value below 150 has been enlarged.

Age of dwellings

- Under 10 years old **Total:** 9 283 (22.3%)
- 10 – 29 years old **Total:** 7 818 (18.8%)
- 30 – 49 years old **Total:** 9 961 (24.0%)
- 50 years old or more **Total:** 14 497 (34.9%)

[1] The results are based on a specific exploitation of the rental price index data from 2014 to 2018.

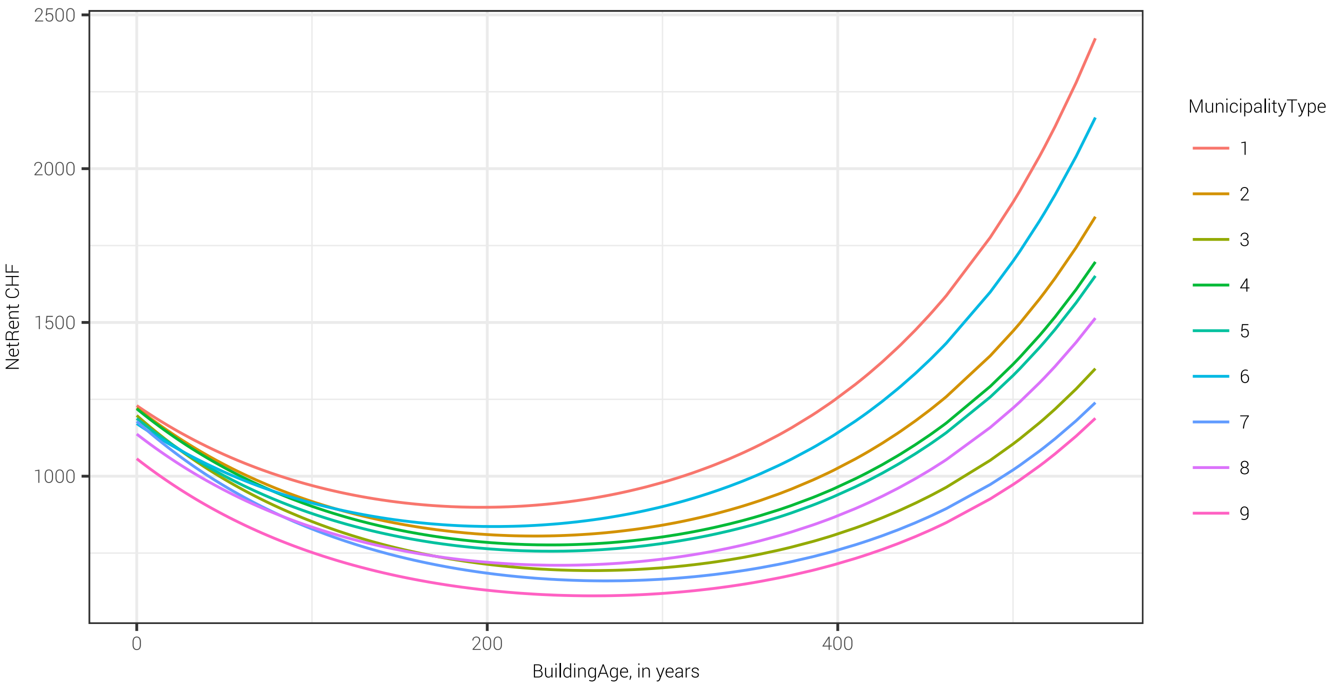
0 25 50 km

Spatial division: cantons

Source: FSO – Consumer Price Index (CPI)

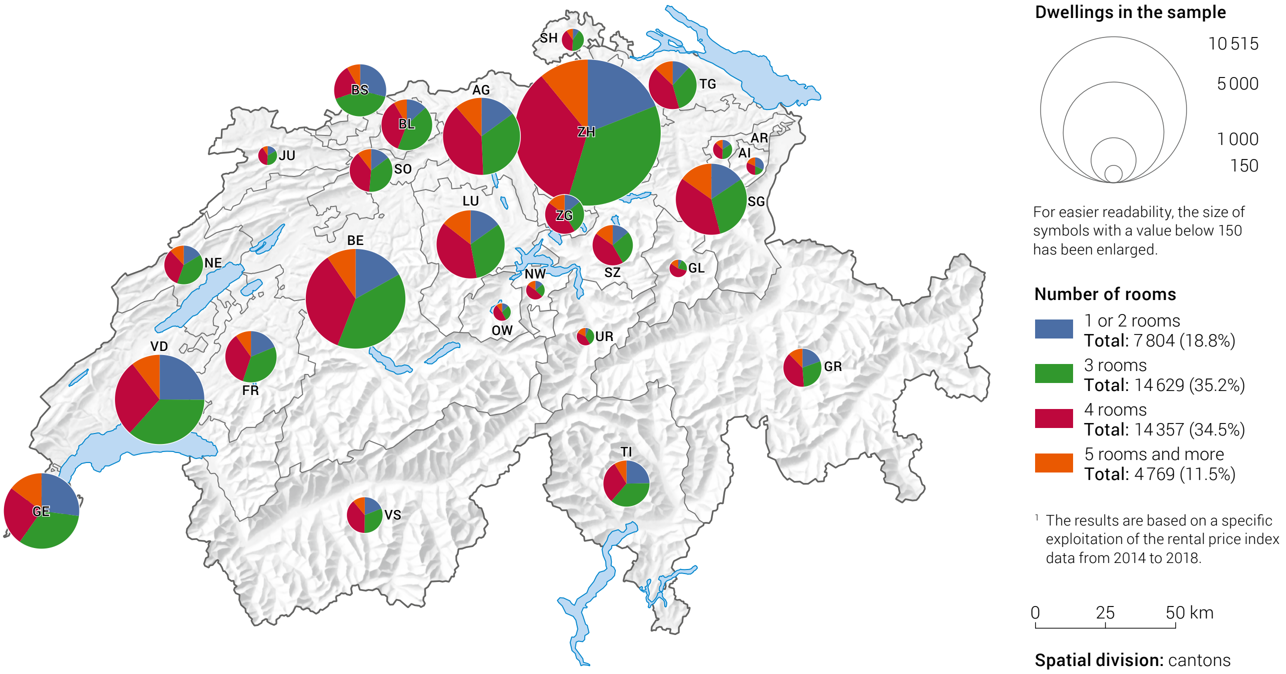
Marginal effect of the age on the rental price by municipality type

G 3



Source: FSO – Consumer Price Index (CPI)

Number of rooms of dwellings in the sample, 2014 – 2018[1] G 4

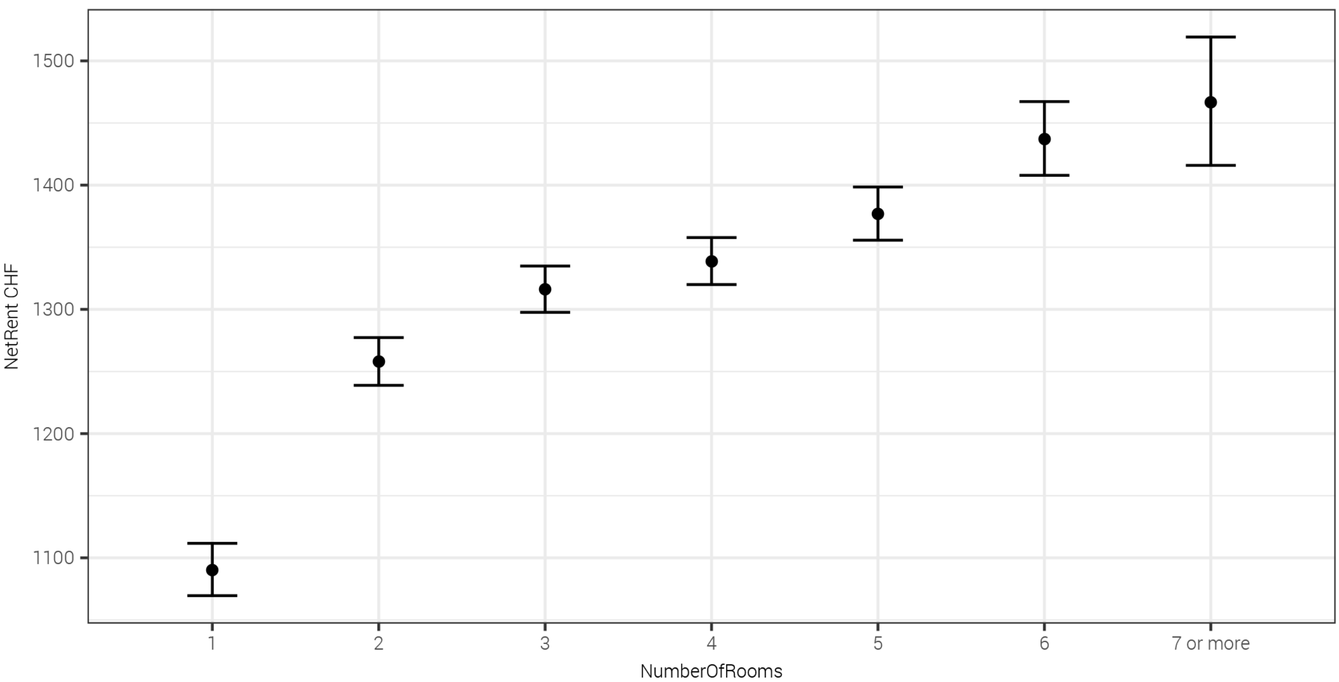


[1] The results are based on a specific exploitation of the rental price index data from 2014 to 2018.

Source: FSO – Consumer Price Index (CPI)

Marginal effect of the number of rooms on the rental price G 5

With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

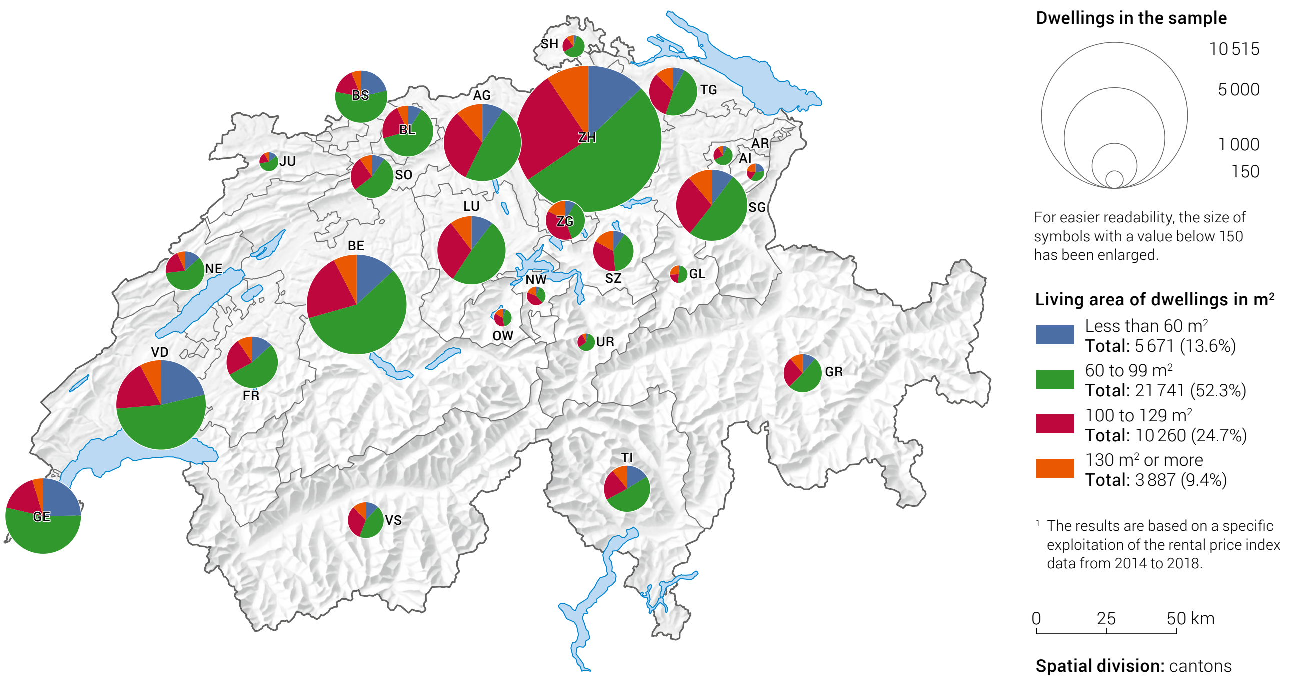
Number of rooms

70% of the dwellings in our sample have three or four rooms. One third of the dwellings in urban municipalities have four rooms compared with 40% in rural municipalities, and 4% of the dwellings have one room compared with 1% in rural municipalities. For each additional room, the rental price of a dwelling increases on average by CHF 63. The most pronounced effect is observed at the transition from one to two rooms where there is an increase in the average rent of CHF 168, all other things being equal.

Living area

The living area of the dwellings in our sample ranges from 10 m² to 355 m² with an average value of 90 m². The average living area is 87 m² in urban municipalities and increases by approximately 10 m² in peripheral or rural municipalities. The average age also varies depending on the living area: under 90 m² the average age is 49 years while above, it is 33 years. In our model, there is a quadratic relationship between the living area and the rent: the rental price increases for each additional square metre up to a living area of about 270 m². An additional square metre does not have the same impact on the rental price in an urban municipality and a rural municipality. The different effects of the living area on the rental price are taken into account in our model by means of interaction coefficients between the living area and municipality type. The same dwelling located in an urban municipality of a large agglomeration (type 1) would experience a rent increase of 17% on average if its living area went from 100 m² to 120 m², all other things being equal. In a peripheral rural municipality (type 9), this number would equal 11%. There is also an interaction between the living area and the duplex or penthouse status of a dwelling. In our model the living area for dwellings of less than 150 m² thus has a greater impact on the rental price if the dwelling is a penthouse or duplex.

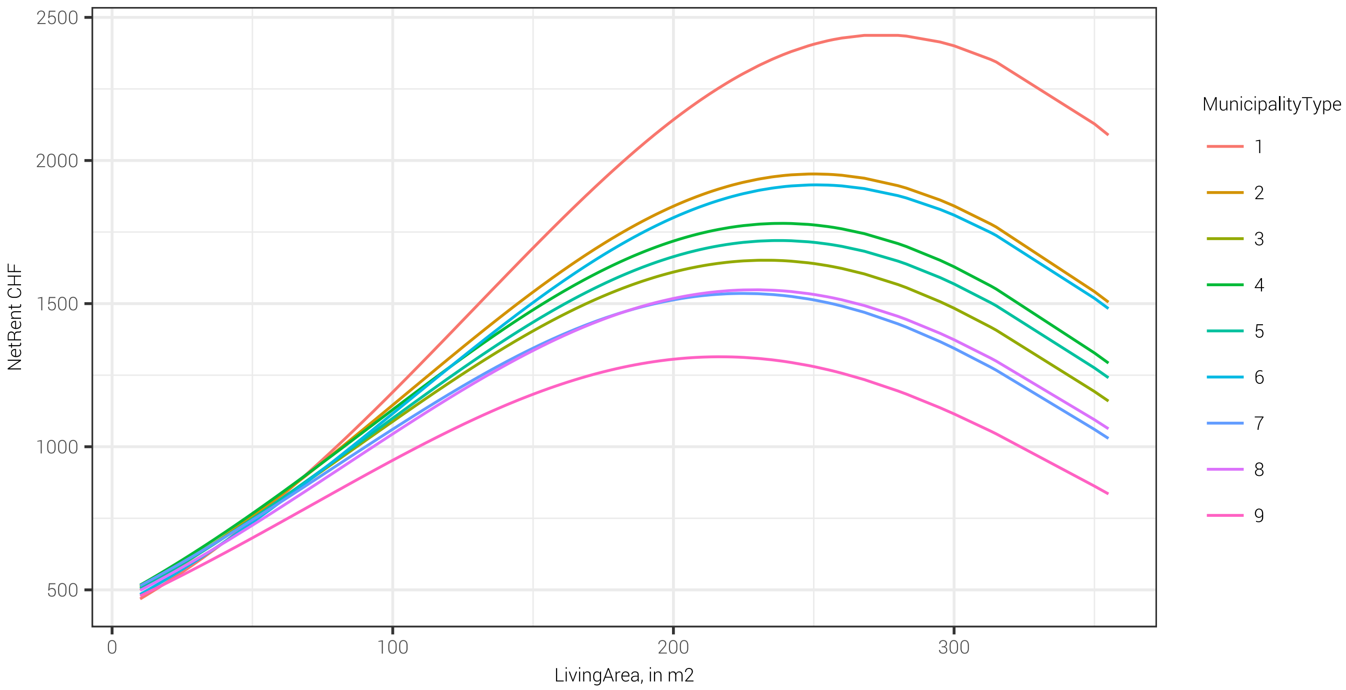
Living area of dwellings in the sample, 2014 – 2018[1] **G 6**



[1] The results are based on a specific exploitation of the rental price index data from 2014 to 2018.

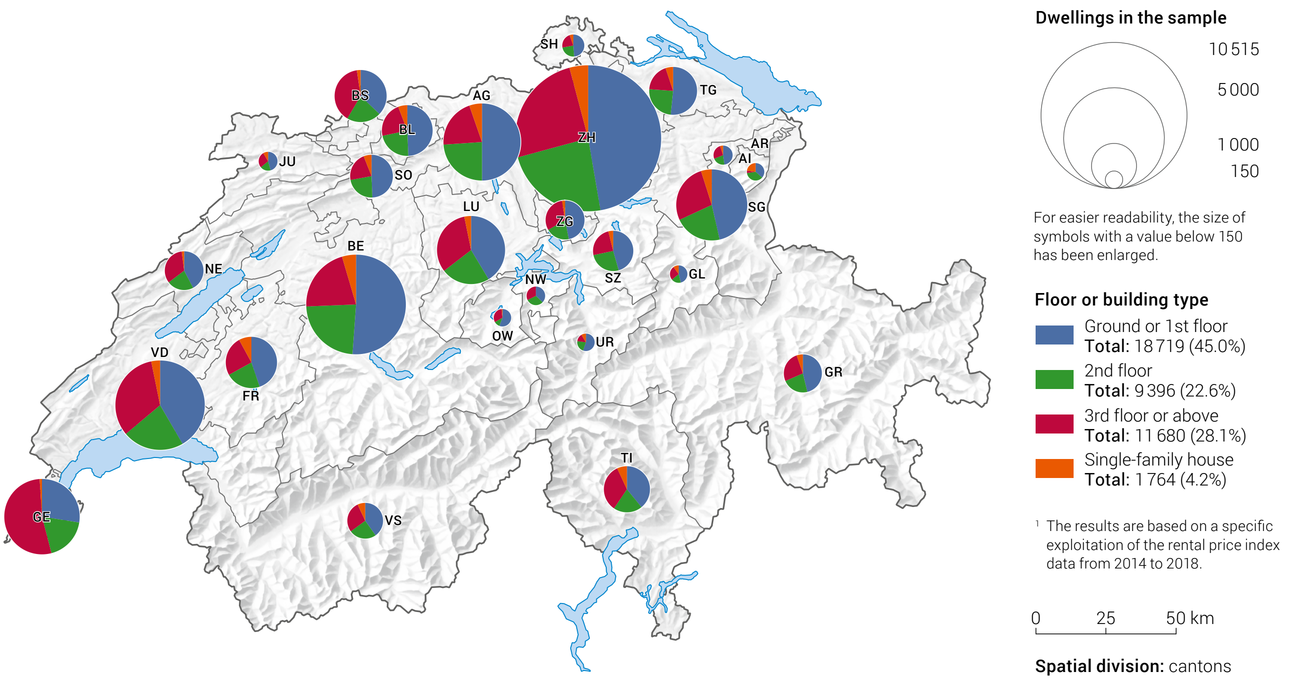
Source: FSO – Consumer Price Index (CPI)

Marginal effect of the living area on the rental price by municipality type G 7



Source: FSO – Consumer Price Index (CPI) © FSO 2022

Floor or building type of dwellings in the sample, 2014 – 2018[1] G 8

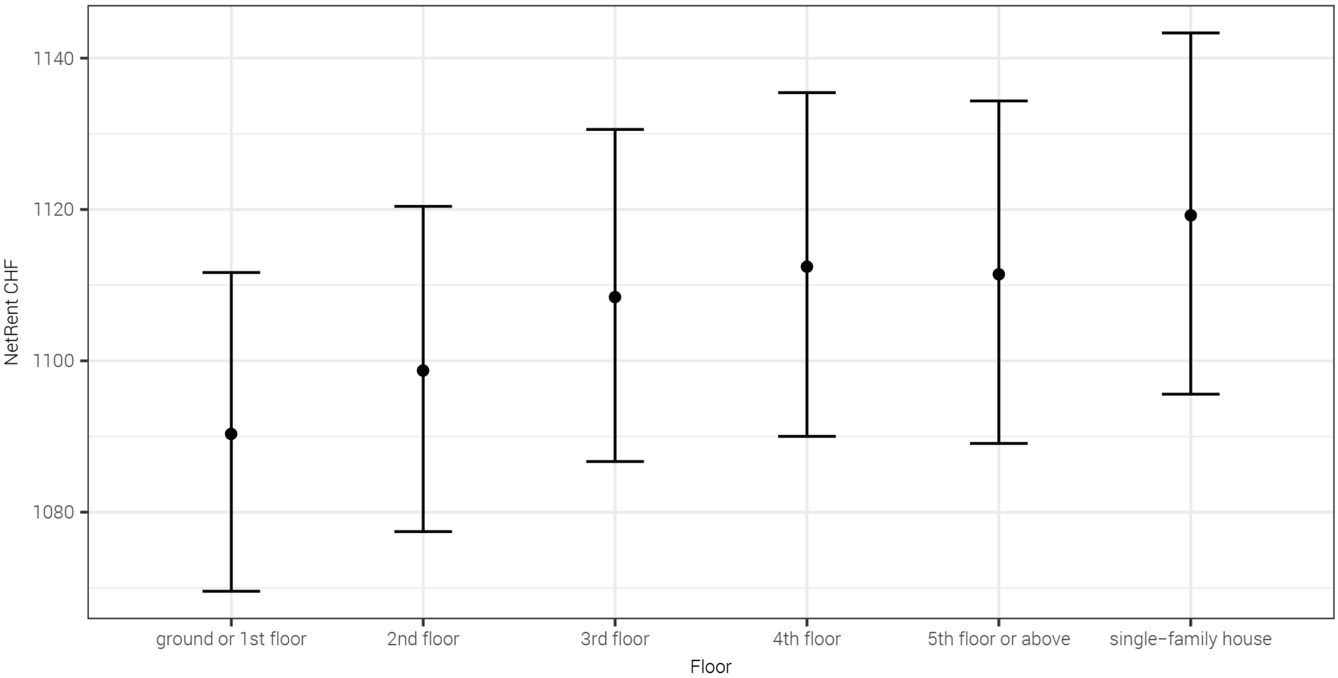


[1] The results are based on a specific exploitation of the rental price index data from 2014 to 2018.

Source: FSO – Consumer Price Index (CPI) © FSO 2022

Marginal effect of the floor and building type on the rental price **G 9**

With confidence interval (95%)

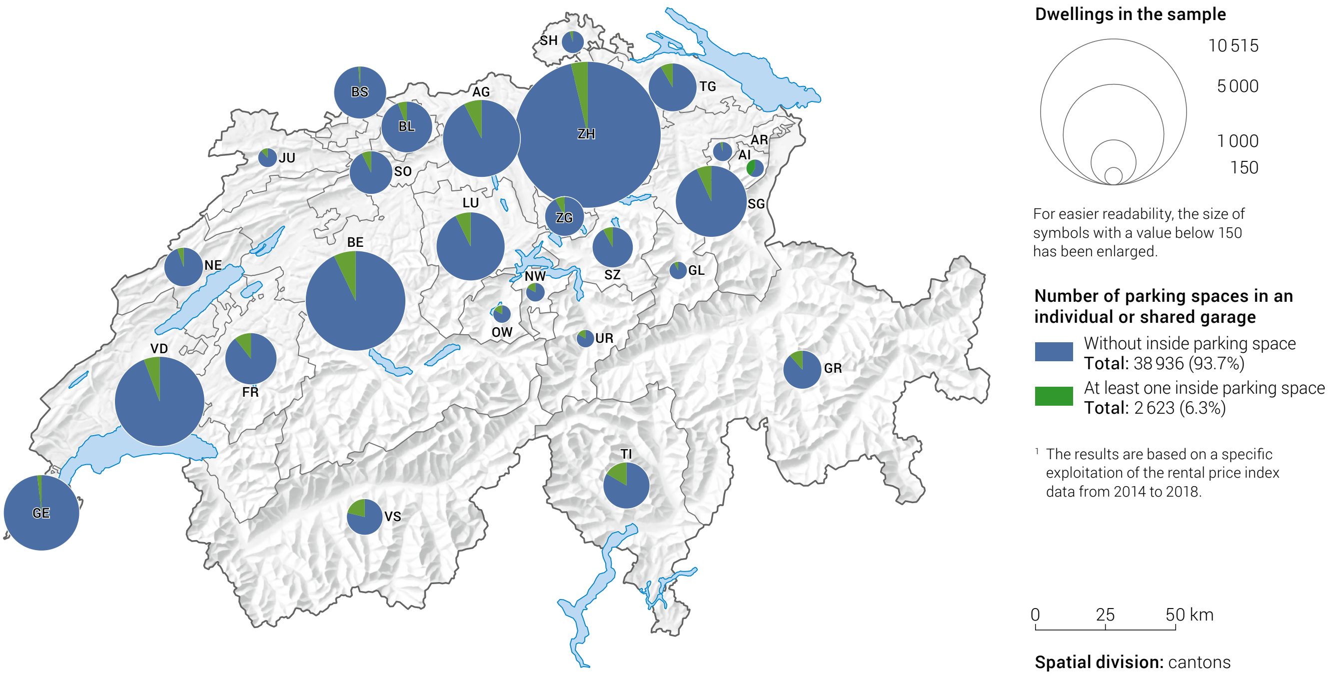


Source: FSO – Consumer Price Index (CPI)

Floor and building type

The floor and the building type are grouped together in the model within a single categorical variable. 45% of the dwellings in our sample are located on the first floor, while rural municipalities have an average of 9% detached houses. The greatest effect is when moving from the second to the third floor, with an average rent increase of CHF 10, all other things being equal. The difference in rent between a dwelling situated on the ground floor and a house amounts to 3%, all other things being equal.

Inside parking spaces of dwellings in the sample, 2014 – 2018[1] G 10

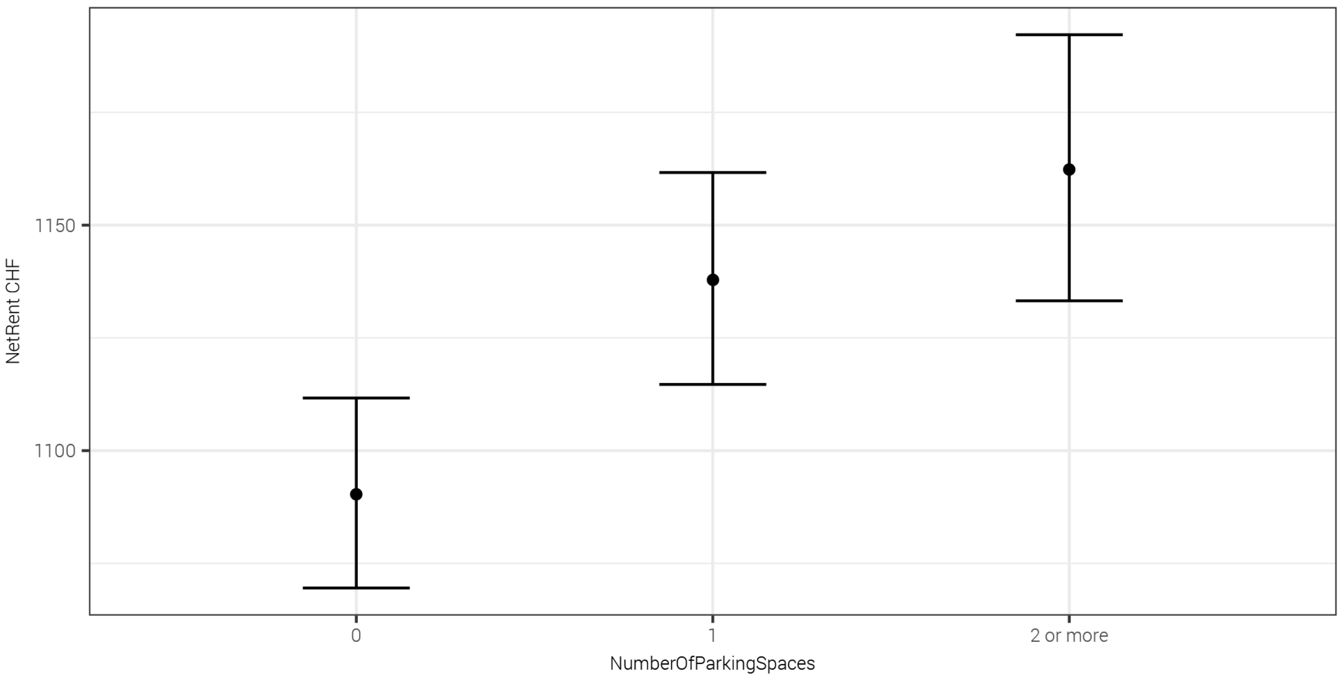


[1] The results are based on a specific exploitation of the rental price index data from 2014 to 2018.

Source: FSO – Consumer Price Index (CPI)

Marginal effect of the number of garages on the rental price G 11

With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

Number of garages

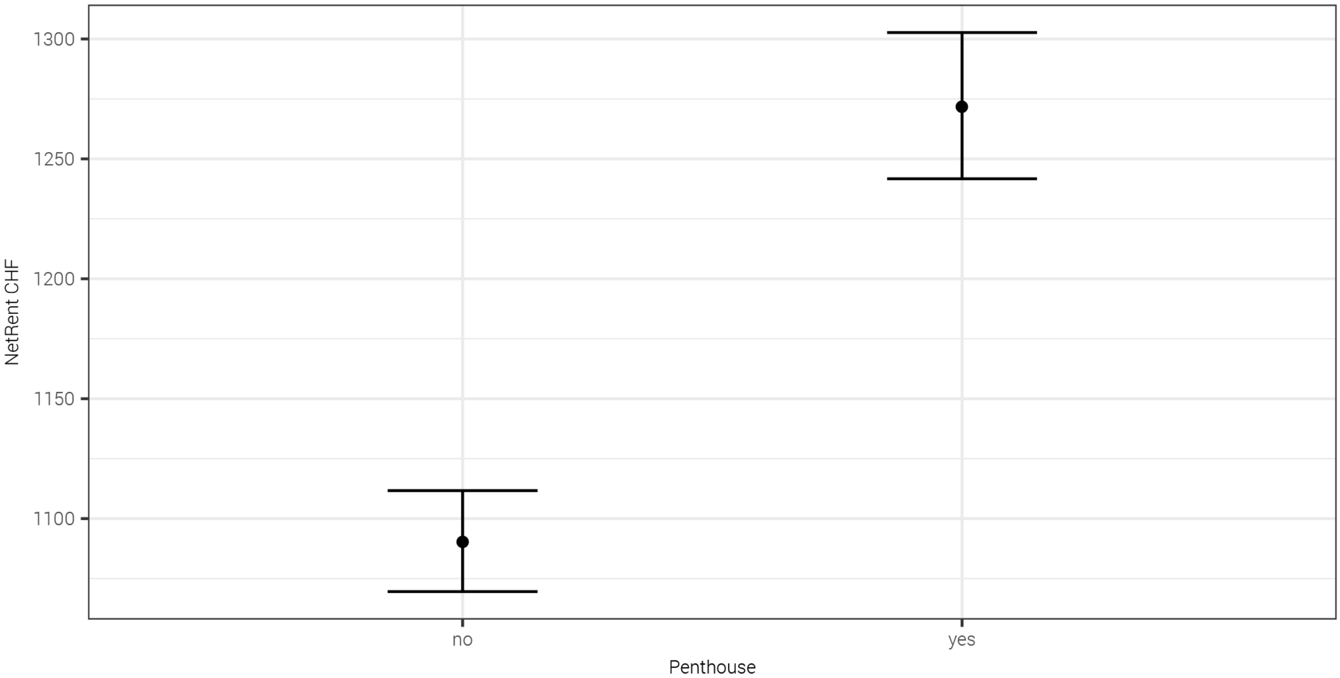
The rental price used in the hedonic model is assumed to be net of additional charges, but an inside parking space is sometimes included in the rent. 6% of the dwellings in our database have at least one parking space in an individual or shared inside garage that is included in the dwelling's net rent. This figure is equal to 15% in rural municipalities and 5% in urban ones. In our model the presence of a garage that is included in the dwelling's net rent increases the rental price by 4%, all other things being equal.

Penthouse

Penthouse flats have a roof terrace and make up 3% of our sample. 75% of these dwellings are located in urban municipalities. A penthouse flat is associated on average with a rent increase by 30%, all other things being equal.

Marginal effect of a penthouse configuration on the rental price **G 12**

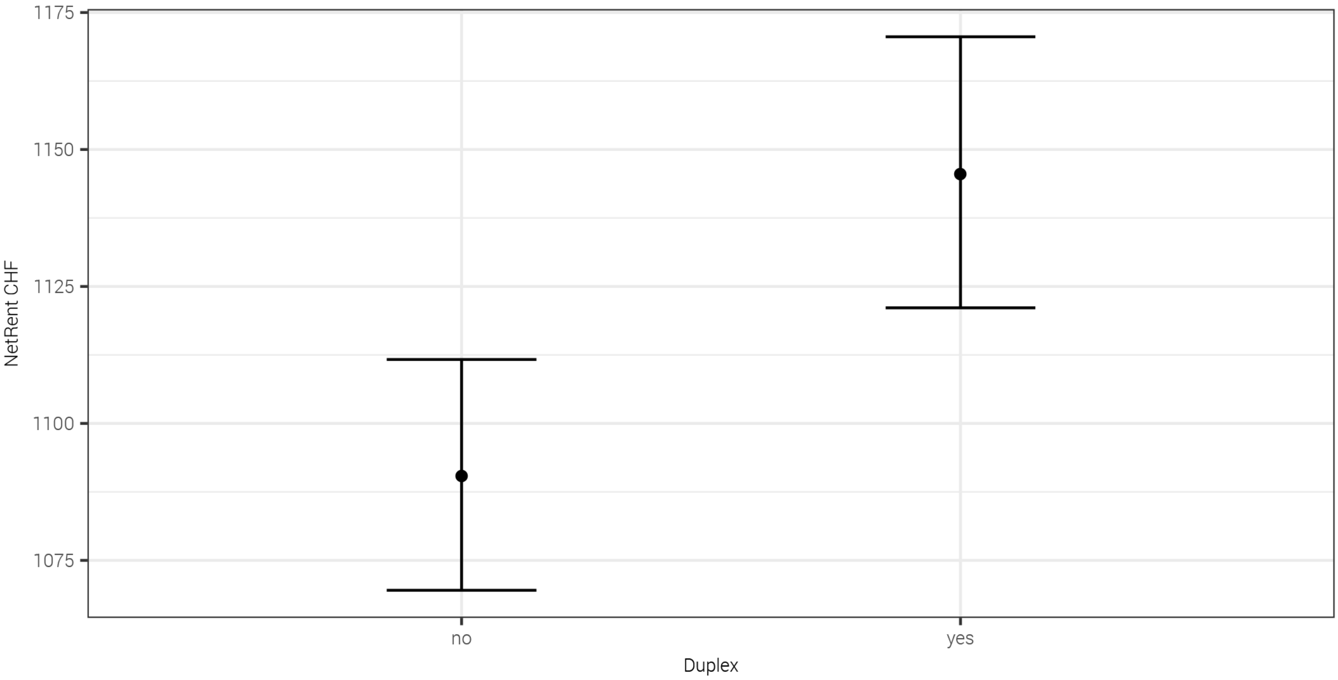
With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

Marginal effect of a duplex configuration on the rental price **G 13**

With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

Duplex

The last structural characteristic included in our model is the duplex flat type, i.e. a flat situated on two floors. Duplex flats represent 5% of our sample; 75% of these dwellings are located in urban municipalities. A duplex flat is associated on average with a rent increase by 14%, all other things being equal.

Variables related to the lease agreement

Variables related to the lease agreement describe certain characteristics of the current lease. Our model includes the date when the lease was signed, the rental status, the owner type and the year when the rental price was observed. Variables related to the lease agreement are important when it comes to predicting observed rental prices. When added to the structural variables, the explained percentage of the variance in the rental prices goes from 57% to 64%.

However, these elements related to the lease agreement are not part of the intrinsic quality of the dwelling. Therefore, these variables are not used to adjust the quality of the rental price index: the impact of these variables on the rental price is set to zero during estimation of the rental prices of dwellings entering and leaving the sample. It is nevertheless necessary to include the variables related to the lease agreement in the model in order to avoid skewing the estimate of other variables present in the model.

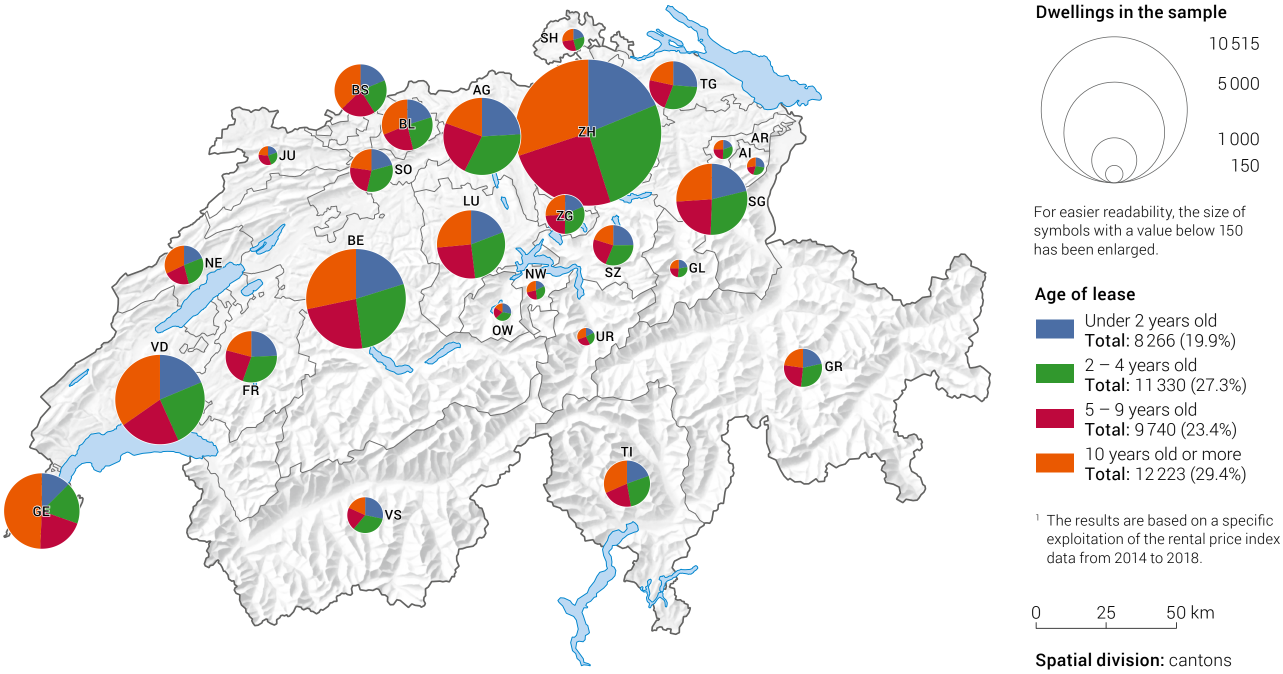
Age of lease agreement

The age of the current lease agreement is an important parameter for predicting the rental price. Half of the lease agreements in our sample were signed within the last five years. The age of current lease agreements is highest in urban municipalities, with an average age of over 9 years compared with about 6 years in peripheral or rural municipalities. Each additional year is associated on average with a 1% decrease in the rent, all other things being equal.

Rental status

85% of our observations do not mention any particular rental status. Cooperative or subsidised dwellings represent 14% of the dwellings in urban municipalities. This rental status is associated on average with a 14% decrease in the rental price compared to a lease without any particular rental status, all other things being equal. Moreover, 3% of the dwellings in our sample report a rent reduction due to a kinship or friendship between the tenant and landlord. This status occurs three times more commonly in rural municipalities than in urban municipalities. It is associated on average with a 22% decrease in the rental price compared to a lease without any particular rental status. Finally, caretaker work is associated on average with an 11% decrease in the rent compared to a lease without any special status.

Age of lease of dwellings in the sample, 2014 – 2018[1] G 14

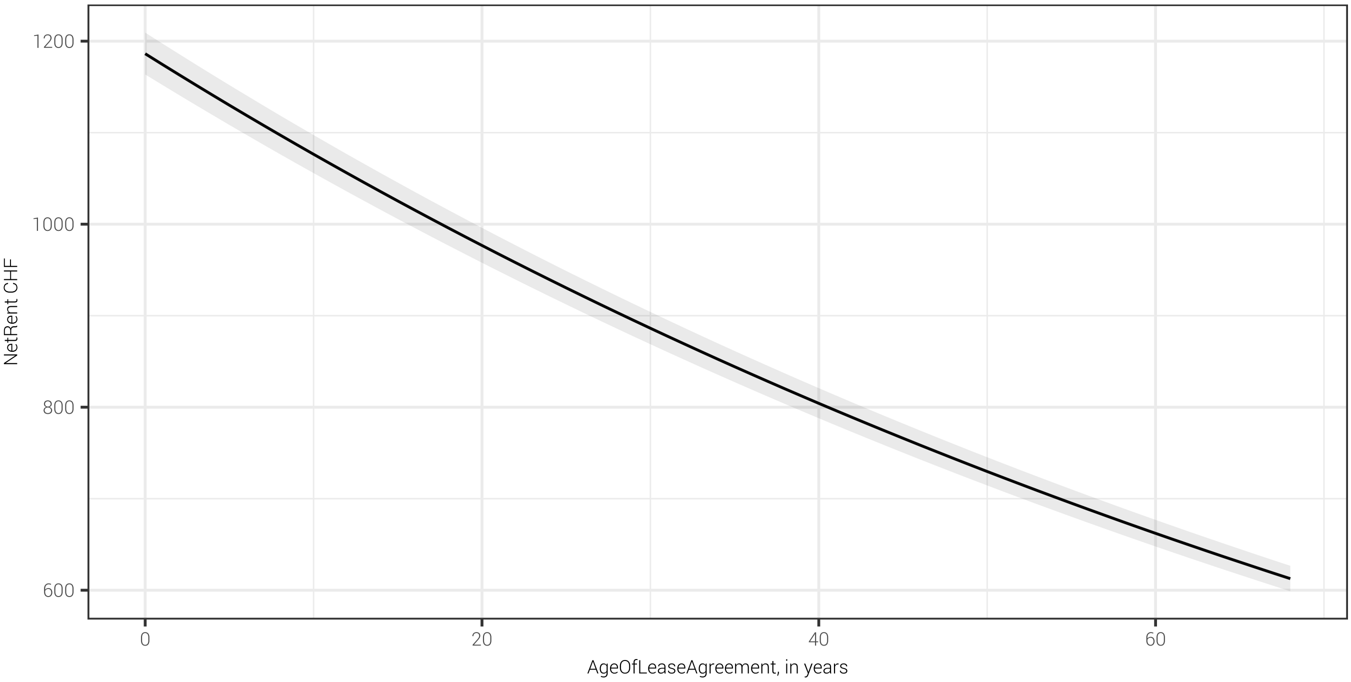


[1] The results are based on a specific exploitation of the rental price index data from 2014 to 2018.

Source: FSO – Consumer Price Index (CPI)

Marginal effect of the age of the lease agreement on the rental price G 15

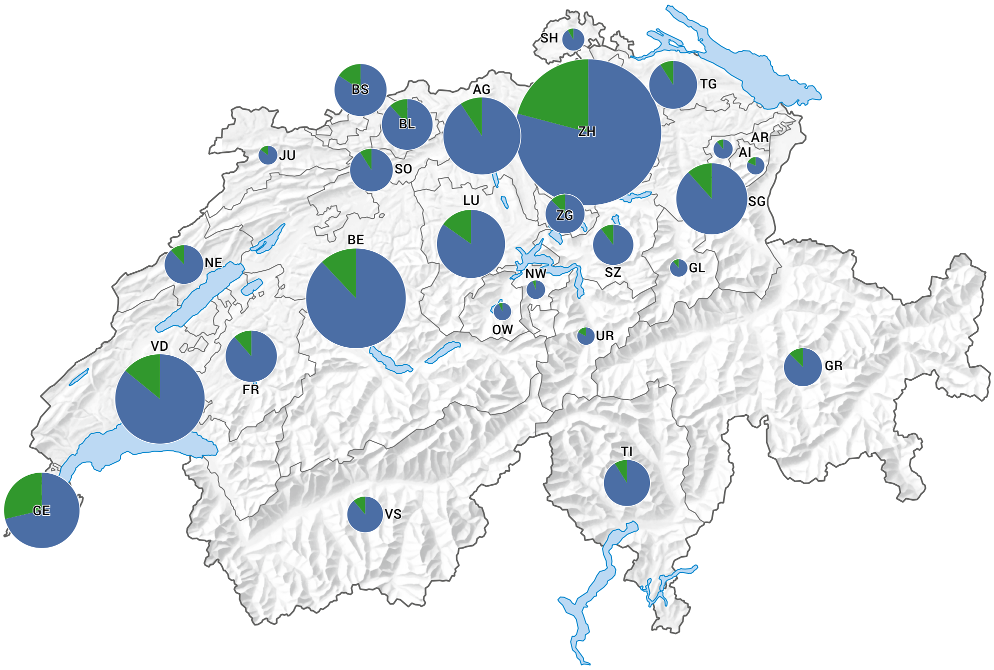
With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

Rental status of dwellings in the sample, 2014 – 2018[1]

G 16



¹ The results are based on a specific exploitation of the rental price index data from 2014 to 2018.

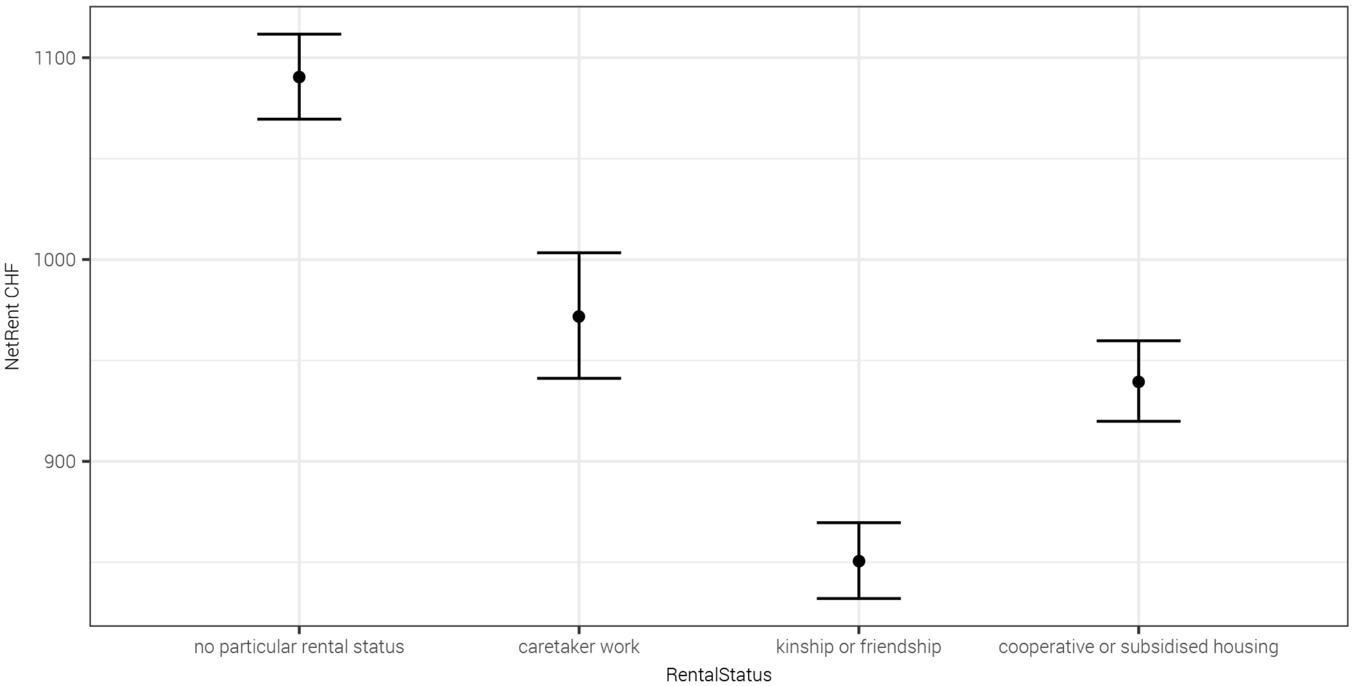
² Cooperative or subsidised housing, reduction of rental due to a relationship of kinship or friendship, reduction of rent due to caretaker work

Source: FSO – Consumer Price Index (CPI)

Marginal effect of the rental status on the rental price

G 17

With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

Owner type

Our model distinguishes six types of owners. In our sample, 41% of owners are private individuals. This type of owner is encountered more frequently in peri-urban or rural municipalities than in urban municipalities. In contrast, cooperatives and dwellings owned by pension, insurance or investment funds are found proportionally more often in urban municipalities. Public authorities represent 4% of our sample and real estate and construction companies represent 10%. Among the owner types, it can be observed that government authorities have the most pronounced downward impact on the rent compared with private owners, all other things being equal. Next are cooperatives, other owners, pension, insurance and investment funds, followed by real estate and building companies.

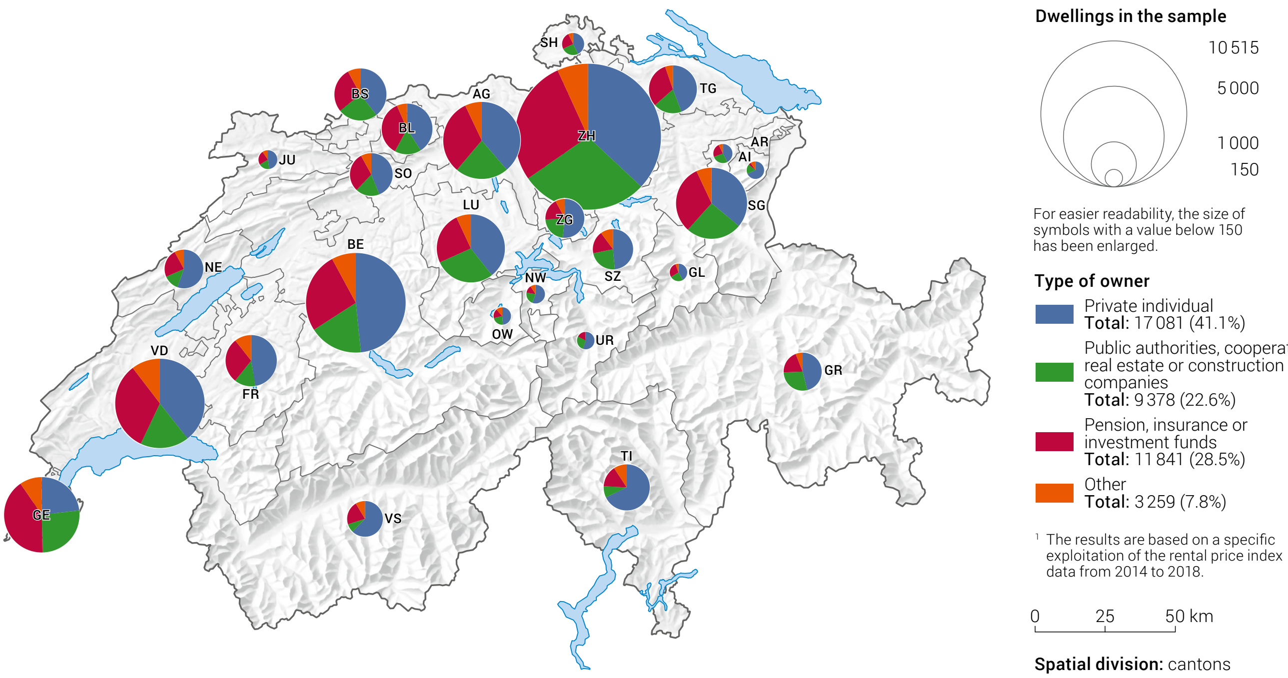
Survey year

Each survey year contains approximately 20% of the observations. We noted that an additional year is associated on average with a rent increase by CHF 11, all other things being equal. This general trend that was observed is consistent with the increasing rental price index. The level of the index has gone from 99.4 points in 2014 to 102.3 points in 2018 (base Dec 2015 = 100). Since the coefficients for 2017 and 2018 are nearly identical, the deviation between these survey years was not judged to be meaningful as indicated in Table T3 on page 14.

Macro location variables

The macro location describes the characteristics of the municipality in which the dwelling is located. Our model includes the canton in which the municipality is located, the rural or urban nature of the municipality based on a classification scheme with nine types, the prevailing tax burden, the travel time via private transport from the municipality to the nearest national centre, and the percentage of second homes in the municipality. The interaction between the rate of second homes and the municipality type also enters into the model. The macro location of a dwelling is an important factor for predicting the observed rental prices. When added to the structural variables and the variables related to the lease agreement, they cause the explained percentage of the variance in the rental prices to rise from 64% to 78%.

Owner type of dwellings in the sample, 2014 – 2018[1] **G 18**



For easier readability, the size of symbols with a value below 150 has been enlarged.

Type of owner

- Private individual **Total:** 17 081 (41.1%)
- Public authorities, cooperatives, real estate or construction companies **Total:** 9 378 (22.6%)
- Pension, insurance or investment funds **Total:** 11 841 (28.5%)
- Other **Total:** 3 259 (7.8%)

[1] The results are based on a specific exploitation of the rental price index data from 2014 to 2018.

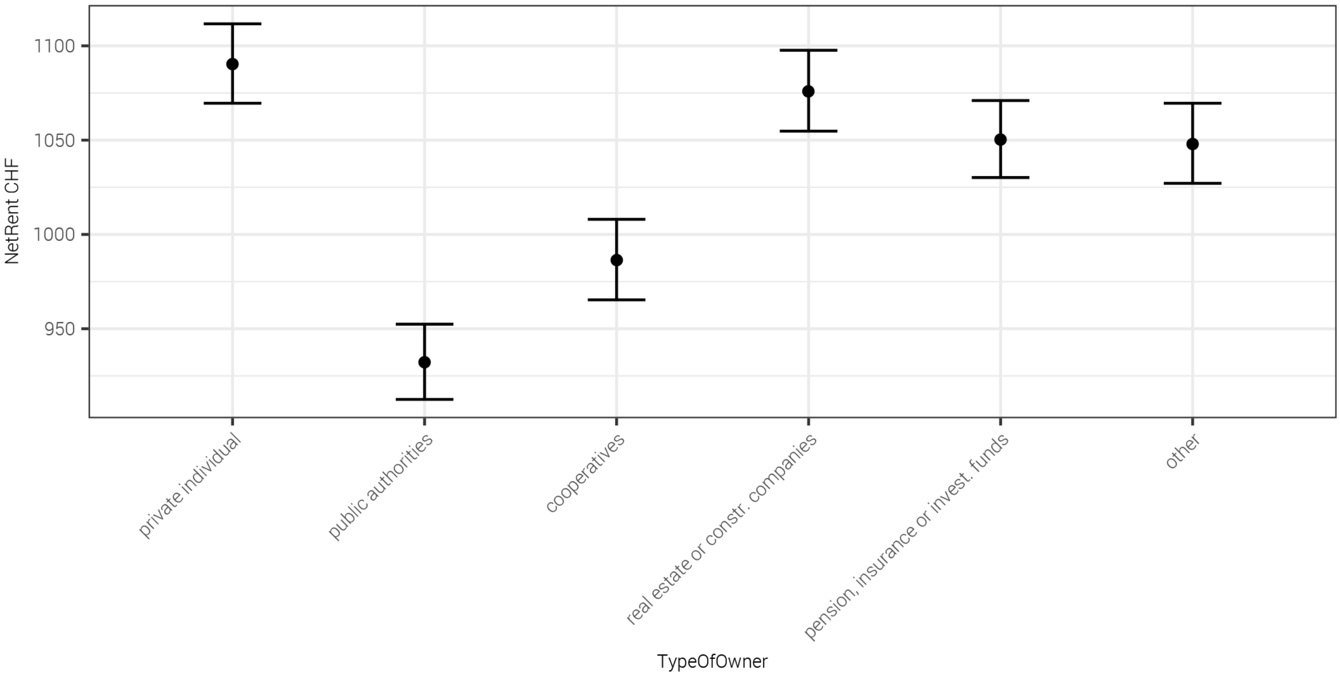
Spatial division: cantons

Source: FSO – Consumer Price Index (CPI)

Marginal effect of the owner type on the rental price

G 19

With confidence interval (95%)

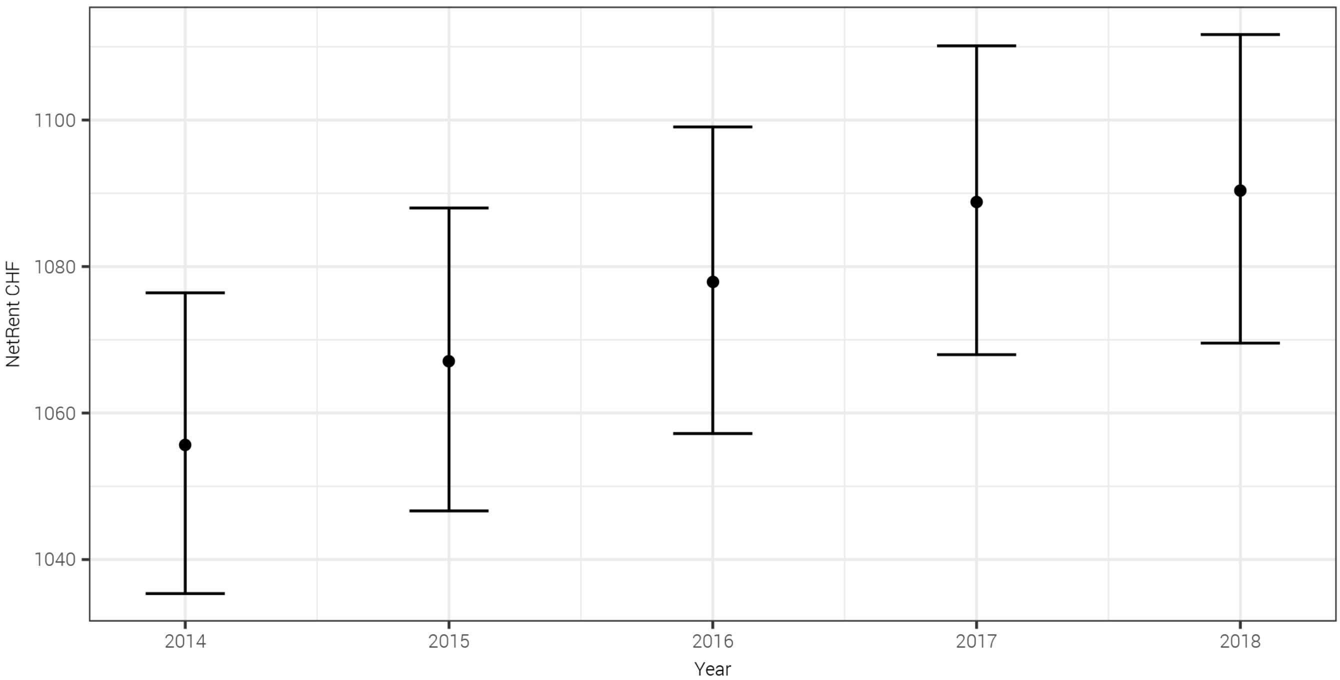


Source: FSO – Consumer Price Index (CPI)

Marginal effect of the survey year on the rental price

G 20

With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

Canton

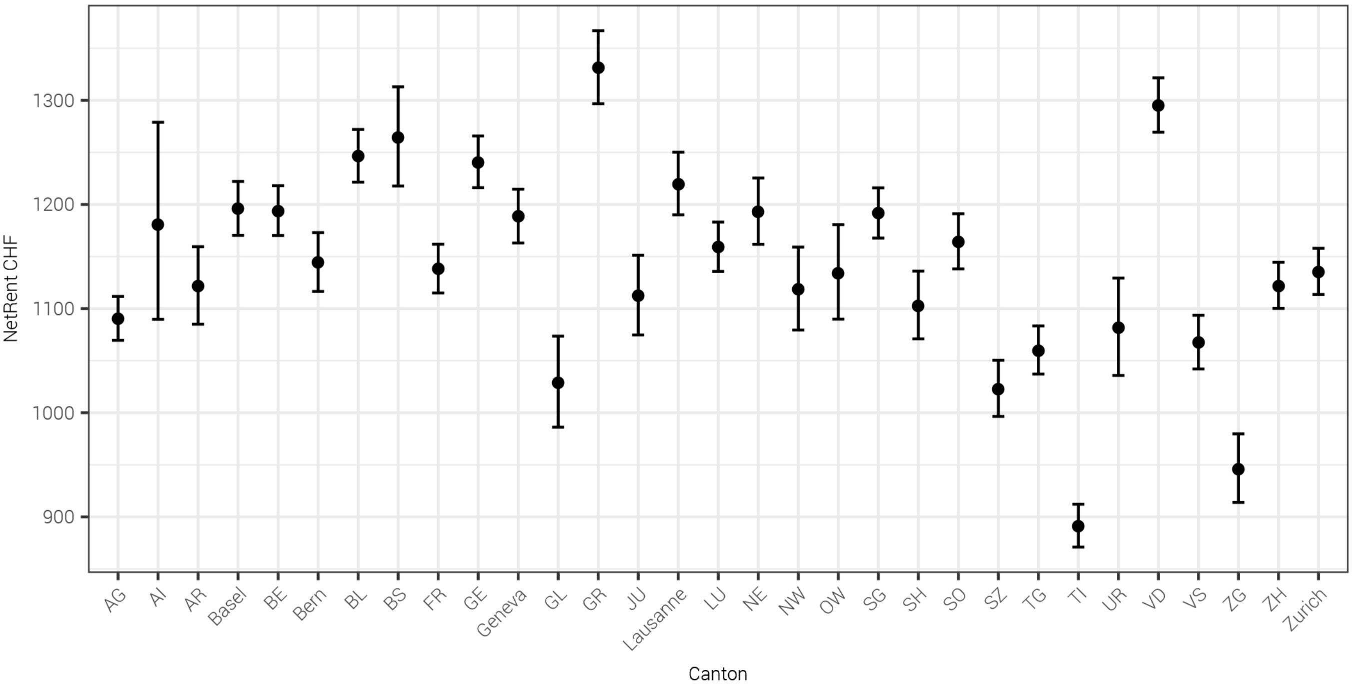
The canton in which a dwelling is located influences its rental price. However, due to the wide range of possible variations within a single canton, we introduced a distinction between the five largest cities of Switzerland and their canton. Thus, the cities of Zurich, Geneva, Basel, Lausanne and Bern are represented in the model separately from their respective canton. According to our model, two otherwise identical dwellings which are both located in the canton of Zurich will exhibit a rental price difference of 1% if one is located in the city of Zurich and the other outside the city. In contrast, two identical dwellings will exhibit a rental price difference of 22% if one is located in the city of Zurich and the other in Ticino. The marginal effects in Figure 21 show the effect of the canton on rent assuming that the other variables in the model are kept at their average value or reference category. For example, the average tax burden can vary greatly from canton to canton (see Tax burden on page 34), and Figure 21 thus shows the effect of the canton assuming, among other things, an identical tax burden for all cantons. The canton of Zurich excluding the city of Zurich has the largest number of observations in our sample (16%), followed by the canton of Bern excluding the city of Bern and the city of Zurich (9% each).

Municipality type

The model takes into account the urban, peri-urban or rural nature of a municipality based on a classification scheme with nine types. The model also takes into account the interaction of the municipality type with the age of the dwelling, its living area, the rate of second homes in the municipality and the slope of the land. These interactions are used to adjust the impact of the municipality type on the rental price according to the other variables that were mentioned. For these variables, a location in any municipality type except an urban municipality of a large agglomeration results in a decrease in rental price compared to an urban municipality of a large agglomeration, all other things being equal. Moreover, 78% of the rental prices in our sample are located in an urban municipality (type 1 to 3), and 42% in an urban municipality of a large agglomeration.

Marginal effect of the canton on the rental price **G 21**

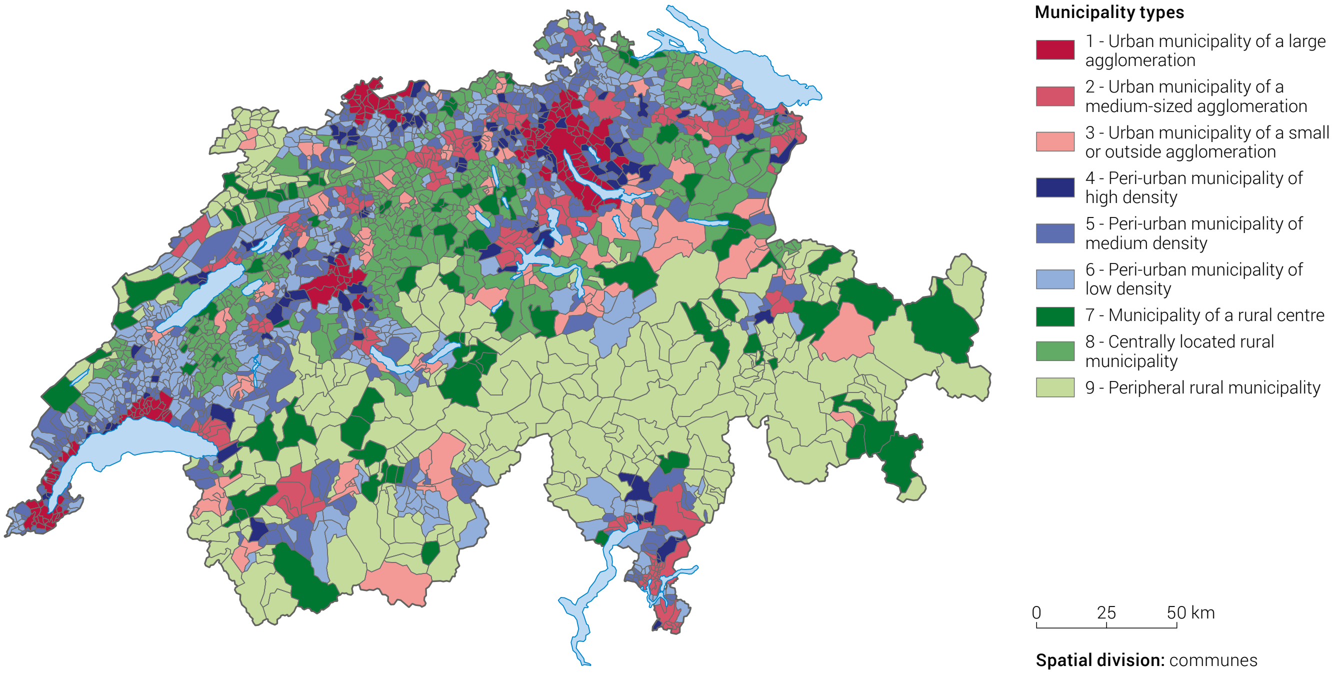
With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

Municipality types, 2020

G 22

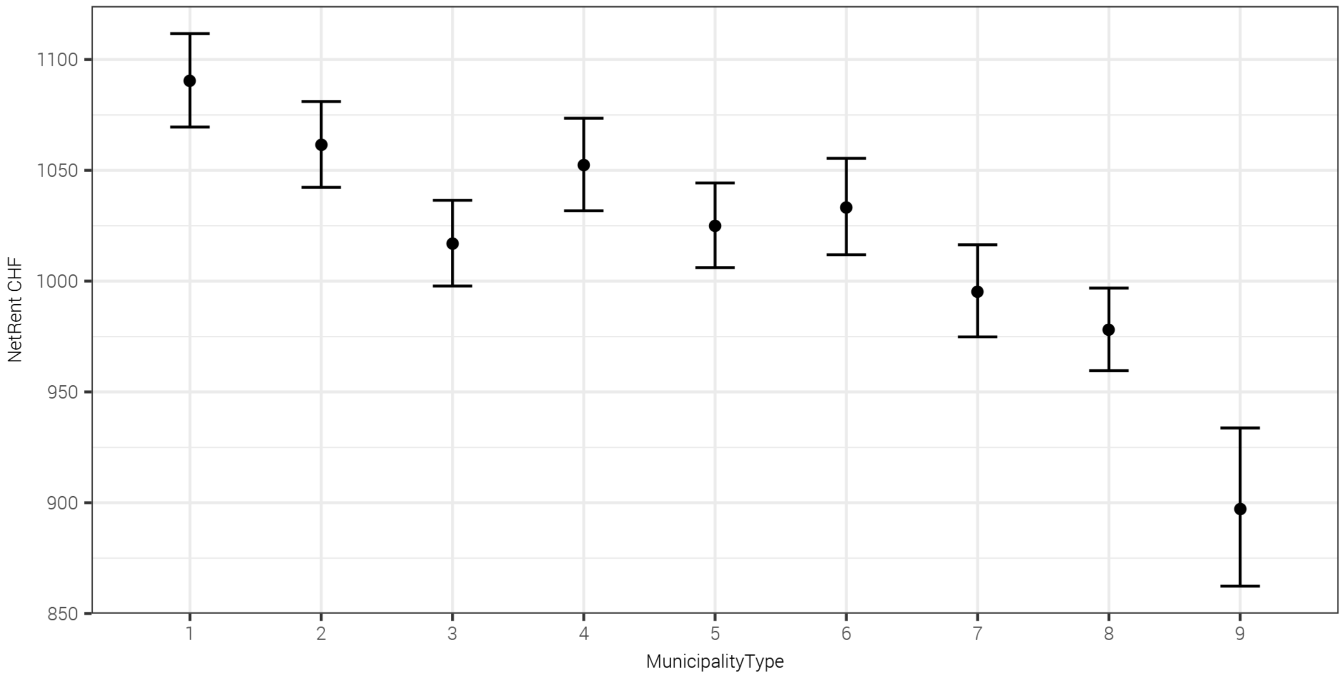


Source: FSO – Territorial typologies of Switzerland

Marginal effect of the municipality type on the rental price

G 23

With confidence interval (95%)

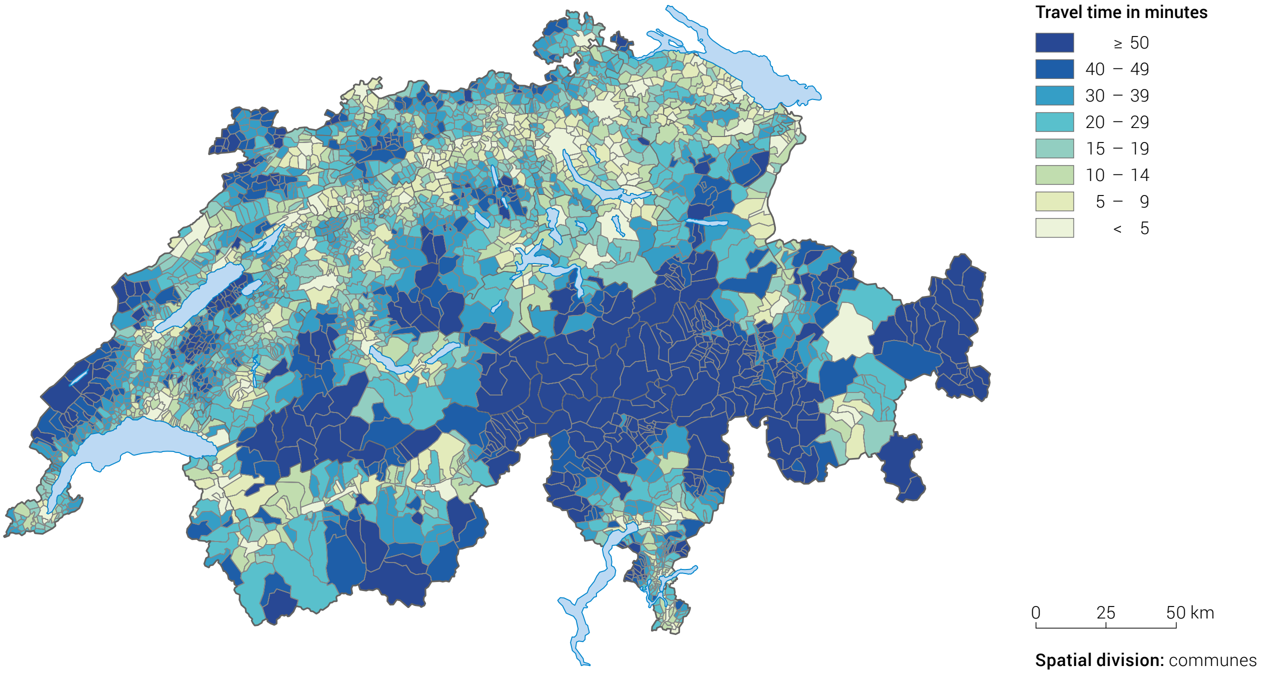


Source: FSO – Consumer Price Index (CPI)

Travel time via private transport

The model includes the travel time via private motorised transport to the most rapidly accessible core city (Basel, Bern, Geneva, Lausanne, Lugano or Zurich). Ten additional minutes of travel time are associated on average with a 4% decrease in the rent, all other things being equal.

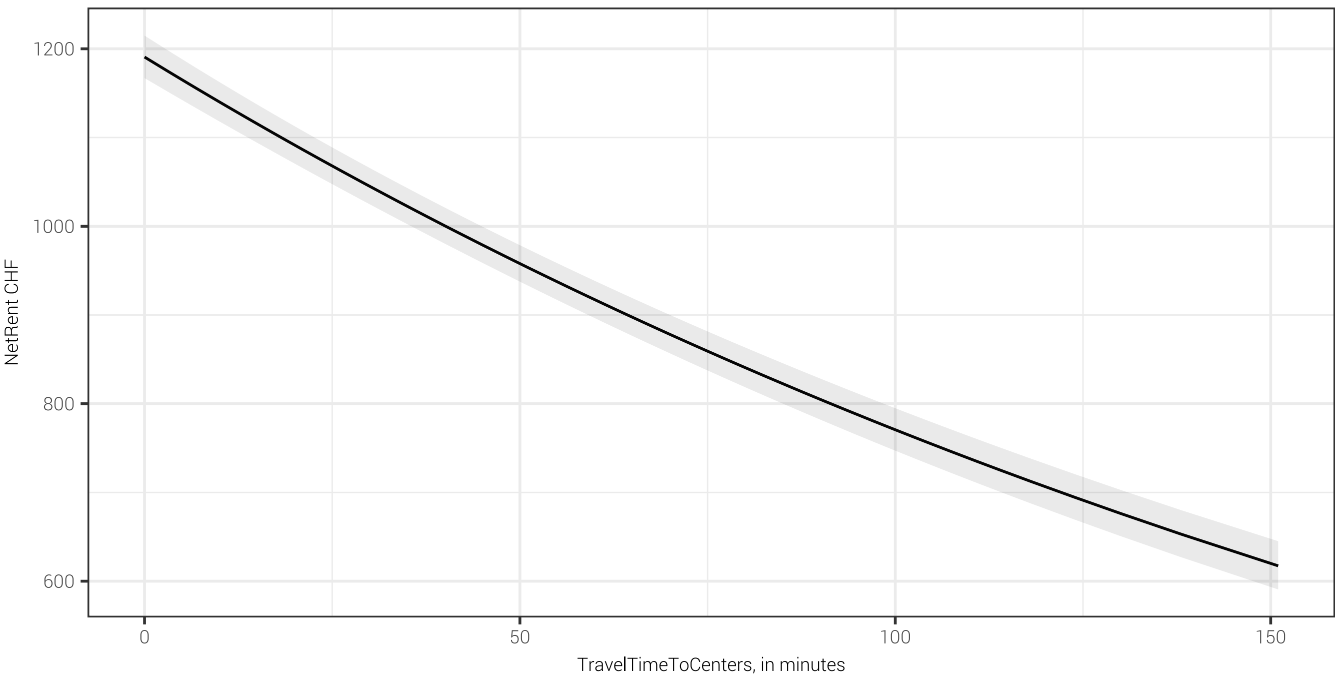
Travel times motorised private transport to core cities, 2017 **G 24**



Source: ARE – National passenger transport model (NPTM) from DETEC

Marginal effect of the travel time via private transport on the rental price **G 25**

With confidence interval (95%)

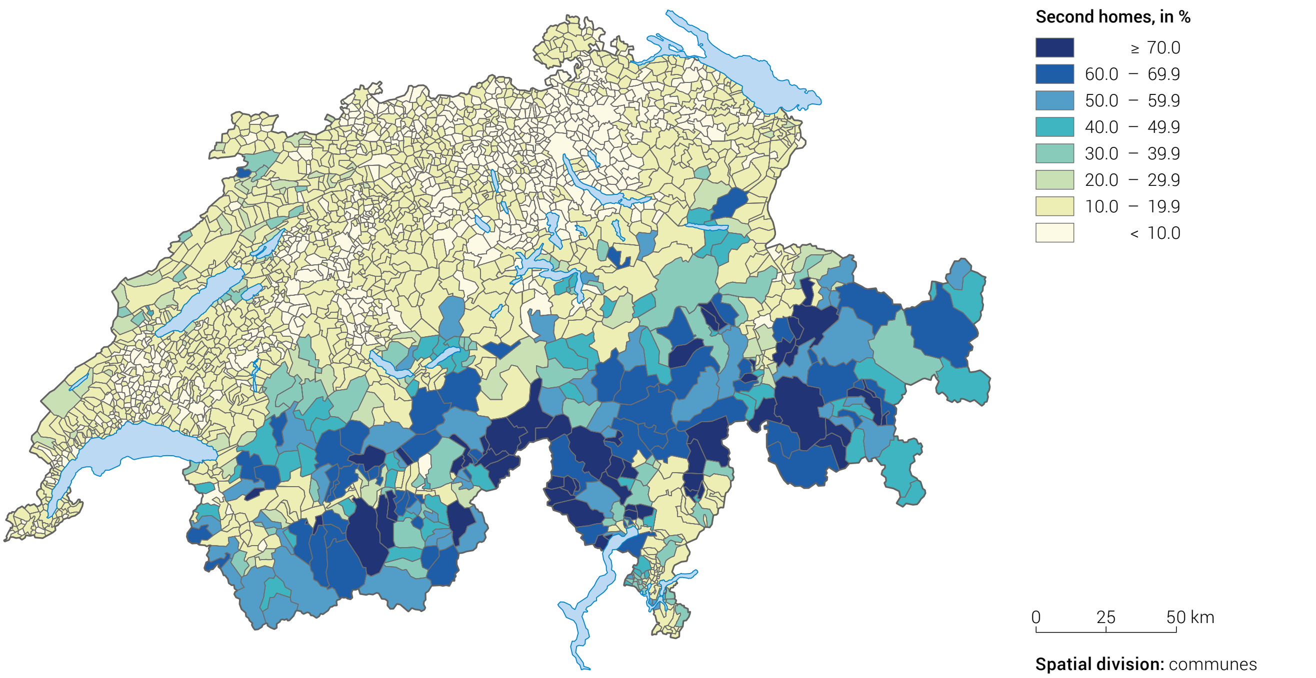


Source: FSO – Consumer Price Index (CPI)

Rate of second homes in the municipality

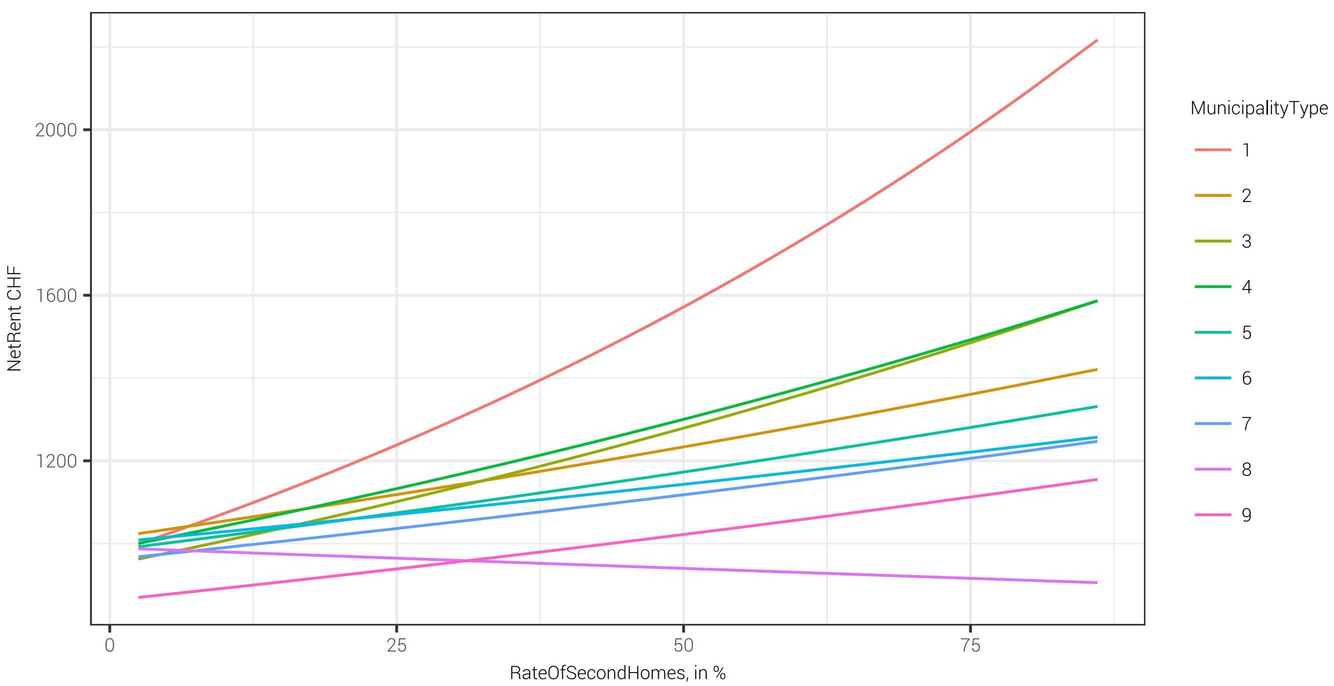
An additional 10% of second homes in the municipality is associated on average with a 10% increase in the rent, all other things being equal. The model takes into account the interaction between the rate of second homes and the municipality type, thereby adjusting the impact of the rate of second homes on the rent according to the municipality type. For most types of municipality, a higher rate of second homes in the municipality is associated with higher rental prices, all other things being equal.

Second home rate, 2020 **G 26**



Source: ARE – Housing inventory

Marginal effect of the rate of second homes on the rental price by municipality type **G 27**

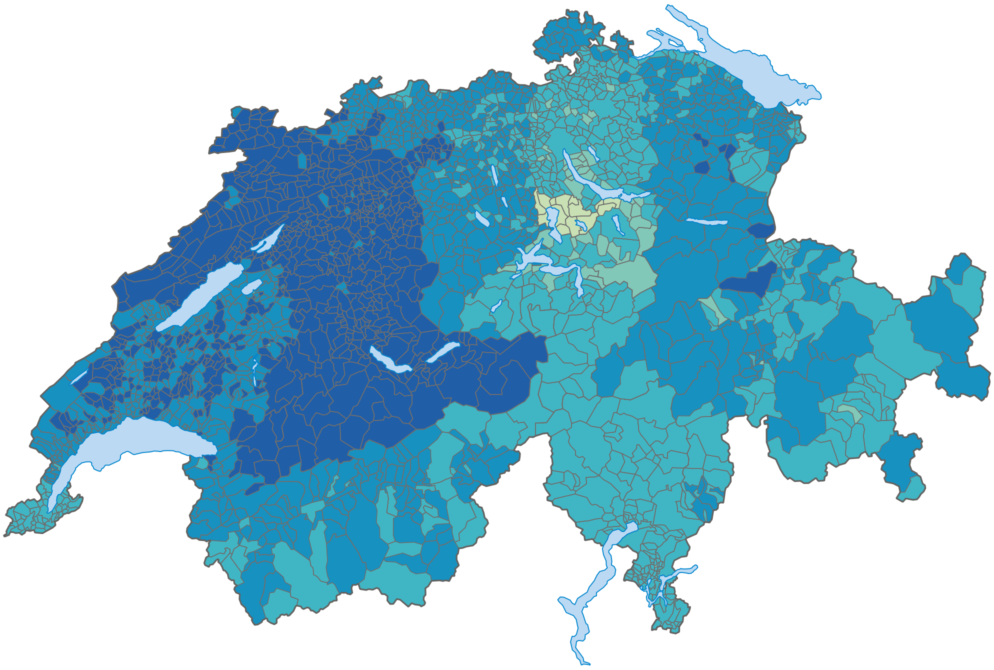


Source: FSO – Consumer Price Index (CPI)

Tax burden

The tax burden in a municipality has been shown to be relevant in the model for predicting the rental prices. In order to represent the tax burden, the model includes the arithmetic average of the tax burdens for the household types "single", "married person without children", "married person with two children", and "both spouses in paid employment with two children" for gross earned income of CHF 50 000, 100 000, 150 000 and 200 000. One additional percent in this aggregate variable is associated on average with a 5% decrease in the rent, all other things being equal.

Aggregate tax burden[1], 2018 **G 28**



Tax burden[2] for gross earned incomes, in %

- ≥ 11.0
- 9.0 – 10.9
- 7.0 – 8.9
- 5.0 – 6.9
- < 5.0

[1] average of the household types "single", "married without children", "married with two children" and "both spouses in paid employment with two children" for gross earned incomes of CHF 50 000, 100 000, 150 000 and 200 000

[2] cantonal, municipal and parish tax

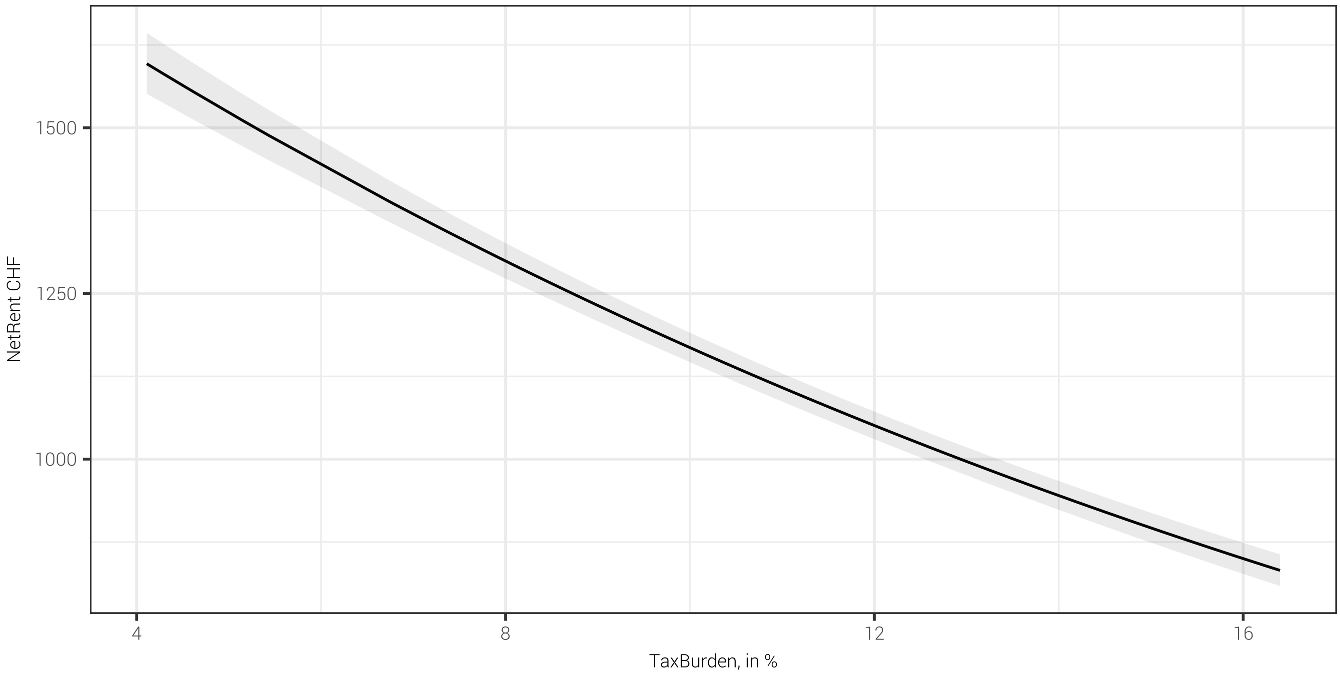
0 25 50 km

Spatial division: communes

Source: FTA – Tax statistics

Marginal effect of the tax burden on the rental price **G 29**

With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

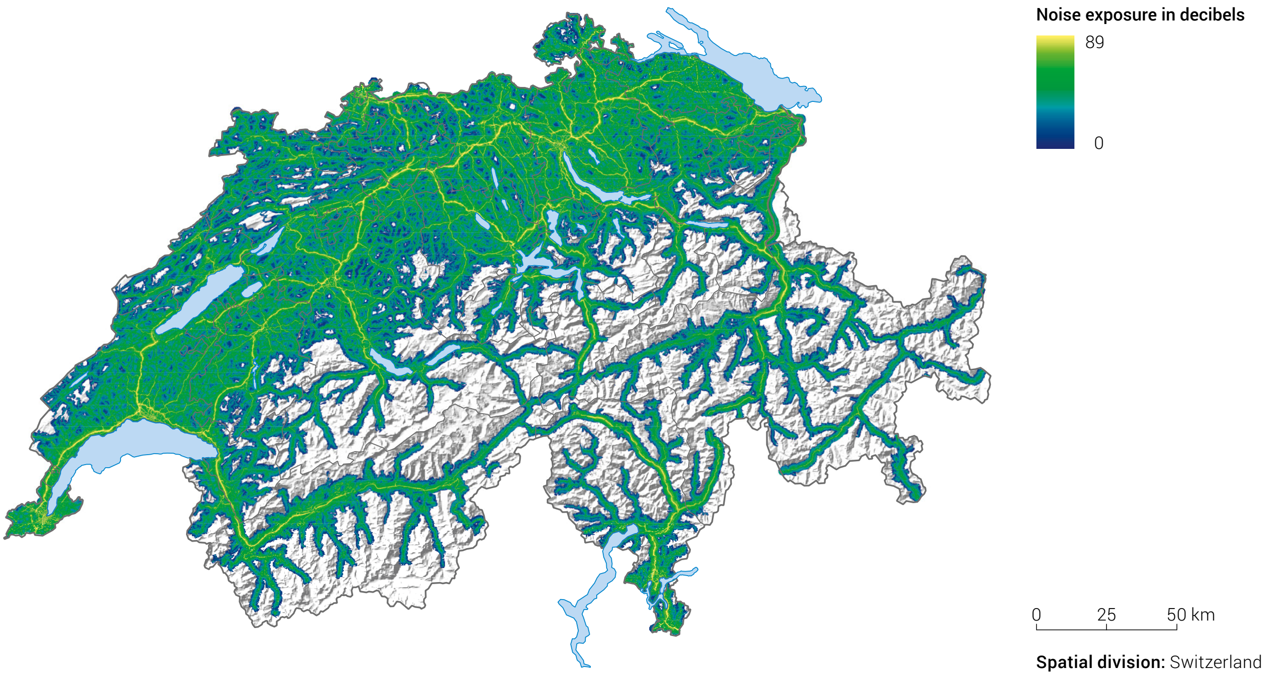
Micro location variables

The micro location of a dwelling reflects the characteristics of the location of the building within the municipality. Our model includes the noise produced by roads, trains and aircraft, the accessibility of public transport, the potential view of lakes and mountains, the proximity to lakes and high-voltage power lines, and the slope of the land. The interaction between the slope of the land and the municipality type also enters into the model. When the micro location variables are added to the structural variables, the variables related to the lease agreement and the macro location variables, the explained percentage of the variance in the rental prices rises from 78% to 79%.

Road noise

The model takes night-time road noise into account. In our sample, it has an average value of 39 decibels and a maximum value of 69 decibels. One additional decibel of night-time road noise is associated on average with a 0.1% decrease in the rent, all other things being equal.

Road traffic noise at night, 2015 **G 30**

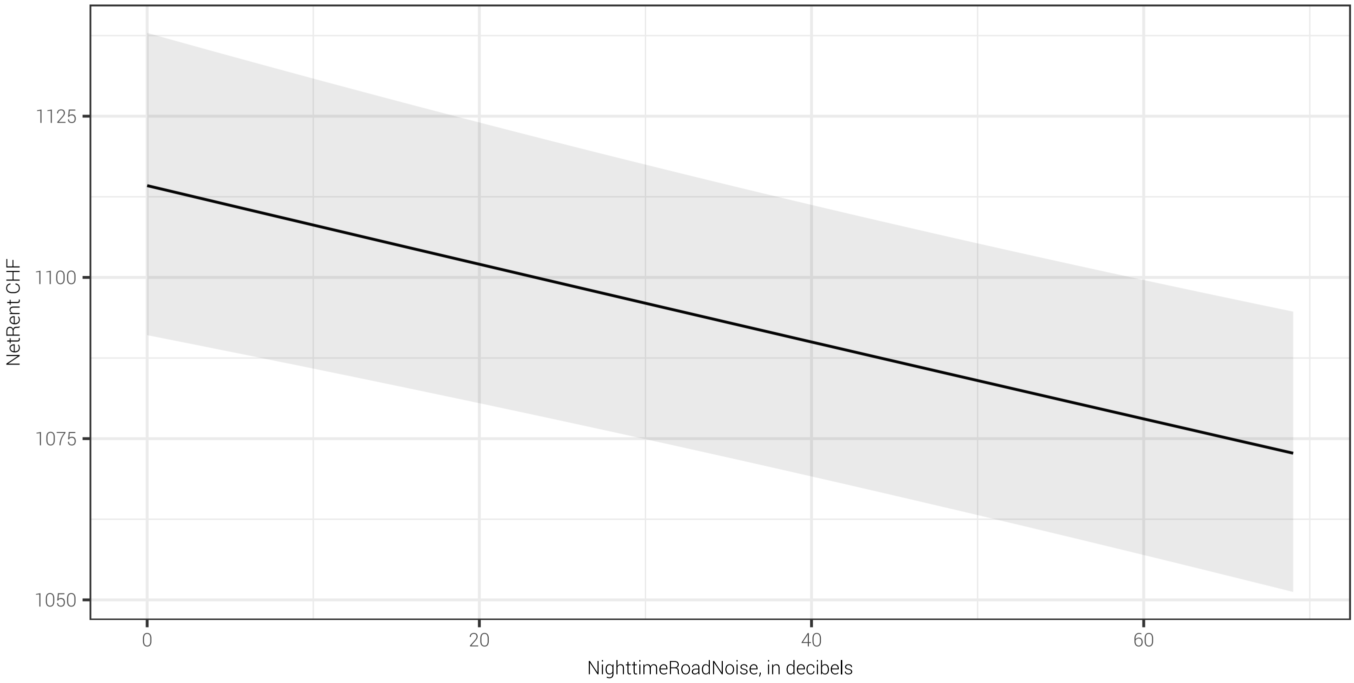


Spatial division: Switzerland

Source: FOEN, sonBASE - Noise Database of Switzerland 2015

Marginal effect of night-time road noise on the rental price **G 31**

With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

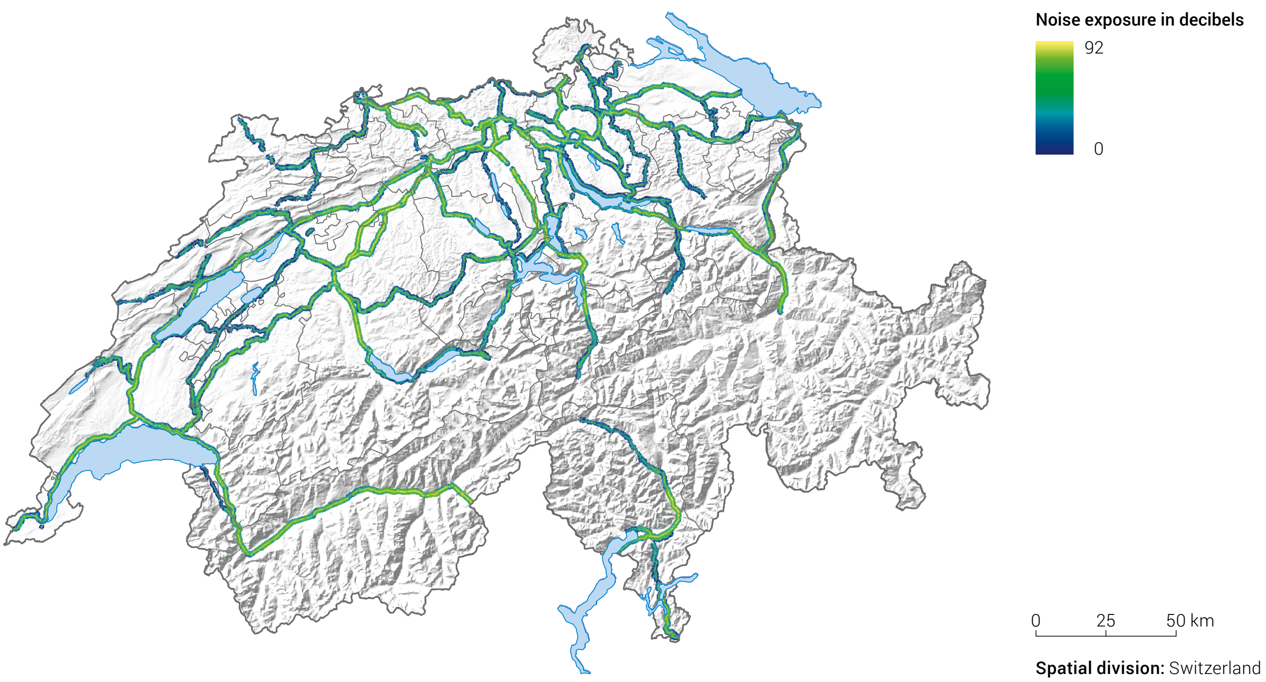
Railway noise

The model takes daytime railway noise into account. 36% of our sample does not experience any disturbance related to railway noise; the average disturbance level is 17 decibels. Five additional decibels of daytime railway noise is associated on average with a 0.1% decrease in the rent, all other things being equal.

Aircraft noise

The model takes daytime aircraft noise into account. 94% of our sample experience disturbance related to aircraft noise below 50 decibels, while 2% experience a disturbance level between 50 and 55 decibels and 4% over 55 decibels. Compared to a dwelling with a disturbance below 50 decibels, the rental price decreases by 2% for a disturbance level up to 55 decibels and by 3% for a disturbance level over 55 decibels, all other things being equal.

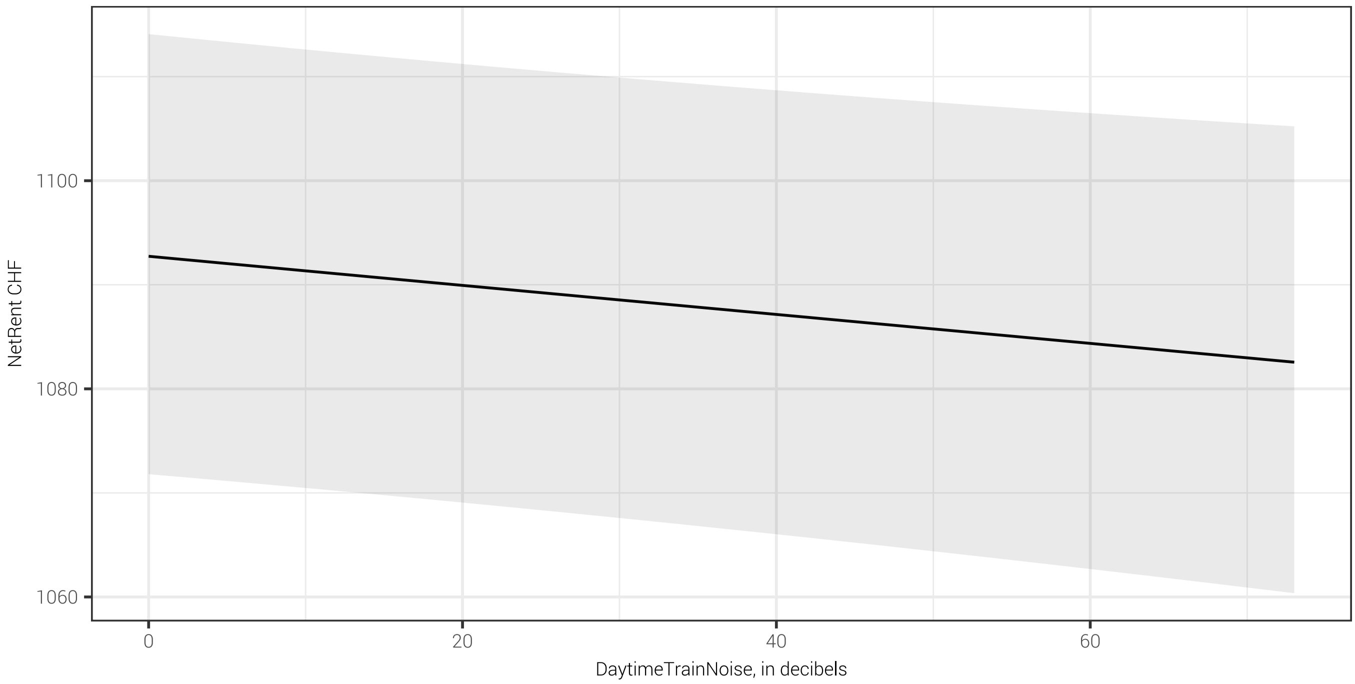
Railway noise during the day, 2015 G 32



Source: FOEN, sonBASE - Noise Database of Switzerland 2015 © FSO 2022

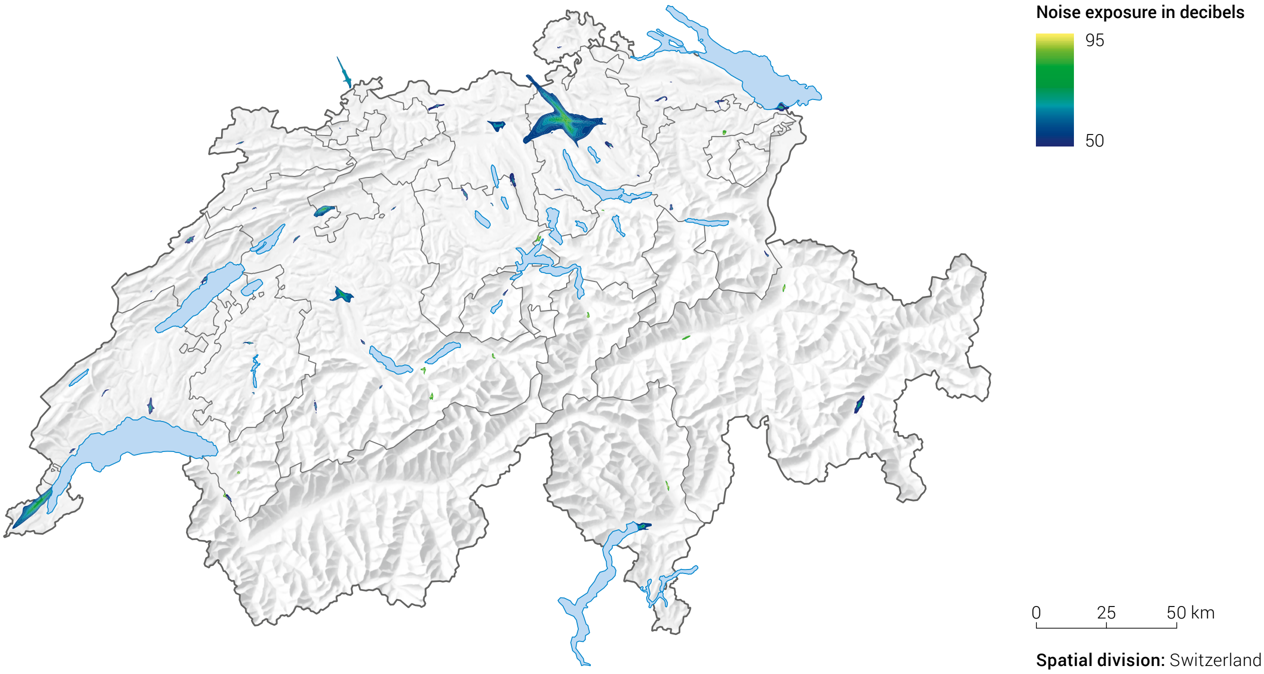
Marginal effect of daytime railway noise on the rental price G 33

With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI) © FSO 2022

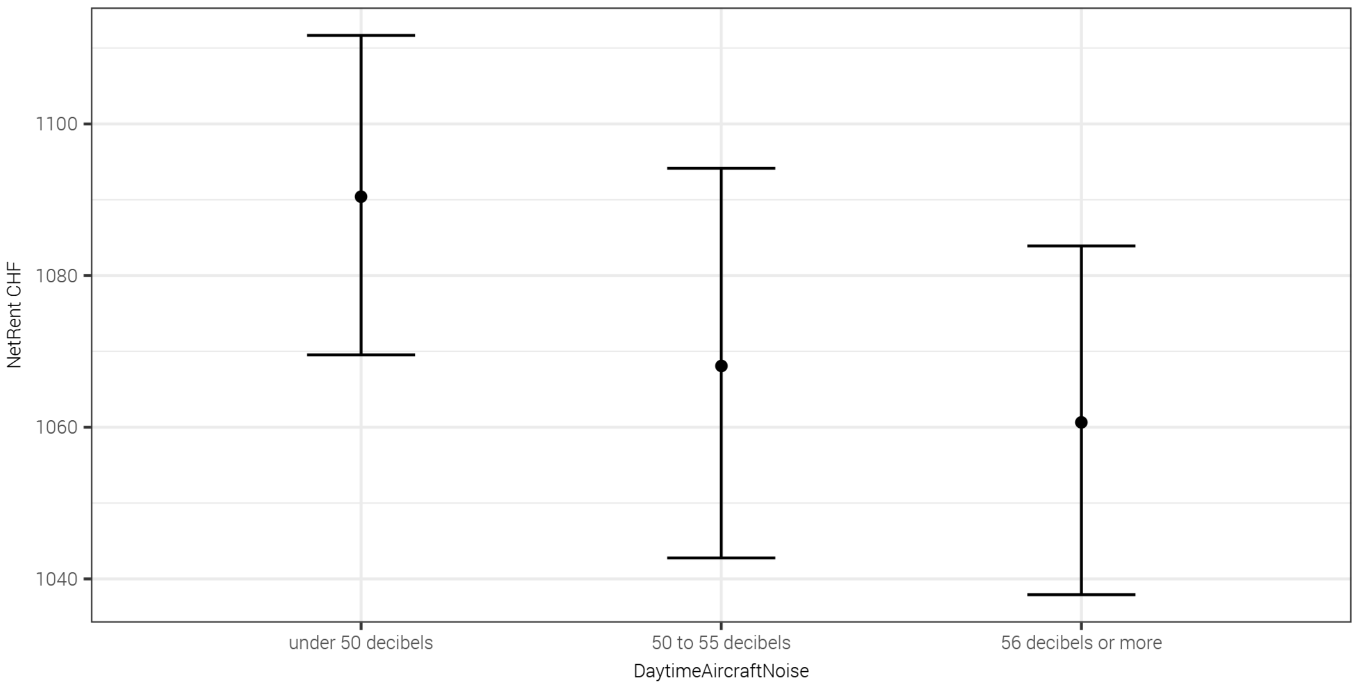
Aircraft noise during the day, 2020 G 34



Source: FOCA – Noise pollution register for civil aerodromes

Marginal effect of daytime aircraft noise on the rental price G 35

With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

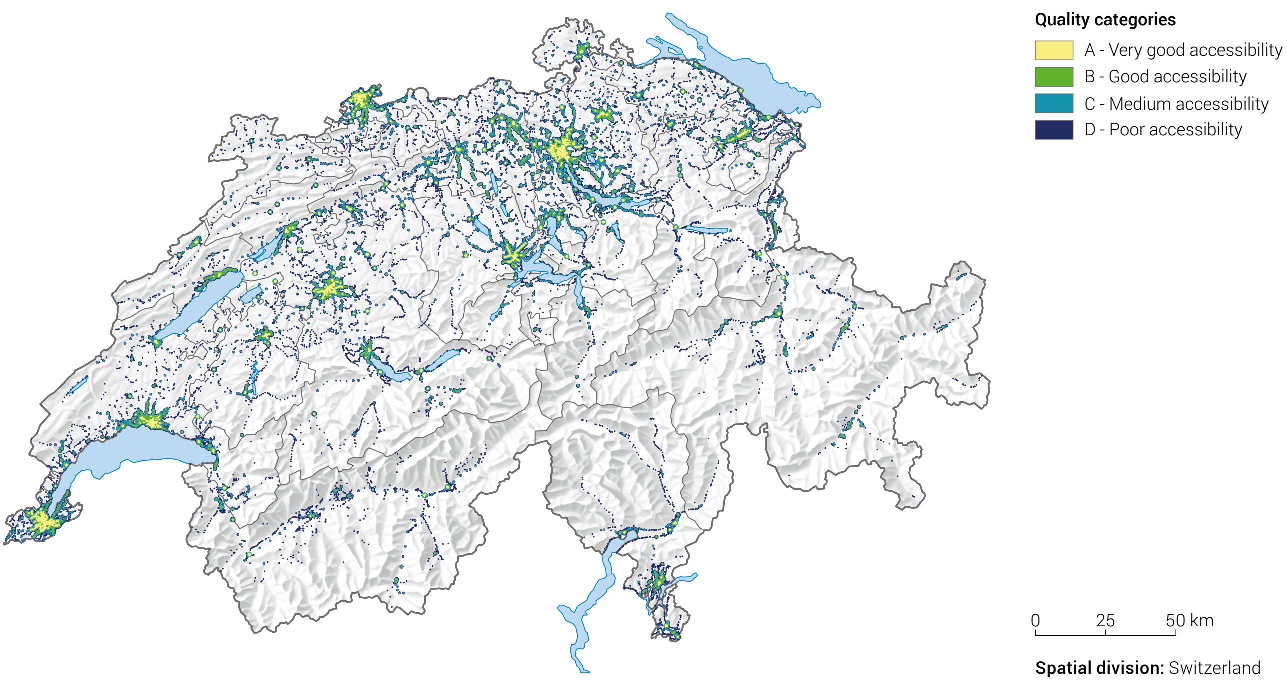
Public transport quality

The quality of public transport service is rated using a letter from A to D that is determined as a function of the distance to transit stops, the type of public transport and the frequency of service. If a distance to transit stops of 1 kilometre is exceeded, no accessibility rating is provided. In our model, this situation is the reference category. Dwellings located more than 1 kilometre from a stop represent 7% of our sample, while dwellings with very good accessibility (class A) account for 24%. All other things being equal, the rental price of a dwelling with very good accessibility is on average 6% higher than that of a dwelling located more than 1 kilometre from a stop.

Proximity to a lake

The model includes four categories related to the distance from a lake. 97% of the dwellings in our sample are located more than 200 metres from a lake, 1% are located 100 metres or less, 1% between 101 and 150 metres, and 1% between 151 and 200 metres. The difference in rental price between a dwelling located more than 200 metres or less than 100 metres to a lake is equal to 9%, all other things being equal.

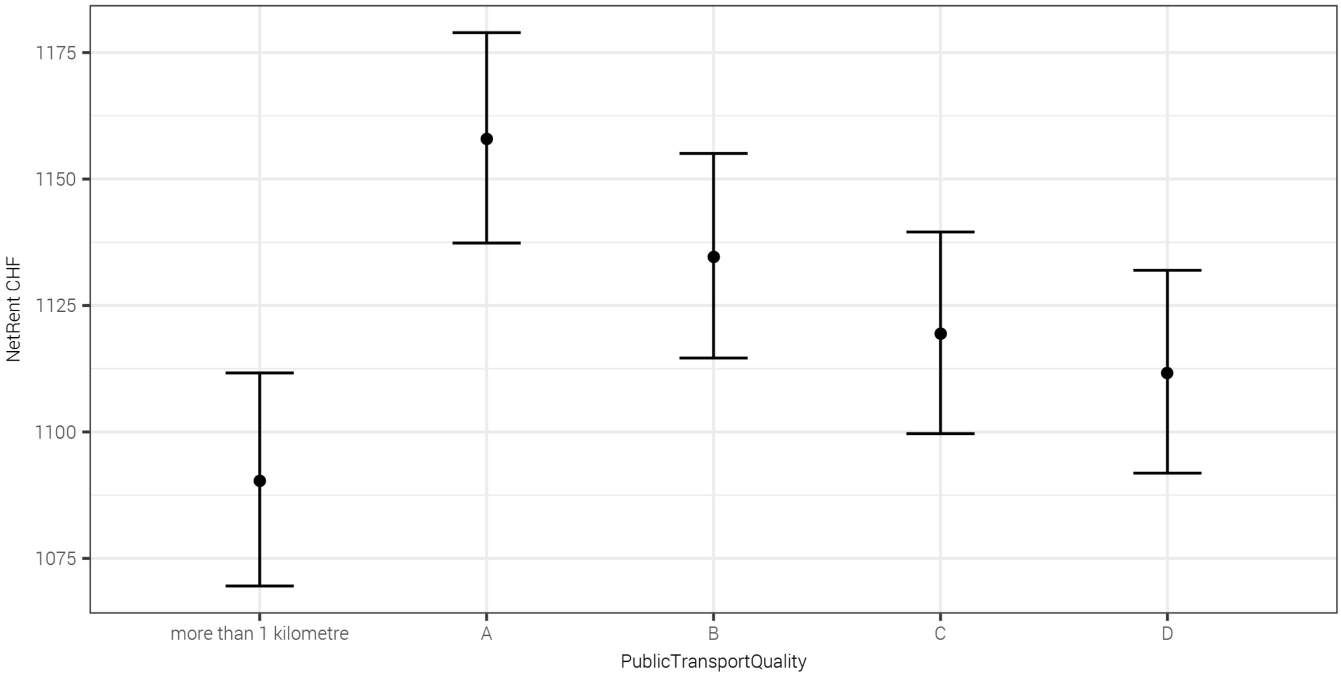
Public transport quality categories, 2020/2021 **G 36**



Source: INFOPLAN-ARE, opentransportdata.swiss

Marginal effect of accessibility of public transport on the rental price **G 37**

With confidence interval (95%)



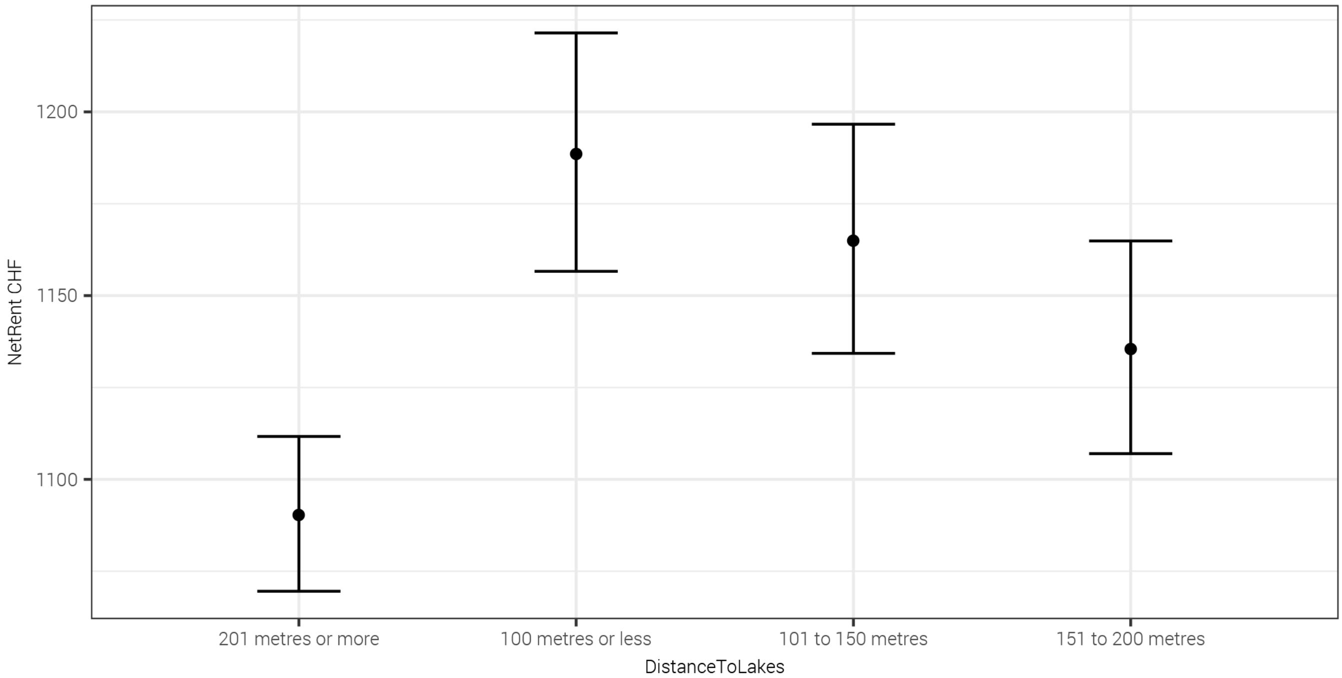
Source: FSO – Consumer Price Index (CPI)

Lakes **G 38**

Source: swisstopo

Marginal effect of the proximity to a lake on the rental price **G 39**

With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

High voltage power lines

The model includes two categories for the distance from high voltage power lines. 97% of the dwellings in the sample are located more than 200 metres from high voltage power lines. The difference in rental price between a dwelling located more than 200 metres or 200 metres or less from high voltage power lines is equal to 2%, all other things being equal.

Potential mountain view

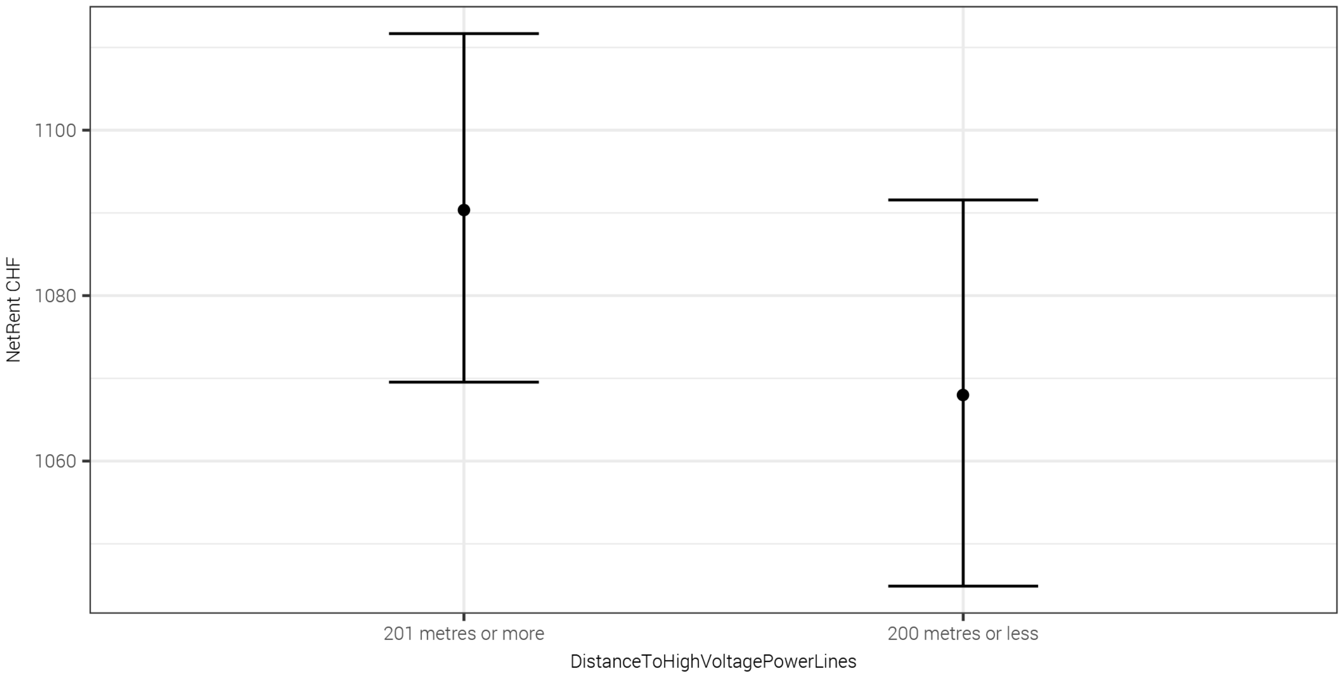
The potential mountain view represents information about the number of potentially visible peaks without considering nearby buildings or vegetation. The dwellings in the sample have on average a potential view of 10 peaks; 15% of the dwellings have no potential peak view. One additional peak is associated on average with a rent increase of 0.1%, all other things being equal.

High voltage power lines, 2018 **G 40**

Source: swisstopo

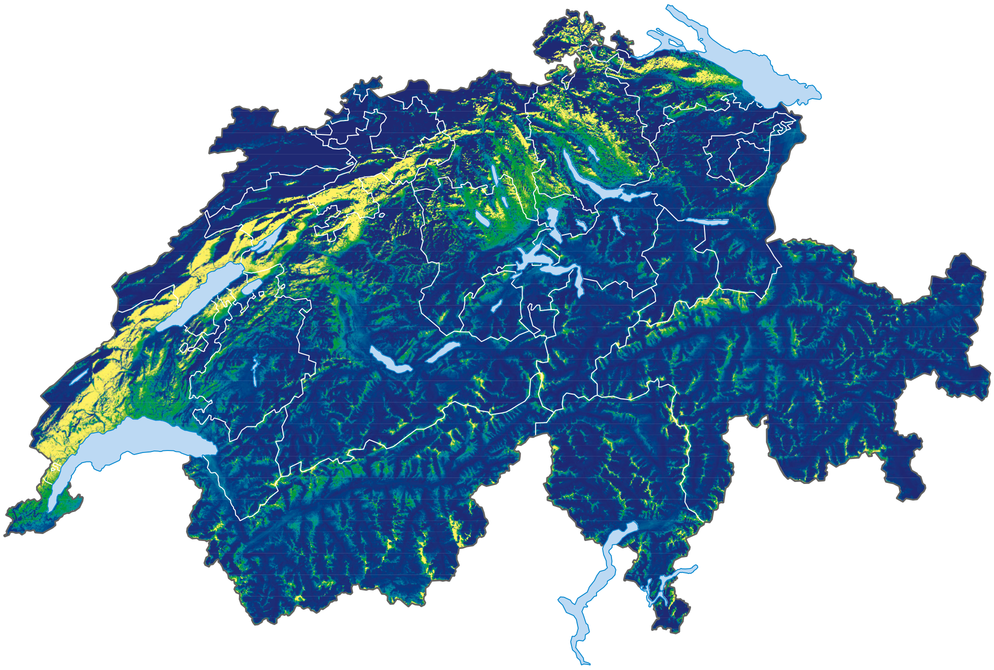
Marginal effect of the distance from high voltage power lines on the rental price **G 41**

With confidence interval (95%)



Source: FSO – Consumer Price Index (CPI)

Potential mountain view, 2017 G 42

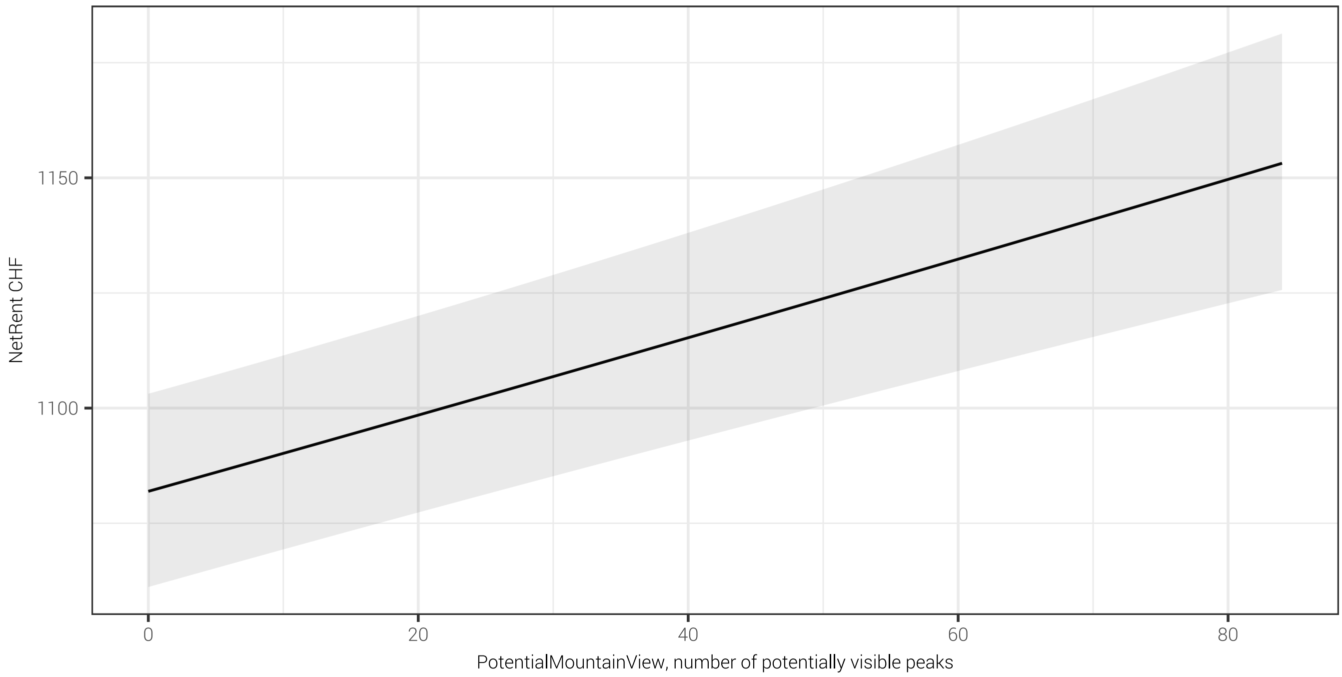


[1] To improve map readability, the colour gradation is exponential. The yellow areas of the map, for example, represent about 35 potentially visible peaks or more.

Sources: swisstopo – Elevation model swissALTI3D; European Environment Agency – Elevation model EU-DEM

Marginal effect of the potential mountain view on the rental price G 43

With confidence interval (95%)



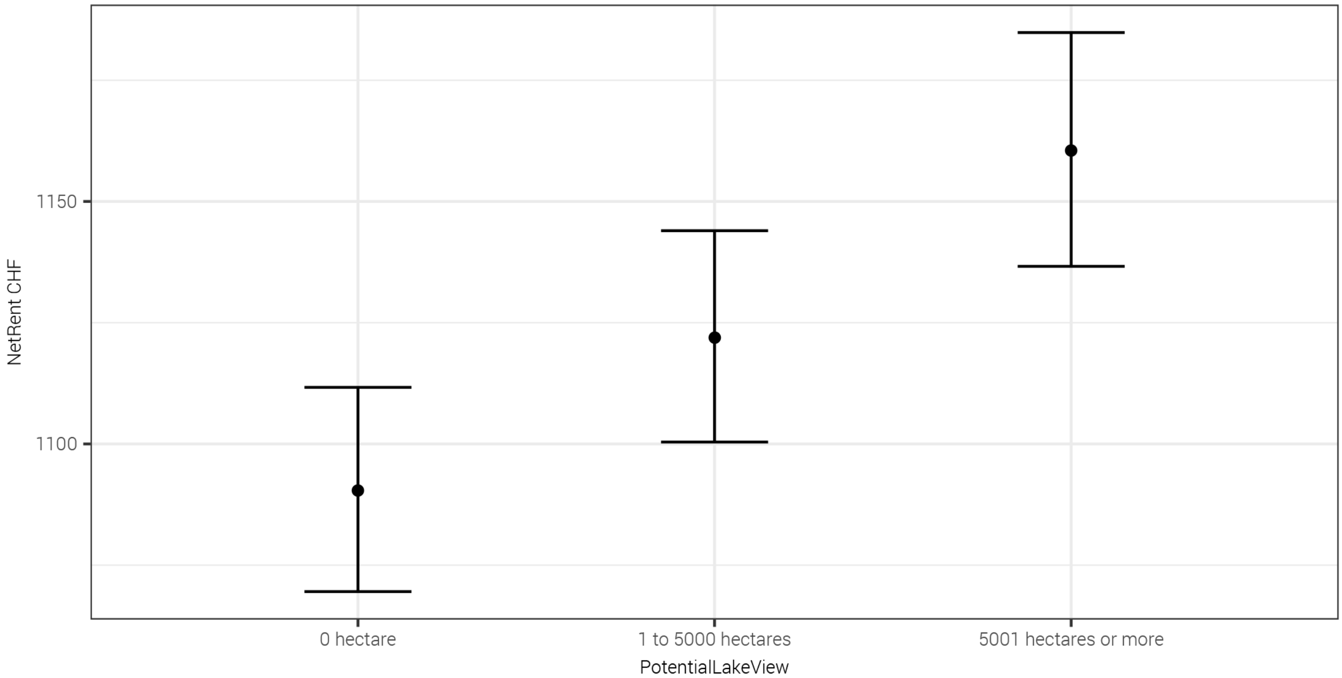
Source: FSO – Consumer Price Index (CPI)

Potential view of lakes

The potential view of lakes represents the number of hectares of lake surface that is potentially visible without considering nearby buildings or vegetation. The model includes three classes of potential lake view: 47% of the sample has no lake view, 45% has a potential view between 1 and 5000 hectares, and 9% has a potential view of over 5000 hectares. Compared to a dwelling with no lake view, the rental price increases by 3% for a potential view up to 5000 hectares and 6% for a potential view over 5000 hectares, all other things being equal.

Marginal effect of the potential lake view on the rental price **G 44**

With confidence interval (95%)

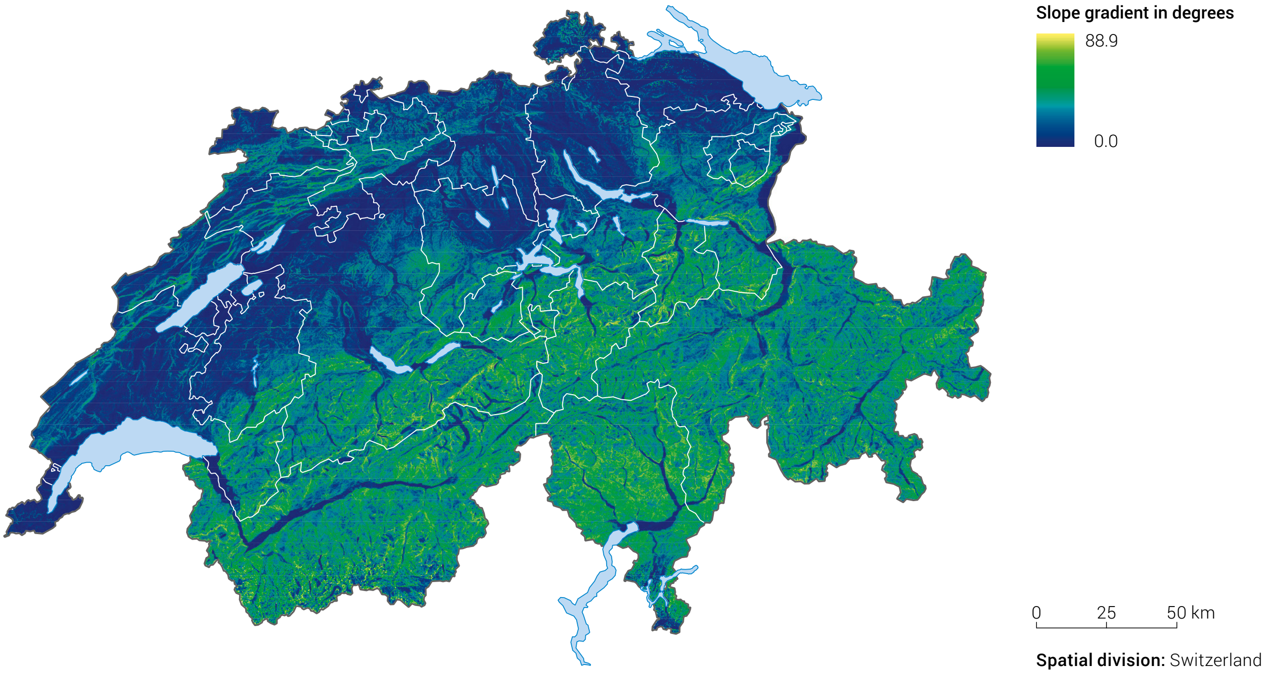


Source: FSO – Consumer Price Index (CPI)

Slope gradient

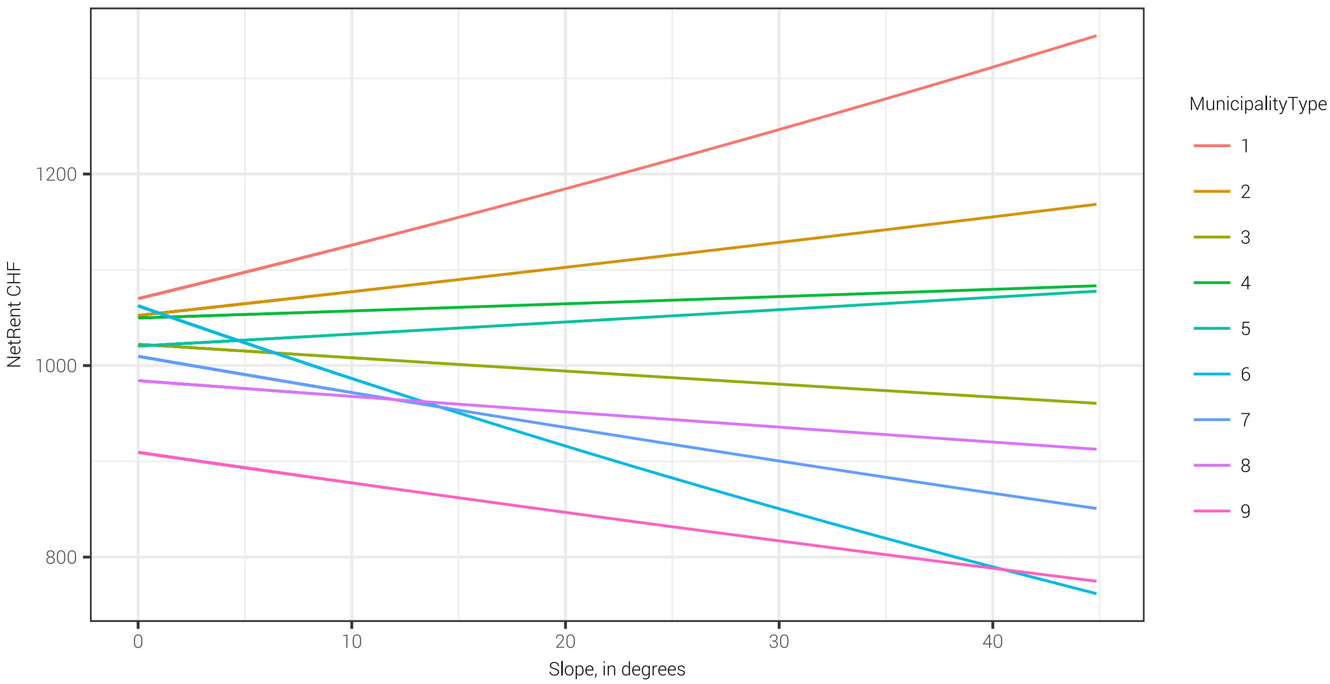
The model takes into account the slope of the land on which the dwelling is located depending on the municipality type. This interaction helps to adjust the impact of the slope of the land on the rental price according to the municipality type. 75% of the dwellings in the sample are built on a slope between 0 and 5 degrees. For each additional degree of slope, the rental price increases on average by 1%, all other things being equal.

Slope gradient, 2018 **G 45**



Source: swisstopo – Elevation model swissALTI3D

Marginal effect of the slope gradient on the rental price by municipality type **G 46**



Source: FSO – Consumer Price Index (CPI)

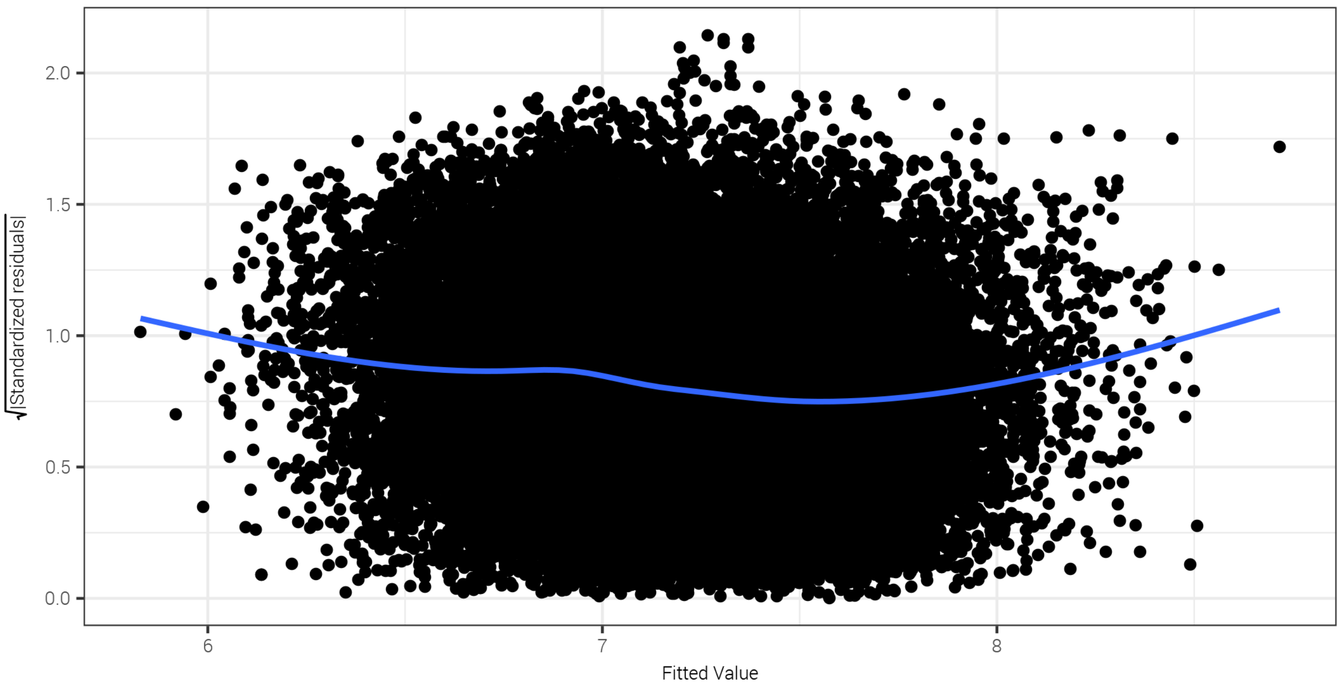
Residuals

The residuals represent the share of the rental price that is not predicted by the variables in the model. Certain characteristics are required of the residuals in order to ensure proper functioning of the ordinary least squares (OLS) methodology that is used for calculation of our model. According to the Gauss-Markov theorem (Wooldridge, 2012), the optimum unbiased estimation of the coefficients is obtained if the residuals have an expectation value of zero, uniform variance (homoscedasticity) and are not correlated with one another. We verified that these conditions are satisfied using a variety of graphical analyses and tests.

According to our graphical analyses, the residuals are partially centred around zero (Figure 47) and do not follow a normal distribution (Figure 48 on page 47), but their variance appears to be relatively stable (Figure 49 on page 47). The Jarque-Bera normality test indicates that the residuals do not follow a normal distribution (X-squared = 390.03, p-value < 2.2e–16), but the Breusch-Pagan (BP) test indicates the presence of heteroscedasticity in the residuals, i.e. a non-uniform variance (BP = 3577.6, p-value < 2.2e–16). The Ramsey regression equation specification error test (RESET) indicates a poor functional form of the model (RESET = 40.881, p-value < 2.2e–16). Finally, the variance inflation factors (VIF) do not indicate any abnormal multicollinearity of the variables. These results help to refine the conclusions from the graphical analyses. The non-compliance with the hypotheses of heteroscedasticity and normality of the residuals invalidates among other things the t-test of the coefficients. However, a robust estimation of the coefficients allowed us to verify that the deviation between the coefficients estimated in a robust or non-robust manner is low.

Nevertheless, the results of these diagnostic checks of the residuals should be considered from a proper perspective since the hedonic model of rental prices is not an analysis tool. The goal of the model is to obtain a global estimate of rental prices – as opposed to an estimate of the price of different characteristics of the rented properties. Nevertheless, in order to improve the characteristics of the residuals, a long-term objective could involve adding new predictor variables to the model that are relevant in the prediction of rental prices, or implementing a finer division of the cantons and agglomerations (Silver, 2020).

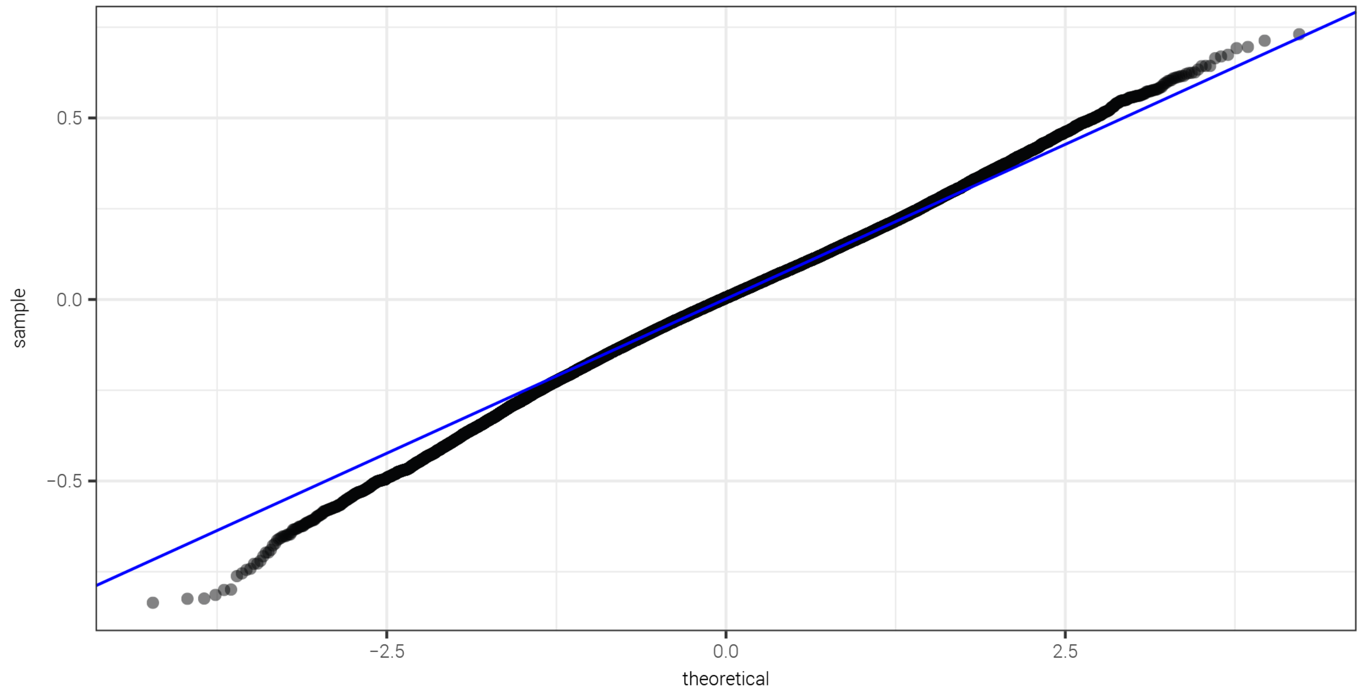
Diagnostic check of the residuals: scale–location plot **G 47**



Source: FSO – Consumer Price Index (CPI)

Diagnostic check of the residuals: normal Q-Q plot

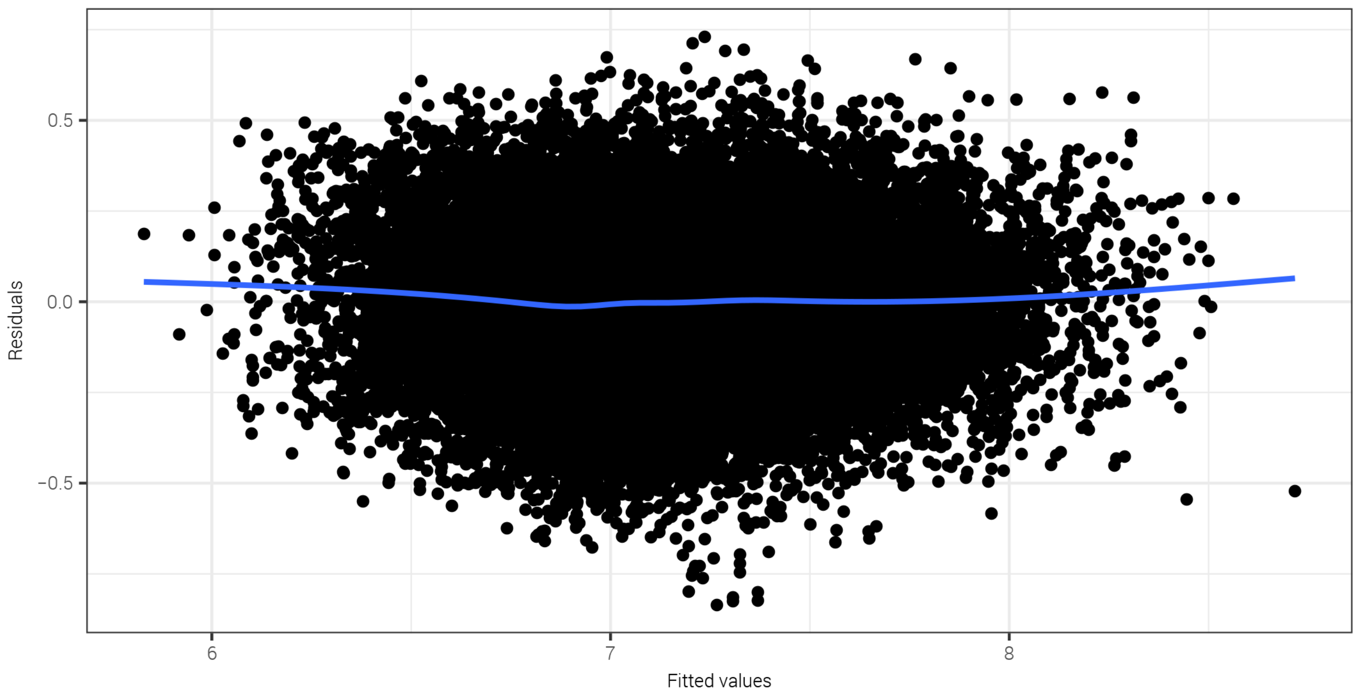
G 48



Source: FSO – Consumer Price Index (CPI)

Diagnostic check of the residuals: residuals vs fitted values

G 49



Source: FSO – Consumer Price Index (CPI)

Performance of the model

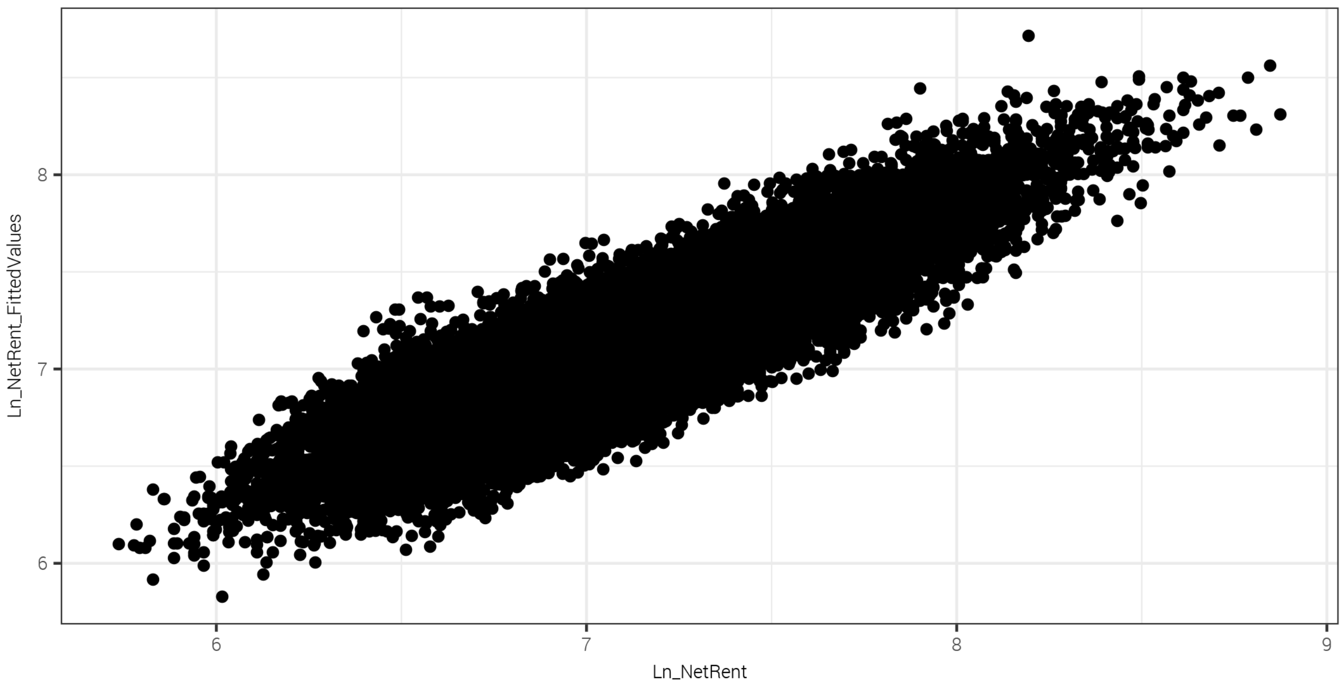
The performance of the model can be evaluated either in-sample or out-of-sample on the basis of different statistics. The in-sample method evaluates the precision of the model on the entire database, while the out-of-sample method re-estimates the coefficients of the model on a fraction of the database and evaluates their precision on observations that were omitted from the estimate. The results of the in-sample analysis and the average for the results of the out-of-sample analysis with ten samplings are presented in Table T4. Figure 50 illustrates the surveyed rental prices compared with the rental prices estimated by the model on a logarithmic scale.

Performance of the model T4

Evaluation type	R^2 adj.	MAE	RMSE	MAE in CHF	RMSE in CHF
In-sample	0.7890	0.1417	0.1815	CHF 197	CHF 269
Out-of-sample	0.7884	0.1421	0.1820	CHF 197	CHF 270

Source: FSO – Consumer Price Index (CPI)

Observed and predicted rental prices on a logarithmic scale G 50



Source: FSO – Consumer Price Index (CPI)

Conclusion

The new hedonic model is based on more than 41 500 observations from the rental price index from 2014 to 2018, supplemented with geolocation variables furnished by various Swiss authorities and government agencies. The raw data from the rental price index was processed to allow its utilisation for modelling purposes, supplemented with geolocation data and selected for modelling in view of an alternative data source. The hedonic model was formulated through careful selection among thousands of candidate models. This was followed by detailed refinement in order to obtain the best results in terms of the predictive capacity and the respect of the basic assumptions of linear regression. Finally, it was vetted by a renowned international expert. The new hedonic model of rental prices thus makes it possible to update the quality adjustment for the rental price index – as is required for managing quality differences between dwellings when the sample is regenerated. It is based on more recent data along with additional variables and disaggregated geographical data, and provides improved predictive capacity compared to the previous model.

Appendix

Annex 1 Algebraic definitions

Adjusted R²

$$R^2 adj. = 1 - \left[\frac{\left(1 - \frac{\sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}\right)(n-1)}{n-k-1}\right]$$

where $\hat{y}_i$ is the estimated rental price of dwelling i,
$\bar{y}$ is the average rental price in the sample,
y_i is the rental price of dwelling i,
n is the number of dwellings in the sample,
k is the number of parameters in the model.

Akaike information criterion

$$AIC = 2k - 2\ln(\hat{L})$$

where k is the number of parameters in the model,
$\hat{L}$ is the maximum of the likelihood function of the model.

Bayesian information criterion

$$BIC = \ln(n)\, k - 2\ln(\hat{L})$$

where n is the number of dwellings in the sample,
k is the number of parameters in the model,
$\hat{L}$ is the maximum of the likelihood function of the model.

Mean absolute error

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|\hat{y}_i - y_i|$$

where $\hat{y}_i$ is the estimated rental price of dwelling i,
y_i is the rental price of dwelling i,
n is the number of dwellings in the sample.

Root mean square error

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)^2}$$

where $\hat{y}_i$ is the estimated rental price of dwelling i,
y_i is the rental price of dwelling i,
n is the number of dwellings in the sample.

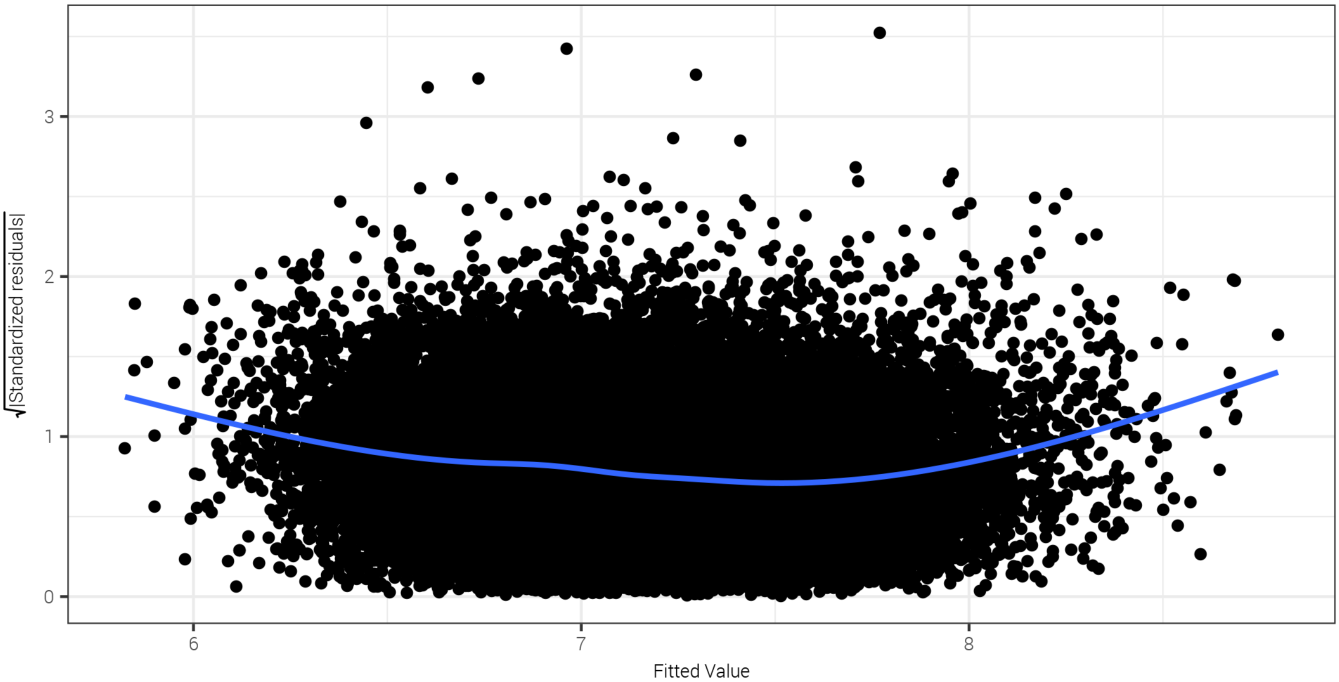
Cook's distance

$$D_j = \frac{\sum_{i=1}^{n}(\hat{y}_i - \hat{y}_{i(j)})^2}{k\frac{1}{n}\sum_{i=1}^{n}(\hat{y}_i - y_i)^2}$$

where $\hat{y}_i$ is the estimated rental price of dwelling i,
$\hat{y}_{i(j)}$ is the estimated rental price of dwelling i
based on the adjusted model without observation j,
k is the number of parameters in the model.

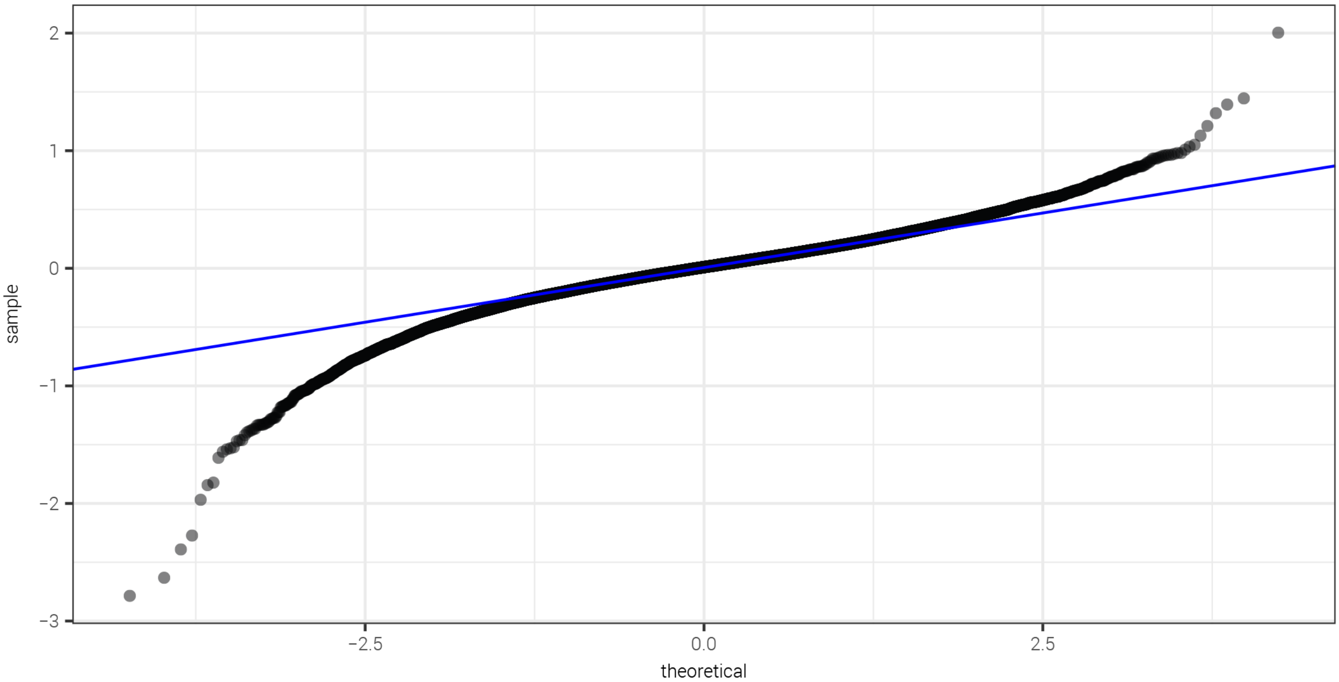
Annex 2 Residuals prior to exclusion of influential data

Diagnostic check of residuals prior to exclusion of influential data: scale-location plot **G 51**



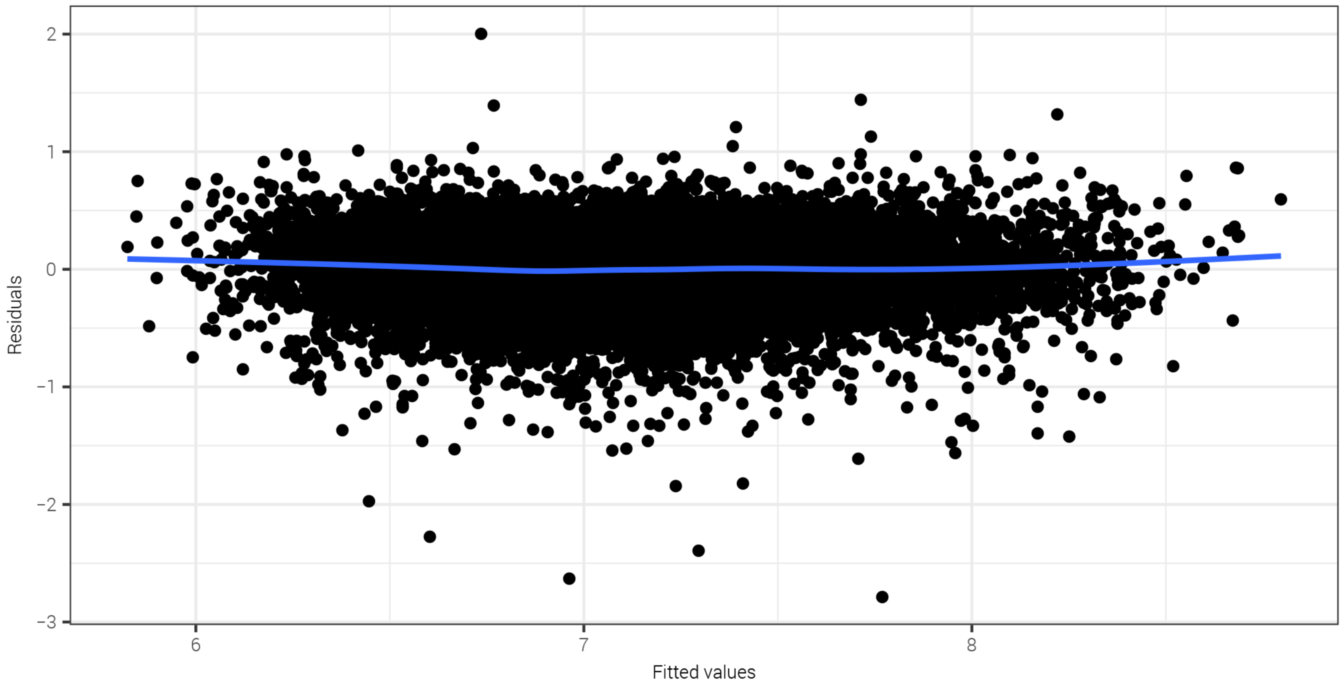
Source: FSO – Consumer Price Index (CPI)

Diagnostic check of residuals prior to exclusion of influential data: normal Q–Q plot **G 52**



Source: FSO – Consumer Price Index (CPI)

Diagnostic check of residuals prior to exclusion of influential data: residuals vs fitted values **G 53**



Source: FSO – Consumer Price Index (CPI)

Annex 3 Nomenclature

Nomenclature for variables in the model

Variable name	Description
(Intercept)	Intercept
BuildingAge	Age of dwelling at time of survey in years since construction
BuildingAge^2	Age of dwelling at time of survey in years since construction, squared
NumberOfRooms2	Dwelling with 2 rooms
NumberOfRooms3	Dwelling with 3 rooms
NumberOfRooms4	Dwelling with 4 rooms
NumberOfRooms5	Dwelling with 5 rooms
NumberOfRooms6	Dwelling with 6 rooms
NumberOfRooms7 or more	Dwelling with 7 or more rooms
LivingArea	Living area in square metres
LivingArea^2	Living area in square metres, squared
Floor2nd floor	Dwelling located on 2nd floor
Floor3rd floor	Dwelling located on 3rd floor
Floor4th floor	Dwelling located on 4th floor
Floor5th floor or above	Dwelling located on 5th floor or higher
FloorHouse	Detached house
NumberOfParkingSpaces1	One garage included in net rent for dwelling
NumberOfParkingSpaces2 or more	Two or more garages included in net rent for dwelling
PenthouseYes	Penthouse (with roof terrace)
DuplexYes	Duplex (on two floors)
AgeOfLeaseAgreement	Age of current lease agreement in years at time of survey
RentalStatusConcierge	Rent reduction due to caretaker work
RentalStatusRelative or friend	Rent reduction due to kinship or friendship between tenant and landlord
RentalStatusSubsidized or cooperative housing	Subsidised or cooperative housing
TypeOfOwnerGovernment	Government-owned dwelling
TypeOfOwnerCooperative	Cooperative-owned dwelling
TypeOfOwnerReal estate or building company	Dwelling owned by real estate or building company
TypeOfOwnerPension, insurance or investment fund	Dwelling owned by pension, insurance or investment fund
TypeOfOwnerUnknown	Dwelling with unknown owner type
Year2017	Rental price survey in year 2017
Year2016	Rental price survey in year 2016
Year2015	Rental price survey in year 2015
Year2014	Rental price survey in year 2014
CantonAI	Dwelling located in canton of Appenzell Innerrhoden
CantonAR	Dwelling located in canton of Appenzell Ausserrhoden
CantonBasel	Dwelling located in city of Basel

Source: FSO – Consumer Price Index (CPI)

Nomenclature for variables in the model (Continued)

Variable name	Description
CantonBE	Dwelling located in canton of Bern (except city of Bern)
CantonBern	Dwelling located in city of Bern
CantonBL	Dwelling located in canton of Basel-Landschaft
CantonBS	Dwelling located in canton of Basel-Stadt (except city of Basel)
CantonFR	Dwelling located in canton of Fribourg
CantonGE	Dwelling located in canton of Geneva (except city of Geneva)
CantonGenève	Dwelling located in city of Geneva
CantonGL	Dwelling located in canton of Glarus
CantonGR	Dwelling located in canton of Graubünden
CantonJU	Dwelling located in canton of Jura
CantonLausanne	Dwelling located in city of Lausanne
CantonLU	Dwelling located in canton of Lucerne
CantonNE	Dwelling located in canton of Neuchâtel
CantonNW	Dwelling located in canton of Nidwalden
CantonOW	Dwelling located in canton of Obwalden
CantonSG	Dwelling located in canton of St Gallen
CantonSH	Dwelling located in canton of Schaffhausen
CantonSO	Dwelling located in canton of Solothurn
CantonSZ	Dwelling located in canton of Schwyz
CantonTG	Dwelling located in canton of Thurgau
CantonTI	Dwelling located in canton of Ticino
CantonUR	Dwelling located in canton of Uri
CantonVD	Dwelling located in canton of Vaud (except city of Lausanne)
CantonVS	Dwelling located in canton of Valais
CantonZG	Dwelling located in canton of Zug
CantonZH	Dwelling located in canton of Zurich (except city of Zurich)
CantonZürich	Dwelling located in city of Zurich
MunicipalityType2	Dwelling located in an urban municipality of a medium agglomeration
MunicipalityType3	Dwelling located in an urban municipality of a small or outside agglomeration
MunicipalityType4	Dwelling located in a peri-urban municipality of high density
MunicipalityType5	Dwelling located in a peri-urban municipality of medium density
MunicipalityType6	Dwelling located in a peri-urban municipality of low density
MunicipalityType7	Dwelling located in a municipality of a rural centre
MunicipalityType8	Dwelling located in a centrally located rural municipality
MunicipalityType9	Dwelling located in an peripheral rural municipality
TravelTimeToCenters	Travel time in minutes by private transport to the most easily accessible centre (Basel, Bern, Geneva, Lausanne, Zurich)
RateOfSecondHomes	Rate of second homes in municipality in which dwelling is located
TaxBurden	Average tax burden in CHF in municipality in which dwelling is located

Source: FSO – Consumer Price Index (CPI)

Nomenclature for variables in the model (Continued)

Variable name	Description
NighttimeRoadNoise	Night-time road noise in decibels
DaytimeTrainNoise	Daytime train noise in decibels
DaytimeAircraftNoiseFrom 50 to 55 dB	Daytime aircraft noise from 50 to 55 decibels
DaytimeAircraftNoiseOver 55 dB	Daytime aircraft noise over 55 decibels
PublicTransportQualityA	Public transport quality A
PublicTransportQualityB	Public transport quality B
PublicTransportQualityC	Public transport quality C
PublicTransportQualityD	Public transport quality D
DistanceToLakes100 m or less	Distance to lakes of 100 metres or less
DistanceToLakesFrom 100 to 150 m	Distance to lakes from 100 to 150 metres
DistanceToLakesFrom 150 to 200 m	Distance to lakes from 150 to 200 metres
DistanceToHighVoltagePowerLines200 m or less	Distance to high-voltage power lines of 200 metres or less
PotentialMountainView	Potential mountain view in number of peaks
PotentialLakeViewFrom 1 to 5000 ha	Potential lake view from 1 to 5000 hectares
PotentialLakeViewOver 5000 ha	Potential lake view of over 5000 hectares
Slope	Slope of land on which dwelling is located in degrees
LivingArea:MunicipalityType2	Interaction between living area of dwelling in square metres and location of dwelling in an urban municipality of a medium-sized agglomeration
LivingArea:MunicipalityType3	Interaction between living area of dwelling in square metres and location of dwelling in an urban municipality of a small or outside agglomeration
LivingArea:MunicipalityType4	Interaction between living area of dwelling in square metres and location of dwelling in a peri-urban municipality of high density
LivingArea:MunicipalityType5	Interaction between living area of dwelling in square metres and location of dwelling in a peri-urban municipality of medium density
LivingArea:MunicipalityType6	Interaction between living area of dwelling in square metres and location of dwelling in a peri-urban municipality of low density
LivingArea:MunicipalityType7	Interaction between living area of dwelling in square metres and location of dwelling in a municipality of a rural centre
LivingArea:MunicipalityType8	Interaction between living area of dwelling in square metres and location of dwelling in a centrally located rural municipality.
LivingArea:MunicipalityType9	Interaction between living area of dwelling in square metres and location of dwelling in an peripheral rural municipality
LivingArea:PenthouseYes	Interaction between living area of dwelling in square metres and configuration of dwelling as a penthouse (with roof terrace)
LivingArea:DuplexYes	Interaction between living area of dwelling in square metres and configuration of dwelling as a duplex (on two floors)
BuildingAge:MunicipalityType2	Interaction between age of dwelling in years and location of dwelling in an urban municipality of a medium-sized agglomeration
BuildingAge:MunicipalityType3	Interaction between age of dwelling in years and location of dwelling in an urban municipality of a small or outside agglomeration
BuildingAge:MunicipalityType4	Interaction between age of dwelling in years and location of dwelling in a peri-urban municipality of high density
BuildingAge:MunicipalityType5	Interaction between age of dwelling in years and location of dwelling in a peri-urban municipality of medium density
BuildingAge:MunicipalityType6	Interaction between age of dwelling in years and location of dwelling in a peri-urban municipality of low density
BuildingAge:MunicipalityType7	Interaction between age of dwelling in years and location of dwelling in a municipality of a rural centre

Source: FSO – Consumer Price Index (CPI)

Nomenclature for variables in the model (End)

Variable name	Description
BuildingAge:MunicipalityType8	Interaction between age of dwelling in years and location of dwelling in a centrally located rural municipality
BuildingAge:MunicipalityType9	Interaction between age of dwelling in years and location of dwelling in a peripheral rural municipality
BuildingAge:PenthouseYes	Interaction between age of dwelling in years and configuration of dwelling as a penthouse (with roof terrace)
BuildingAge:DuplexYes	Interaction between age of dwelling in years and configuration of dwelling as a duplex (on two floors)
MunicipalityType2:Slope	Interaction between location of dwelling in an urban municipality of a medium-sized agglomeration and slope gradient in degrees
MunicipalityType3:Slope	Interaction between location of dwelling in an urban municipality of a small or outside agglomeration and slope gradient in degrees
MunicipalityType4:Slope	Interaction between location of dwelling in a peri-urban municipality of high density and slope gradient in degrees
MunicipalityType5:Slope	Interaction between location of dwelling in a peri-urban municipality of medium density and slope gradient in degrees
MunicipalityType6:Slope	Interaction between location of dwelling in a peri-urban municipality of low density and slope gradient in degrees
MunicipalityType7:Slope	Interaction between location of dwelling in a municipality of a rural centre and slope gradient in degrees
MunicipalityType8:Slope	Interaction between location of dwelling in a centrally located rural municipality and slope gradient in degrees
MunicipalityType9:Slope	Interaction between location of dwelling in a peripheral rural municipality and slope gradient in degrees
MunicipalityType2:RateOfSecondHomes	Interaction between location of dwelling in an urban municipality of a medium-sized agglomeration and rate of second homes in municipality
MunicipalityType3:RateOfSecondHomes	Interaction between location of dwelling in an urban municipality of a small or outside agglomeration and rate of second homes in municipality
MunicipalityType4:RateOfSecondHomes	Interaction between location of dwelling in a peri-urban municipality of high density and rate of second homes in municipality
MunicipalityType5:RateOfSecondHomes	Interaction between location of dwelling in a peri-urban municipality of medium density and rate of second homes in municipality
MunicipalityType6:RateOfSecondHomes	Interaction between location of dwelling in a peri-urban municipality of low density and rate of second homes in municipality
MunicipalityType7:RateOfSecondHomes	Interaction between location of dwelling in a municipality of a rural centre and rate of second homes in municipality
MunicipalityType8:RateOfSecondHomes	Interaction between location of dwelling in a centrally located rural municipality and rate of second homes in municipality
MunicipalityType9:RateOfSecondHomes	Interaction between location of dwelling in a peripheral rural municipality and rate of second homes in municipality

Source: FSO – Consumer Price Index (CPI)

Bibliography

Cook, R. (1977). *Detection of Influential Observation in Linear Regression.* Technometrics, 19(1), 15 – 18.

European Environment Agency. (2021, 02 16). *Copernicus Land Monitoring Service.* European Environment Agency: www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-eu-dem

Eurostat. (2017). *Technical manual on Owner-Occupied Housing and House Price Indices.* Luxembourg: Eurostat.

Federal Office for Spatial Development. (2010). *Desserte et accessibilité en Suisse avec les transports publics et le trafic individuel motorisé.* Bern: Federal Office for Spatial Development.

Federal Office for Spatial Development. (2017). *Loi sur les résidences secondaires: Notice explicative sur l'inventaire des logements.* Bern: Federal Office for Spatial Development.

Federal Office for Spatial Development. (2021, 02 16). *Desserte en Suisse: temps de parcours.* Federal Office for Spatial Development: www.are.admin.ch/are/fr/home/mobilite/bases-et-donnees/desserte-en-suisse.html

Federal Office for the Environment. (2021, 02 16). *Noise: Data, indicators and maps.* Federal Office for the Environment: www.bafu.admin.ch/bafu/en/home/topics/noise/state.html

Federal Office of Civil Aviation. (2021, 02 16). *Cadastre d'exposition au bruit.* Federal Office of Civil Aviation: www.bazl.admin.ch/bazl/fr/home/politique/environnement/bruit/Cadastre_dexposition_au_bruit.html

Federal Statistical Office. (2007). *Enquête de structure sur les loyers 2003, résultats détaillés.* Neuchâtel: Federal Statistical Office.

Federal Statistical Office. (2017). *Niveaux géographiques de la Suisse: Typologie des communes et typologie urbain-rural 2012.* Neuchâtel: Federal Statistical Office.

Federal Statistical Office. (2019). *Conception détaillée, Indice des prix à la consommation, révision 2020.* Neuchâtel: Federal Statistical Office.

Federal Statistical Office. (2020). *Schweizerischer Wohnimmobilienpreisindex: Qualitätsbereinigungsverfahren.* Neuchâtel: Federal Statistical Office.

Federal Tax Administration. (2021, 02 16). *Tax burden.* Federal Tax Administration: www.estv.admin.ch/estv/en/home/allgemein/steuerstatistiken/fachinformationen/steuerbelastungen/steuerbelastung.html

Lüscher, A., Salvi, M., Bröhl, A., & Horehájová, A. (2010). *Qualitätsbereinigung im Mietpreisindex: Schlussbericht.* Financial Engineering Immobilien. Zürich: Zürcher Kantonalbank.

Matthey, C., Becker Vermeulen, C., & Corti, M. (2014). *Limitations and impact of hedonic adjustment for the rent index.* Neuchâtel: Federal Statistical Office.

Rosen, S. (1974). *Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition.* The Journal of Political Economy, 82(2), 34 – 55.

Silver, M. (2020). *Repport to the Swiss Federal Statistical Office (FSO) on two hedonic models: the residential propoerty (house) price index (RPPI) and the rent price index (RPI).*

Wooldridge, J. (2012). *Introductory Econometrics, A Modern Approach (5th Ed.).* Mason, USA: South-Western Cengage Learning.

The FSO's publications

As the central statistical agency of the Confederation, the Federal Statistical Office (FSO) has the task of providing Swiss statistical information to a wide range of users. Dissemination is done by topic with different information media via several channels.

The statistical topics

00 Statistical basis and overviews
01 Population
02 Territory and environment
03 Work and income
04 National economy
05 Prices
06 Industry and services
07 Agriculture and forestry
08 Energy
09 Construction and housing
10 Tourism
11 Mobility and transport
12 Money, banks and insurance
13 Social security
14 Health
15 Education and science
16 Culture, media, information society, sports
17 Politics
18 General Government and finance
19 Crime and criminal justice
20 Economic and social situation of the population
21 Sustainable development, regional and international disparities

The key publications

Statistical Yearbook of Switzerland

The "Statistical Yearbook of Switzerland" (German/French) published by the Federal Statistical Office has been the standard reference book for Swiss statistics since 1891. It contains the most important statistical findings regarding the Swiss population, society, government, economy and environment.

Statistical Data on Switzerland

Statistical Data on Switzerland is an appealing and entertaining summary of the year's most important figures. With 52 pages in a practical A6/5 format, the publication is free of charge and available in five languages (German, French, Italian, Romansch and English).

The FSO online – www.statistics.admin.ch

The Swiss Statistics website offers you a modern, attractive and up-to-date gateway to all statistical information. We would like to draw your attention to the following popular offerings:

Publication database – publications offering further information
Almost all publications published by the FSO are available in electronic form on the website free of charge. Print publications can be ordered by telephone on 058 463 60 60 or by emailing order@bfs.admin.ch.
www.statistics.admin.ch → Look for statistics → Catalogues and Databases → Publications

NewsMail – always up to date
Email subscriptions by topic with details and information on the latest findings and activities.
www.news-stat.admin.ch

STAT-TAB – the interactive statistical database
The interactive statistical database offers simple and customisable access to statistical results as well as the option of downloads in various formats.
www.stattab.bfs.admin.ch

Statatlas Switzerland – regional database and interactive maps
With more than 4500 interactive thematic maps, the Statistical Atlas of Switzerland gives you an up-to-date and permanently available overview of captivating regional issues covering all FSO topics. Available in German and French.
www.statatlas-switzerland.admin.ch

Individual inquiries

Statistical information centre
058 463 60 11, info@bfs.admin.ch

The housing rental price index makes up the largest share of the basket underlying the consumer price index (CPI). Since 2011, a hedonic adjustment has been made in the housing rental price index to account for quality differences between dwellings when the sample is regenerated. This quality adjustment is based on a hedonic model that expresses the rental price as a function of the different characteristics of the dwelling. As part of the 2020 revision of the CPI, a new model was prepared based on the most recent data along with additional variables and disaggregated geographical data, and provides improved predictive capacity compared to the previous model. This article describes the data, methodology and final form of the new hedonic rental price model.

Online
www.statistics.admin.ch

Print
www.statistics.admin.ch
Federal Statistical Office
CH-2010 Neuchâtel
order@bfs.admin.ch
tel. +41 58 463 60 60

FSO number
2121-2200

ISBN
978-3-303-05774-2

Statistics
counts **for you.**

www.statistics-counts.ch