Bubble Analysis of the Swiss Real Estate Market

By

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Abstract

This thesis explores the risk of bubbles in the residential real estate market of Switzerland. The study uses the Log-Periodic Power Law (LPPL) model to analyze the development of asking prices between 2005 and 2012, in each of the 166 Swiss districts. The data employed in this work was collected by comparis.ch, and carefully cleaned from duplicate records through a procedure based on the Support Vector Machine (SVM) algorithm. The results suggest that there are 11 critical districts that exhibit the signatures of a bubble, and seven districts where bubbles have already burst. Despite these strong signatures, it is argued that a soft landing, rather than a severe crash is expected, as the current economic environment makes the latter unlikely.

Acknowledgments

I would like to thank Professor Didier Sornette, Dr. Dorsa Sanadgol, and Dr. Peter Cauwels from the Chair of Entrepreneurial Risks, who kindly supervised me throughout the development of this thesis. I appreciate the opportunity that I had to learn from their serious and dedicated research efforts.

Contents

List of Figures

List of Tables

Chapter 1

Introduction

The development of residential property prices over the past years in Switzerland has raised concerns about the existence of a bubble in this market. The topic is extremely relevant as real estate volatility on large scale and intensity can have long-lasting and destructive effects for an economy. This was direly illustrated by the aftershocks of the burst of bubbles in US, Spain, and Ireland (Allen and Carletti 2010), and also by the consequences of the 1988s bubble in Switzerland. The Swiss real estate bubble, which was fueled by extensive mortgage lending practices, caused a sharp GDP decline of about 1.55 percent, severe price corrections, and widespread foreclosures (Bourassa, Hoesli, and Scognamiglio 2009). A repetition of this crisis today could have similar repercussions, as real estate assets represent 43.6 percent of the Swiss households' wealth according to data of 2011 (SNB 2011).

In this context, comparis.ch has started a collaboration with the chair of Entrepreneurial Risks at the department of Management, Technology and Economics (D-MTEC) of ETH Zurich since January 2012. We have been analyzing the Swiss real estate market, particularly the price development of the residential properties to determine the risk of a bubble. This document presents the analysis conducted for the period 2005-2012. The results are based on the comparis.ch database, which comprises data from the 17 largest property portals in Switzerland.

The chair of Entrepreneurial Risks under the leadership of Professor Dr. Didier Sornette has developed a unique competency in detecting real estate and financial bubbles. Together with his collaborators, Dr. Peter Cauwels and Dr. Ryan Woodard at ETH Zurich and Prof. W.-X. Zhou, his former post-doc now at ECUST in Shanghai, he has successfully diagnosed in advance the US real estate market bubble that burst in 2007 (Wei-Xing Zhou and Didier Sornette 2006), the oil bubble that crashed in 2008 (D Sornette, R Woodard, and W-X Zhou 2008), the Shanghai Composite index crashes in 2007 and 2009 (Jiang et al. 2010), among others. The present project, which benefits from focused research and development provided by Dr. Dorsa Sanadgol, Dr. Peter Cauwels and the author at the chair of Entrepreneurial Risks, has been jointly funded by the Commission for Technology and Innovation (CTI) and comparis.ch.

This thesis is organized as follows. Chapter 2 briefly discusses the global and Swiss macroeconomic situation by the end of 2012. Chapter 3 presents the dataset, as well as the deduplication procedure conducted to improve the quality of the data. Chapter 4 describes the specific index employed to track the development of the prices. Chapter 5 presents an overview of the Swiss real estate market. Chapter 6 discusses the methodology to diagnose bubbles. Chapter 7 presents the results of the analysis. Chapter 8 compares the results of this thesis with those of the UBS Bubble Index, which has become an important reference in the matter. Finally, chapter 9 concludes the study.

Chapter 2

Macroeconomic situation

2.1 The world's economy

The international environment of 2012 was marked by political and economic unrest: Europe's sovereign-debt crisis, China's slowdown, and USA's elections and fiscal cliff contributed to feed a generalized atmosphere of uncertainty (The Economist 2013).

The world weathered relatively well these threats, ending with mixed results. Although the Euro zone is expected to contract an estimated 0.3 percent in 2012, Switzerland's main trading partners are expected to grow positively (figures 2.2 and 2.1), at rates varying between 0.4 and 2.3 percent; the exception is Italy, whose GDP is expected to fall 2.3 percent in 2012. Financial markets in turn have kept an upward trend during the second part of the year (figure 2.3), specially after the head of the European Central Bank, Mario Draghi, said he was "ready to do whatever it takes" in order to save the euro zone (Telegraph.co.uk 2013).

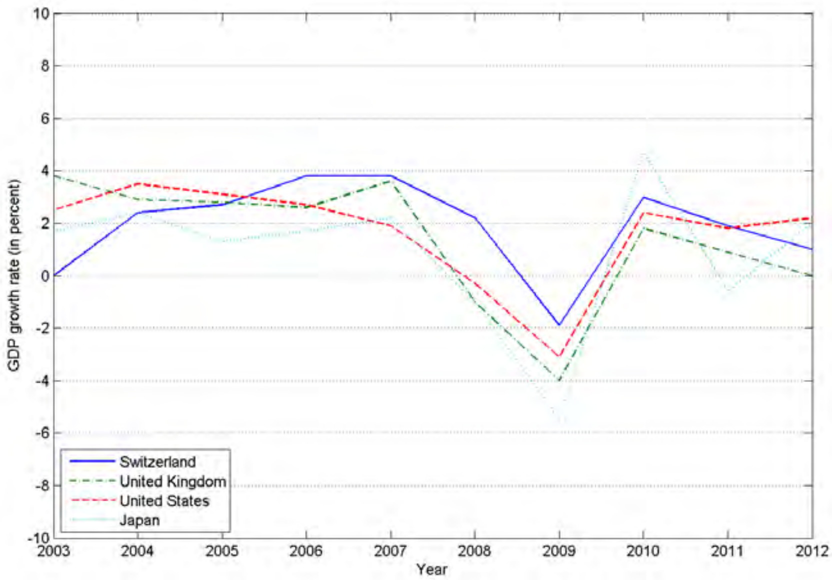


Figure 2.1: GDP growth rate. Switzerland, United Kingdom, United States, and Japan. Source: Eurostat 2012.

The rising unemployment in countries such as Italy and France (figure 2.4) serves as reminder that the recovery is still fragile. For this reason, central banks will most likely maintain the expansionary monetary policy applied during the recent years, which has been characterized by historically low interest rates (figure 2.5), and the implementation of unconventional monetary practices such as quantitative easing ((Benford et al. 2009), (Shiratsuka 2010)).

These measures are expected to be effective in the short term, but scholars coincide that the structural political and economic problems that underlie the global situation have not been addressed, and the

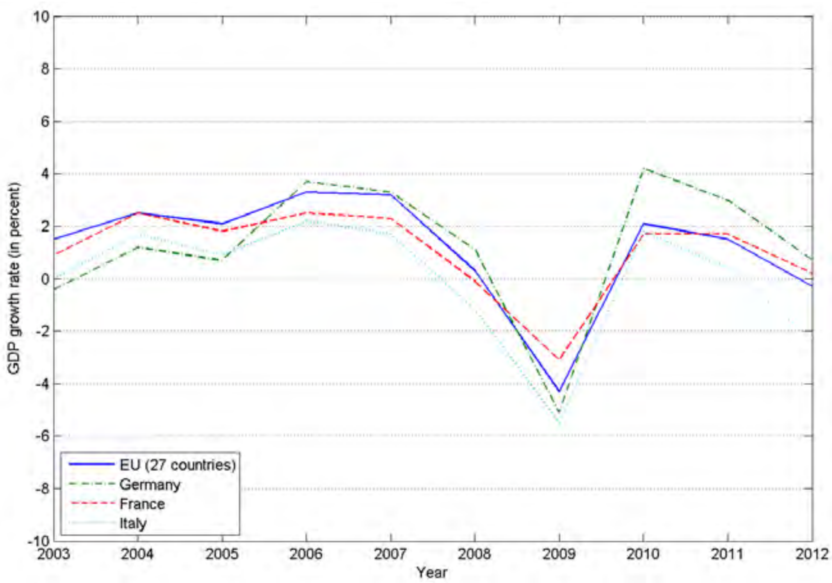


Figure 2.2: GDP growth rate. EU27, Germany, France, and Italy. Source: Eurostat 2012.

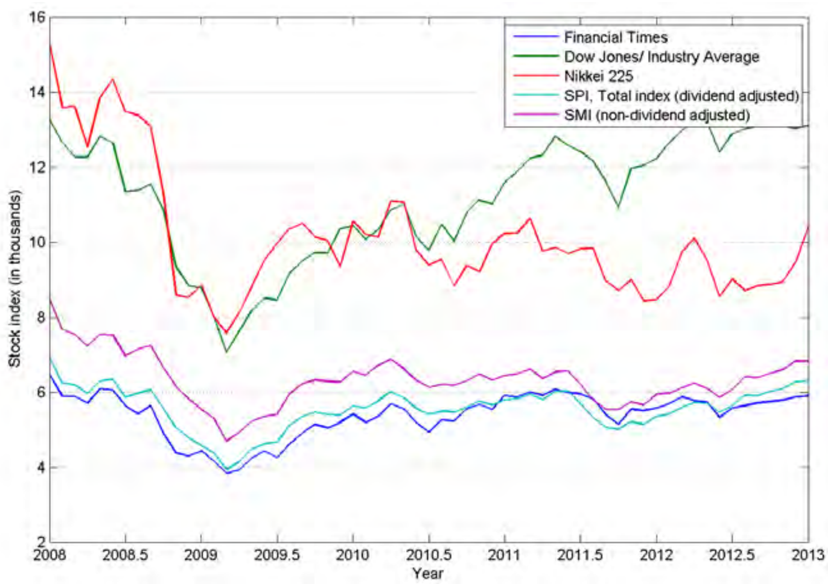


Figure 2.3: Main stock indices. Source: SNB 2013b.

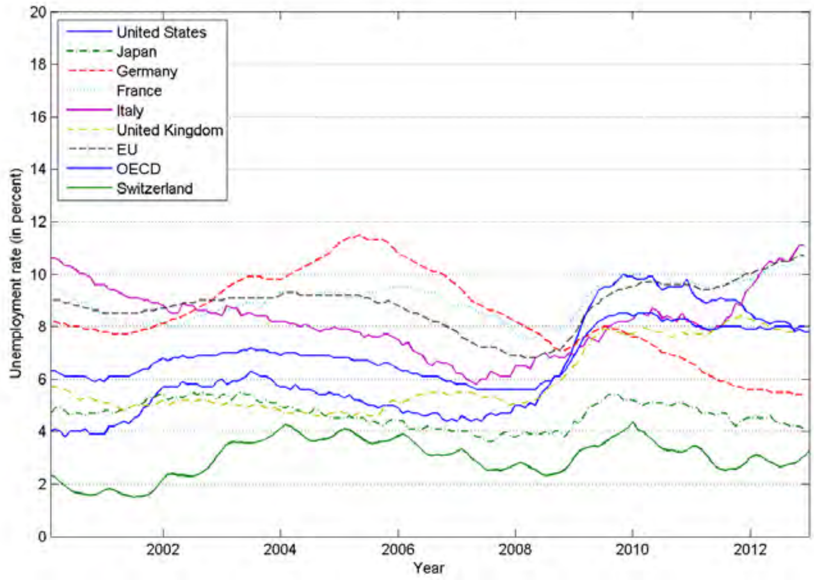


Figure 2.4: Unemployment rate, observed regions. Source: SNB 2013b.

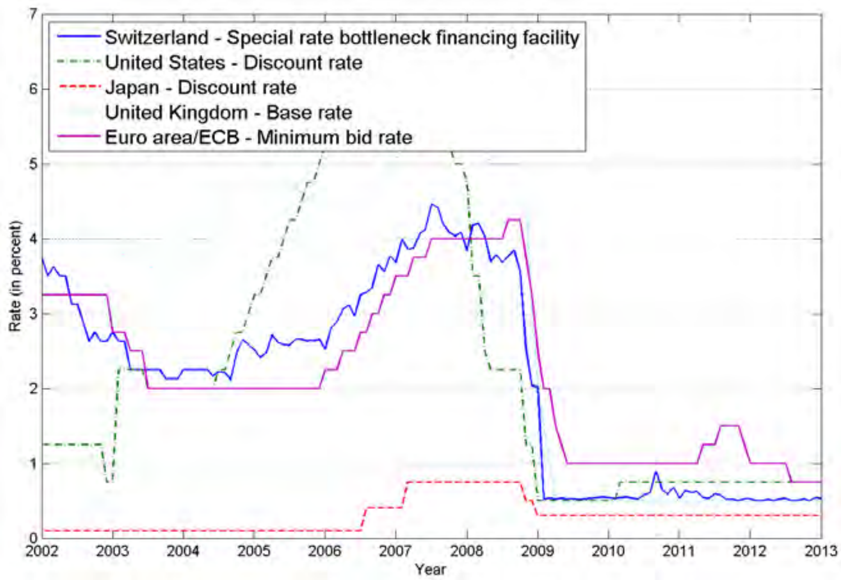


Figure 2.5: Interest rates. Source: SNB 2013b.

capacity of central banks to boost their economies is reaching a limit (e.g. (Ugai 2007), (Krishnamurthy and Vissing-Jorgensen 2011)). In fact, as Cauwels and D. Sornette 2012 suggest, the situation in the long term is unsustainable because the last three decades of consumption have been increasingly funded by smaller savings, booming financial profits, wealth extracted from house price appreciation and explosive debt, rather than the productivity fueled growth that was seen in the 1950s and 1960s.

2.2 The economy of Switzerland

Notwithstanding the gloomy international landscape, Switzerland performed relatively well during 2012. GDP in the third quarter was up 1.4 percent on the previous year's level, and unemployment was recorded at 2.7 percent, lower than in any other European country (figure 2.4). Estimations of the government posit a growth rate close to 1 percent for 2012 and set growth forecasts between 1 and 1.5 percent in 2013. Understandably, the forecasts have been wary since the future of the Swiss economy heavily depends on the opaque future of the euro zone ((KOF 2013), (UBS 2013)).

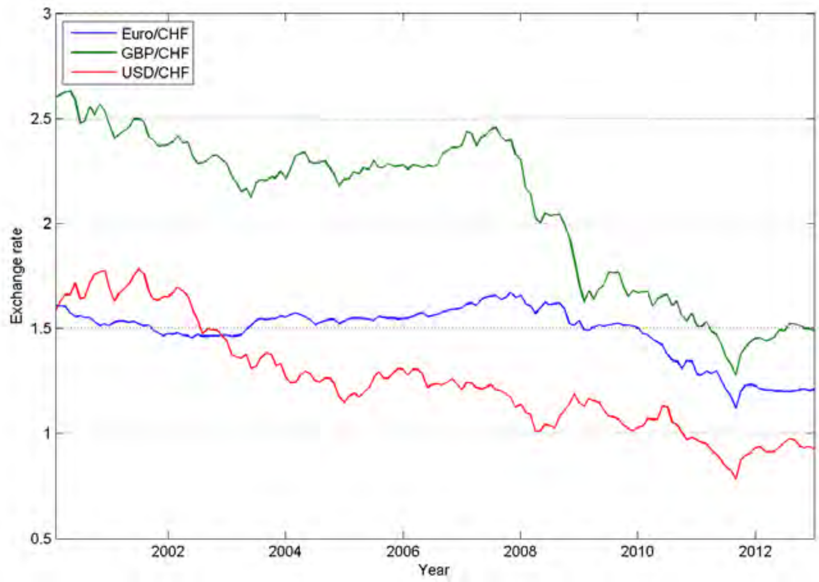
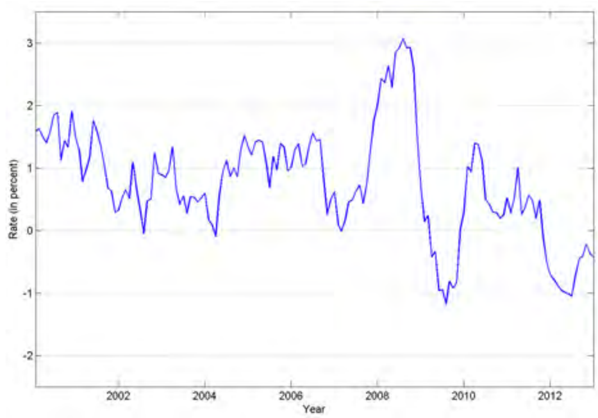


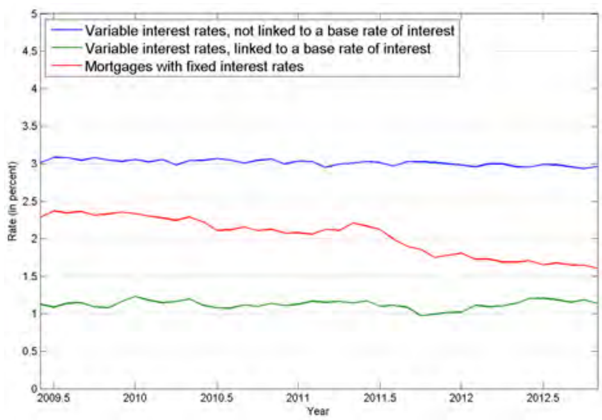
Figure 2.6: Exchange rates. Source: SNB 2013b.

Arguably, the most debated economic policy during this year was the defense of 1.2 CHF/EUR floor(figure 2.6), which was successfully implemented by the Swiss Central Bank (SNB). The floor was established in response to the almost 35 percent appreciation of the Swiss Franc since the financial crisis began in 2007, out of which, about 15 points occurred during the four months previous to the implementation of the policy, in September 2011. The strong movements of the currency were seriously threatening the Swiss economy, as the country is a net exporter. Since July 2011 and until the beginning of 2013, the SNB FX intervention amounts to 32 percent of the GDP (J.P. Morgan 2012), though a less active role from the bank is anticipated for the following months thanks to improving expectations about the euro, which has lessened the appetite for the local currency.

Despite the possible inflationary effects of the floor, inflation has stayed controlled (figure 2.7a), exhibiting a year-on-year negative rate of -0.40 percent during the fourth quarter of 2012. Targeted interest rates have remained the lowest in the region, and considering the global macroeconomic environment, an upward increase is very unlikely. Accordingly, the mortgage interest rates (figure 2.7b) have stayed stable at very low levels: the fixed mortgage rate has remained close to 1.5 percent, whereas the variable rate linked to a base rate has hovered around 1.1 percent.



(a) Inflation rate.



(b) Mortage rates.

Figure 2.7: Inflation and mortage rates in Switzerland. Source: SNB 2013b.

As for the Swiss real estate market, the indices have risen an average of 14.73 percent since 2009 (figure 2.8). Prices of rental apartments have increased 9.5 percent, owner occupied apartments have

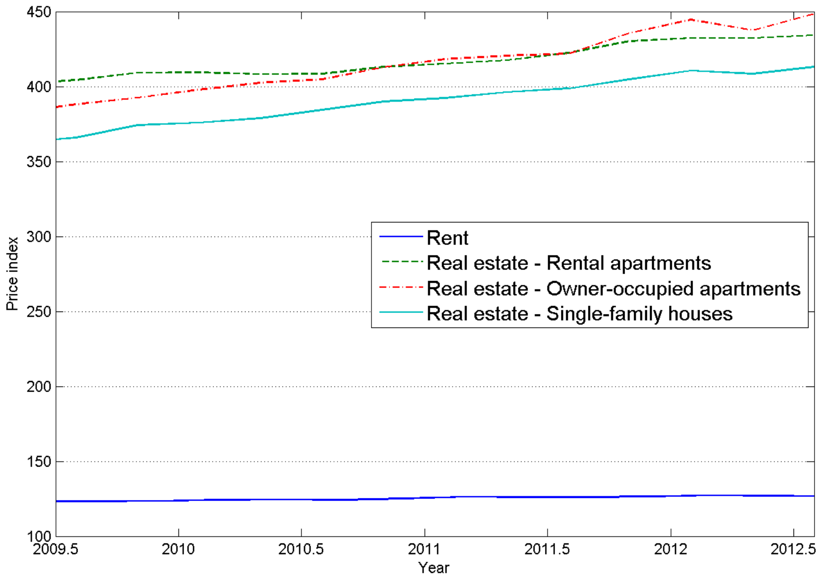


Figure 2.8: Real estate and rent price indices. Source: SNB 2013b.

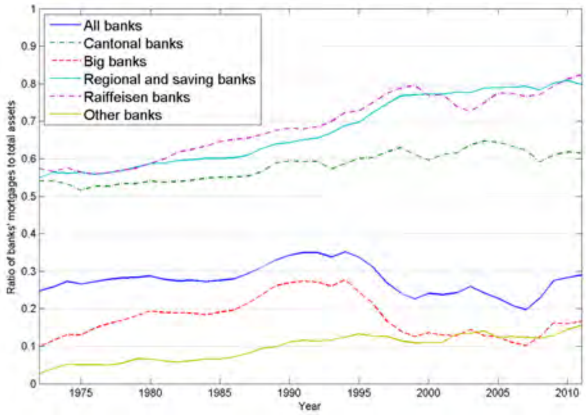
grown 19 percent, and single family dwellings have experienced an increase of 15.28 percent. In contrast, the rent price index has only risen by 3 percent. As a result, the ratio of home to rent prices is deviating from the long term equilibrium, in which rent and real estate prices move together because the price of a house equals the expected stream of future income (rents) (Hilbers, Lei, and Zacho 2001).

Direct exposure of banks to real estate has also grown during the last years (figure 2.9a). The Regional and Raiffasein banks are currently the most vulnerable, whereas big and cantonal banks have flattened their exposure after 2009 (figure 2.9b). However, credit growth rates are still substantially below the levels observed during the bubble of the 80-90s (figure 2.9c), and hence reckless lending practices are not yet apparent.

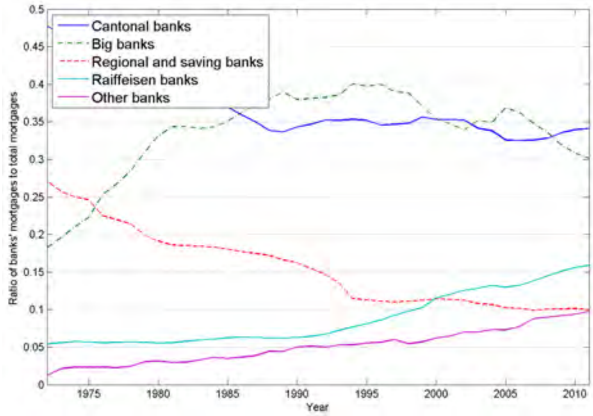
In this context, UBS 2012 and Credit Suisse 2012 have argued that the recent development of prices is due to a mismatch between supply and demand. On the one hand, the demand has benefited from three factors: first, historically low interest rates; second, a sustained rate of immigration 2.10a[1], with an average yearly net value of about 68'000 immigrants between 2009 and 2011; and third, increasing real wages, which rose around 1.4 percent on a year-over-year basis during the last quarter of 2012 (figure 2.10b). On the other hand, the supply has had problems to adapt to the strong demand as it suffers from lengthy production times (Credit Suisse 2012). In fact, the number of new apartments in 2012 is unlikely to exceed the 46'152 dwellings that were built in 2011 since only 31'512 new properties were completed by the third quarter of 2012 (figure 2.10c[2]).

Nevertheless, this conclusion is grounded on the same fundamental-based reasoning that failed to detect the US real estate bubble in 2007. At that time, it was boldly argued that there were little basis for bubble concerns as home prices had - allegedly - moved in line with increases in family income and declines in nominal mortgage interest rates (McCarthy and Peach 2004). Yet, the bubble burst and we are still bearing the consequences of it. This stresses the importance of a dynamic approach as the one conducted in this thesis, and it represents a strong case for prudence since the diagnosis of bubbles remains an elusive topic.

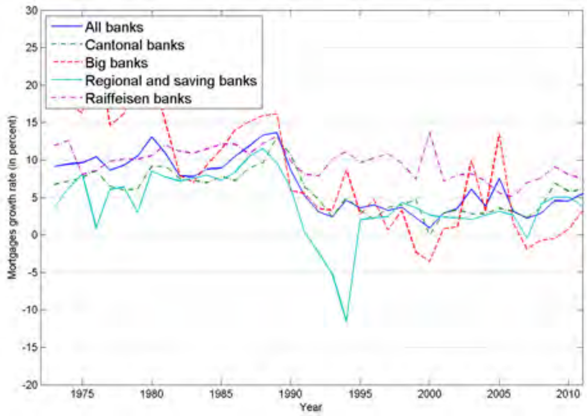
[1] 2012 value only include data up to the third quarter.
[2] 2012 values only include data up to the third quarter.



(a) Ratio of banks' mortgages to their total assets.

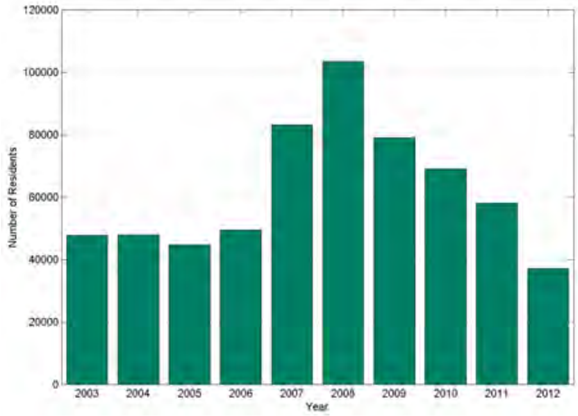


(b) Ratio of banks' mortgages to total mortgages.

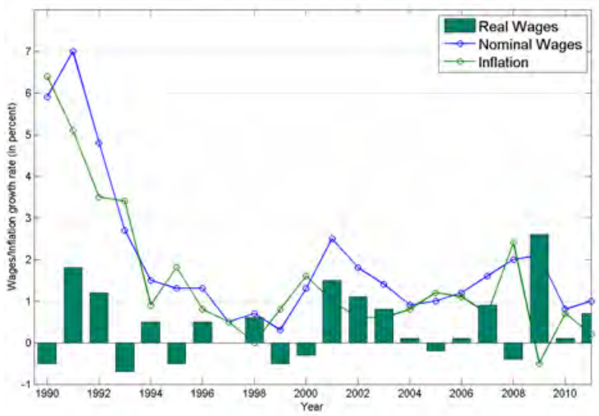


(c) Mortgages growth rate.

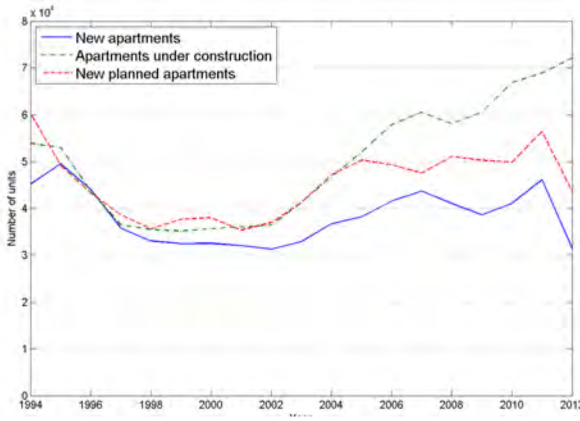
Figure 2.9: Development of mortgages in the banking sector. Source: SNB 2013b.



(a) Net immigration.



(b) Nominal and real wages.



(c) Construction activity.

Figure 2.10: Development of demand and supply factors of the Swiss real estate market. Source: SNB 2013b.

Chapter 3

Data description and processing

The data used in this project was collected by comparis.ch between January 2005 and December 2012. The property market division of comparis.ch gathers data from the 17 largest property portals in Switzerland, creating a rich view of the market, but also introducing a large and un-estimated number of duplicate ads. These duplicates advertise the same property, during the same period, and sometimes, with conflicting information.

Within the scope of this project, the identification of the duplicates is crucial, as they can potentially affect the development of the price indices. In addition, the task is also relevant because there are records with unreliable information that do not reflect the actual characteristics of the selling property (e.g. advertising the lowest possible price of a condominium), and hence must be controlled.

This section describes the solution to deal with the deduplication problem that was implemented in this project. The reader should be aware that the deduplication task has been widely studied in the literature under different names such as Record linkage, Data Linkage and Entity Recognition (e.g. (Winkler 2006), (Nadeau and Sekine 2007)), and spreads far beyond the concepts and tools employed in this document. Therefore, the proposed approach is a simplification that can doubtlessly be extended.

3.1 Simplifications

In order to deal with the deduplication problem, the following simplifications were made:

- The proposed solution was applied to residential ads on sale. That is, commercial and rental ads, also available in the comparis.ch database, were discarded. However, the same method could be used to deduplicate other categories of ads.
- The solution deduplicates the data by quarters since quarters was the temporal unit of analysis of this project. Consequently, one of the preprocessing tasks consisted of identifying the quarters in which each ad is active. An ad is considered active during a quarter if it presented a price change during that period. The deletion date of the ad was not used in this matter since this field was found not reliable between 2008 and 2010. Thus, using this field to determine the active period of the ads could have overestimated the effect of past properties on sale on the current prices. This point will be further explained in section 3.4.
- The specific properties of an ad that are analyzed by the deduplication procedure are presented in Table 3.1. These attributes tend to have similar quality in the whole dataset.
- Only ads with positive price and living space are considered since these two properties are essential for the construction of any price index.
- Ads with different prices are considered different ads since this project does not intend to track the life cycle of individual ads. As a result, no pair of ads with different prices will be aggregated.

3.2 General description of the solution

The pseudo-code of the solution is presented below.

ID	Canton	Zip	PurchasePrice
Title	Street Name	Num Rooms	Living Space
Description	Street Number	Year Of Construction	Building Area
City	Site ID	Floor	Quarter (derived from CreateDate)

Table 3.1: Representation of an ad.

```
Data: residential real estate ads, zips, quarters, purchasePrices
Result: deduplicated ads
initialization;
searchSpaces = Create Search Spaces(zips, quarters, purchasePrices);
foreach searchSpace in searchSpaces do
    tupleSet = Create Set of Tuples (searchSpace);
    foreach tupple in tupleSet do
        tuple.areDuplicate = matcher (tuple.Ad1, tuple.Ad2);
    end
    aadSet := merge (tupleSet);
end
```

Algorithm 1: Pseudo-code of the solution.

Initially all the ads are partitioned by the canton, zip, purchase price, and quarter in which they were active. Each partition constitutes a Search Space. Ads within the same Search Space are considered as potential duplicates of one another, whereas two ads from different Search Spaces are regarded as non-equal.

Inside each Search Space, all possible tuples or pairs of ads (ad_i, ad_j) are formed. Hence, if the Search Space contains N ads, $N(N-1)/2$ tuples are created. Each tuple represents a potential duplicate case, which is analyzed by a matcher function in order to assign a score that reflects the extent to which the tuple is a duplicate or not: a positive score marks the tuple as duplicate, and negative one as not. In a subsequent step, the individual classifications yielded by the matcher are merged so that a set of deduplicated ads is obtained.

The merging process starts by sorting the tuples according to the classifier score in decreasing order. Thereafter, the tuples are merged, aggregating only those positively marked. As an example, consider the following tuples and matching decisions: $A := ((ad_1, ad_2), 4.5), B := ((ad_2, ad_3), -4), C := ((ad_1, ad_3), 0.5), D := ((ad_2, ad_4), 1),$. The output of the merging step will yield two aggregated ads: $((ad_1, ad_2, ad_4))$ and (ad_3). The approach solves the possible conflicts that might arise between scores by processing the tuples greedily or on a first-come, first-serve basics. In the example, although there is actually a conflict among A, B, C scores - ad_1 was voted equivalent to ad_2 and ad_3, but ad_2 was classified as different from ad_3 -, this is solved silently by using the greedy procedure. The approach is a simplification that fits well the context of this application in which the expected conflicts are few; an alternative and much more powerful method can be found in (Bansal, Blum, and Chawla 2004) or (Swamy 2004).

3.2.1 Identifying duplicate tuples

The matcher is the function that determines whether a given tuple is a pair of duplicate ads or not. The problem of finding this function was conceptualized as a supervised learning binary classification problem (Bishop 2006). In this kind of problem, a classification rule is obtained using a set of pairs consisting of an input object and a desired output value. The procedure to obtain the rule is called *training*, the classification rule is called a *classifier*, and the input set is called the *training set*. The classifier must be able to generalize so that it can take an arbitrary data point, and determine the corresponding output.

In the context of this work, a candidate duplicate tuple $((ad_i, ad_j))$ constitutes the input object. It is represented as a similarity vector, where each of its dimensions corresponds to a possible method to compare the ads; for example, based on their title, their descriptions, or the price of the properties they advertised. Table 3.2 shows the specific features that are used as a basis for a comparison, as well as the similarity function that is employed to obtain the concrete similarity value. Accordingly, the

Property	Type	Similarity Measure	Description	Complexity
Year Of Construction Number of Rooms Living Space Building Area	int	Subtraction	Simple subtraction.	O(1)
Site ID	boolean	Equivalent relationship	Equivalent relationship.	O(1)
Title Description Street Number City (Title + Description)	string	Levenshtein Distance	Minimum number of changes in spelling required to change one string into another.	O(nm)
		Jaro-Winkler	Distance Number of matching characters of two strings weighted by the necessary transpositions.	O(nm)
		Longest Common Substring.	The longest string that is a substring of the two strings.	O(nm)

Table 3.2: Ad properties and similarity measures.

matching decision constitutes the output, taking two labels or values: 1 when the pair is a duplicate, and 0 otherwise.

3.2.2 Derivation of the classification rule

The specific algorithm that was used to train the classifier is called *Support Vector Machine SVM* (Scholkopf and Smola 2001). Given a dot product space H, a set of input objects $x_1, x_2, \ldots, x_m \in H$, and a set of labels $y_1, y_2, \ldots, y_m \in \{0, 1\}$, the basic formulation of the algorithm attempts to find a linear hyperplane $\{x \in H| < w, x > +b = 0\}$ that separates the positive input objects from their negative counterpart.

The SVM problem can be stated as follows:

$$\min_{w \in H, b \in R} \tau(w) = \frac{1}{2} |w|^2 \tag{3.1}$$

$$s.t. y_i(< x_i, w > +b) \geq 1, \text{ for all } i = 1, \ldots, m \tag{3.2}$$

Where the vector w characterizes the separating hyperplane, and the quantity $1/\|w\|$ denotes the margin; namely, the distance of the hyperplane to the closest points of the input set. Ultimately, the classifier corresponds to the decision function of equation.

$$f_(w, b) : H \rightarrow \pm 1 \tag{3.3}$$

$$x \rightarrow f_{w,b}(x) = sgn(< x_i, w > +b)$$

A limitation of this SVM formulation is that the decision surface is linear in the data. However, the algorithm can be generalized to allow for general nonlinear surfaces. This can be done by nonlinearly transforming the input data into a high dimensional feature space (using a map $\varphi : x \rightarrow x'$), performing the separation there, and updating the decision function 3.3 as stated by equation 3.5.

$$s.t. y_i(< \varphi(x_i), w' > +b) \geq 1, \text{ for all } i = 1, \ldots, m \tag{3.4}$$

$$f_(w,b) : H \to \{\pm 1\} \quad (3.5)$$
$$x \to f_{w,b}(x) = sgn(< x, w > +b)$$

Figure 3.1 illustrates this process for a two dimensional case. By mapping the R^2 input data into a higher dimensional space R^3, and constructing a separating hyperplane there, a nonlinear separating surface is constructed in the original input space.

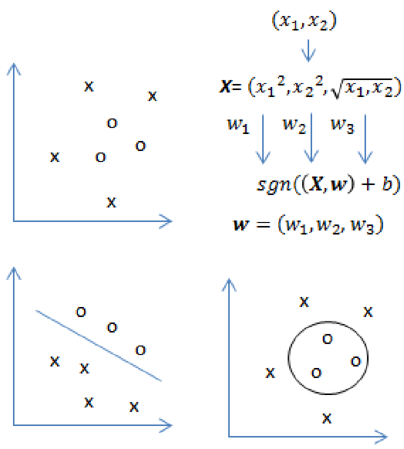


Figure 3.1: SVM nonlinear separating function example (Scholkopf and Smola 2001).

In practice, the procedure is substantially simplified since it is not necessary to perform explicitly the mapping and conduct the computations in the new space. Instead, it is possible to substitute the original dot product in equations 3.2 and 3.1 for a special class of functions called kernels. Intuitively, a kernel k is interpreted as a similarity measure in the input space. Alternatively, one can think of a kernel as a function that yields the dot product in a Hilbert space H so that it is always possible to obtain a representation of the form: $k(x, x') = \langle \varphi(x_i), \varphi(x'_i) \rangle$., where $\varphi(x_i)$ and $\varphi(x'_i)$ are elements of H. Using kernels, equations 3.4 and 3.5 change to equations 3.6 and 3.7 respectively.

$$s.t.y_i(k(x_i, w') + b) \geq 1, \text{ for all} i = 1, \dots, m \quad (3.6)$$

$$f_(w,b) : H \to \{\pm 1\} \quad (3.7)$$
$$x \to f_{w',b}(x) = sgn(k(x, w) + b)$$

The latter substitution is called the kernel trick, and extends well beyond the SVM domain: "given an algorithm which is formulated in terms of a positive definite kernel k, one can construct an alternative algorithm by replacing k by another kernel k'". In the SVM context, since by definition the dot product is itself a kernel that operates in the space of the input objects, the kernel trick can be directly applied.

3.3 Training and evaluation of the classifier

Before training the classifier, a sampling and labeling procedure was necessary since a dataset that could be used as an input for the SVM algorithm was not available. Two main types of sampling were performed. On the one hand, selected ads with equal price and living space were labeled with the idea of identifying informative positive examples. On the other hand, selected ads with equal price but different living space were labeled with the idea of identifying informative negative examples. Although a formal definition of an information case was not developed, intuitive examples of this kind of cases are:

- Ads with several missing fields or diverse degree of incomplete information, e.g. one ad provided the exact address whereas the other only the city.
- Ads with different spelling for the same city.
- Different ads with equal title or description.

Description	Number of tuples	Number of positive tuples	Number of negative tuples
Ads with equal price and living space	1250	800	450
Ads with equal price but different living space	1150	700	450
Random Search Spaces	3180	2300	880
Total	5580	3800	1780

Table 3.3: Description of the labeled dataset.

Parameter	Description	Range of values	Value selected
Kernel	This parameter determines the space in which the algorithm tries to find the surface. In the simplest case, it is the original input space.	Gaussian, Polynomial	Gaussian
C	This parameter determines the cost that has for the algorithm if it mis-classifies a point when looking for the surface.	[10, 1000, 10000,100000]	10000
Gamma	The parameter of the Gaussian kernel. Intuitively, it determines the smoothness of the separating place.	[0.25, 0.5, 0.75, 1, 2, 4, 8, 16,32, 64, 128, 256, 512, 1024, 2048]	4

Table 3.4: Collection of training parameters.

- Different ads with close addresses.
- Duplicate ads with titles that overflowed into the description fields.
- Duplicate ads with different number of rooms or living spaces.
- Plausible combinations of the previous examples.

As a complementary sampling procedure, additional Search Spaces were randomly sampled in order to ensure that the dataset represented the distribution of the population. Each of the possible tuples of these Search Spaces was formed and subsequently labeled. In the end, including the three sampling procedures, more than 5'580 tuples were sampled and labeled. Further details are presented in table 3.3.

3.3.1 Preparation of training and test set, and execution of the algorithm

Once the sampling and labeling were completed, the dataset was divided into two parts. 70% of the data was used to train and select the classifier, whereas 30% was reserved to evaluate the matcher against that of comparis.ch (details in the following section). Out of the 70%, a cross-validation procedure was conducted in order to guide the selection of the algorithm's parameters : 70% (out of the original 70%) was used to train the classifier, and 30% (out of the original 70%) was used to test its performance. The detailed list of parameters explored along with the values that were selected to build the final classifier is presented in table 3.4.

Measure	Interpretation	Definition
Precision(P)	The percentage of matching predictions that are correct. This value represents how good the matcher is identifying positive samples.	$\frac{TruePositives}{(TruePositives+FalseNegatives)}$
Recall(R)	The percentage of matches that were predicted as matches. This value represents how powerful the classifier is identifying duplicates.	$\frac{TruePositives}{(TruePositives+FalseNegatives)}$
Specificity(S)	The percentage of predicted non-matching tuples that are correct. This values represents how prone the classifier is identifying tuples that are actually different.	$\frac{TrueNegatives}{(TrueNegatives+FalsePositives)}$
Accuracy(A)	The percentage of predictions that are correct. This is the most aggregated measure.	$\frac{(TruePositives+TrueNegatives)}{(Negatives+Positives)}$

Table 3.5: Description of performance measures.

3.3.2 Evaluation of the matcher

The evaluation of the matcher was conducted using standard performance measures from information retrieval. The classifier's predictions were categorized in the four different regions depicted in Figure 3.2. 1) The shaded region within the oval, which corresponds to the correct matching predictions or true positive. 2) The white area within the oval representing the false matching predictions or false positive. 3) The shaded tuples outside the oval representing correct negative predictions or true negative. 4) The white area outside the oval that comprises the false negatives predictions.

Using this categorization, four complementary measures were computed to evaluate the different properties of the matcher. Table 3.5 summarizes these measures.

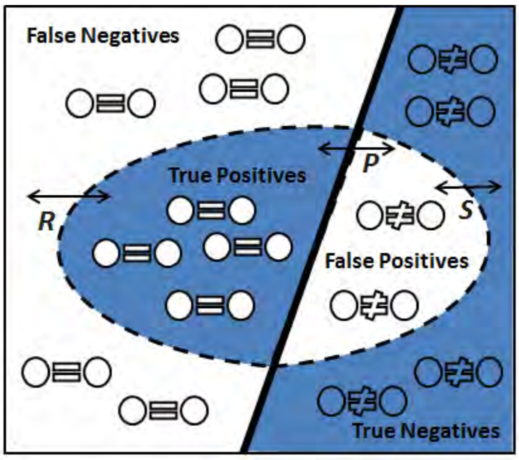


Figure 3.2: Categorization of the classifier's predictions. Blue areas represent correct predictions. White areas represent errors.

Measure	comparis.ch matcher	SVM classifier (simplified)	SVM classifier
Precision	97%	83.4%	96.8%
Recall / Sensitivity	44.7%	83.4%	95.0%
Specificity	86.3%	70.6%	73.1%
Accuracy	48.8%	80.2%	92.8%

Table 3.6: Performance of matchers.

3.3.3 Performance measures

The outcome of the evaluation is presented in table 3.6. It can be observed that the SVM outperforms the comparis.ch matcher's recall, but under-performs its specificity. As a result, the matcher will tend to identify most of the tuples with duplicates, but will be prone to produce incorrect aggregated ads more frequently than its comparis.ch counterpart. Although this behavior might collide with the conservative policy that comparis.ch internally implements to ensure customer satisfaction, this outcome is preferable when higher statistical accuracy is the priority. In addition, it is worth noting that the outcome might be affected by the unbalanced nature of the sampled data where most of the values were matching tuples; one can hypothesize that enriching the dataset with more negative samples will improve substantially the sensitivity of the SVM matcher.

The table also shows the results for a simplified classifier that does not use the string-based distances. The classifier was trained in order to assess the extent to which the deduplication procedure was benefiting from these kind of distances. As expected, this classifier performs worse than the SVM classifier, and the inclusion of these distances is plenty justified. The simplified classifier also outperforms the comparis.ch matcher, which was also expected as it is trained based on the same features as the comparis.ch's matcher but it separates the data with maximum margin.

3.4 Overview of the results

The solution (from now on SVM solution) was applied to the complete residential database. Additionally, and for benchmarking purposes, a modified solution that uses the matcher of comparis.ch (from now on comparis.ch solution) was also tested. The applied setting differed from the simplifications of section 3.1 on the way an ad is considered active in the quarter: an ad was active in this setting if the difference between its creation and deletion date overlaps with the period of the quarter. The latter treatment was the original attempt in this project as there was also an interest in the ads' life cycle.

The overview of the results for the database as of 2012Q3[1] is shown in figure 3.3. In line with the previous performance measures, the SVM solution aggregates the data significantly more than the comparis.ch solution. Nevertheless, despite the important aggregations that take place, the median price trend remains essentially the same, regardless of what trend is analyzed. Hence, the duplicates seem to have a minor impact on the price development (though the overall deduplication procedure is still justified as a quality assessment process).

[1]These experiments were conducted at the beginning of 2012Q4, so these were the latest data available

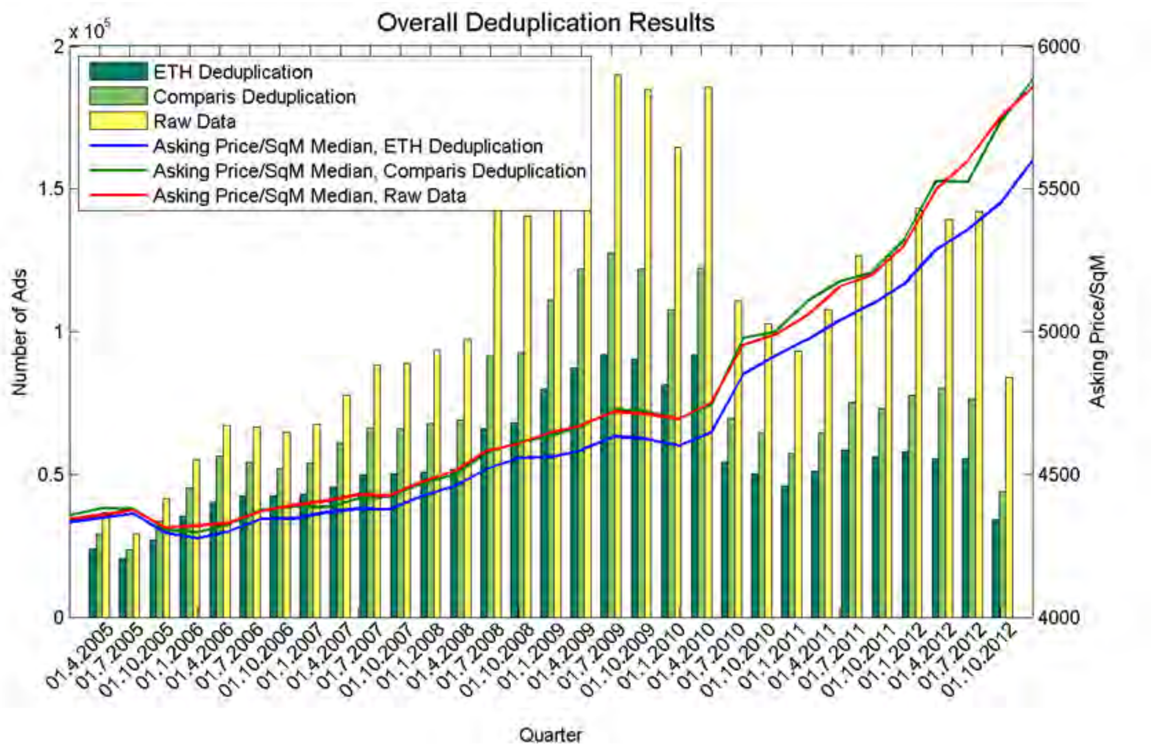


Figure 3.3: Number of aggregated and non-aggregated ads, and corresponding median prices per square meter.

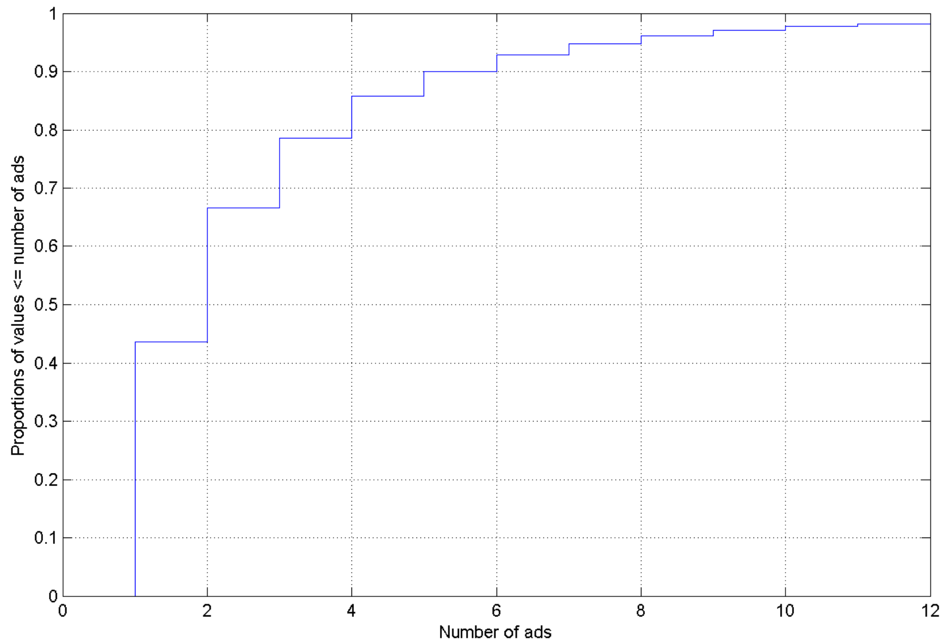


Figure 3.4: Accumulated empirical distribution of Search Spaces.

A possible explanation to this trend robustness might lie on the distribution of the Search Spaces, which reflects the heterogeneous nature of the real estate market. Figure 3.4 illustrates this idea: up to 75% of the Search Spaces contain no more than three ads, a modest number considering that the fields used to partition the data (canton, zip, quarter, and purchase price) are reasonably general. This suggests that, when residential properties are on sale in Switzerland, they tend to be identifiable by these fields and it is difficult to find several properties sharing the same values. The deduplication procedure has its highest effectiveness whenever this happens, but this is the exception, rather than the rule in the Swiss real estate market.

In addition, the results evidenced an important issue in the data. In the third quarter of 2010, a sharp drop in the number of ads and a strong increase in the aggregated median price per square meter can be observed. This happens in the raw data and does not change with the deduplication procedure. A closer revision to this behavior revealed that during the period 2008-2010 the deletion date of the ads was not properly recorded. As a result, ads remain active for a longer period of time, and since they are different from newly created ads the duplication procedure is unable to identify them.

This issue had two implications: first, an overestimation of the volume in the market; second, an impact of old ads on future prices, which ultimately yields the anomaly of 2010. Therefore, it was clear that the deletion date had to be forgone, and only ads with price changes in a quarter could be safely regarded as active in the corresponding quarter. This reasoning led to the assumption stated in section 3.1, which was maintained for all the diagnosis.

Chapter 4

Development of the price index

This project studied the development of prices in each of the 166 districts of Switzerland. In order to analyze the market, the deduplicated ads in each district were categorized by type (i.e. apartment or house), and subsequently subdivided in three groups, according to their number of rooms. As shown in table 4.1, apartments and houses were sub-classified differently since the rooms distribution of a typical apartment varies substantially from that of a typical house. Thereafter, the properties in each subgroup were aggregated quarterly using the median asking price and the median asking price per square meter for houses and apartments respectively. The classification procedure was conducted to control for the thin nature of the Swiss Real Estate market in which every property has a unique set of characteristics. This not only makes the valuation difficult, but complicates the comparison between periods. By segmenting the market into more similar properties the impact of this complication was lessened.

Property type	Houses		Apartments	
Measure	Median price		Median price per square meter	
Size	Min Rooms	Max Rooms	Min Rooms	Max Rooms
Small	1	4.5	1	3.5
Medium	5	6.5	4	5.5
Large	≥ 7		≥ 6	

Table 4.1: Classification of real estate ads.

Although a price index based on the median has well-known drawbacks, as it tends to overstate price increases when relatively expensive properties are overrepresented, and understate price increases when relatively inexpensive properties are overrepresented (B. Case and Wachter 2005, p. 4), the methodology that was used in this project is robust to this issue. The bubble diagnostic is based on a dynamic analysis of the market (see the description of the method in section 6). Thus, regular oscillations and relative price variations between periods are more important than absolute changes.

Moreover, other approaches could have introduced more crucial difficulties. For example, Hedonic models (Lucas 1975) requires to specify the set of variables and the functional form to estimate the relationship. This is a sensible requirement in a bubble regime in which the price of a house is not fully explained by the fundamentals. The application of the so called repeat sales model (Bailey, Muth, and Nourse 1963) was not feasible since few properties on the database were on sale multiple times during the period of analysis. Table 4.2 summarizes the different methods, which are further detailed in (American Institute of Real Estate Appraisers 1987).

Method	Description	Strengths/Weaknesses
Median Price	Simple statistical median.	+ Can be understood and built easily. - Does not control for changes in quality. The method might overestimate changes in prices when new properties are built.
Hedonic Model	The method estimates the relationship between the selling prices of the properties and their physical and locational characteristics using cross-sectional samples.	+ Explicitly controls for changes in quality. + Requires greater amount of information as very specific details of properties are needed. - Requires the identification of the factors and functional form.
Repeat Sales Model	The approach consist of measuring the price of the same house at several points in time. It typically specifies a random walk in housing prices.	+ Controls for qualitative and quantitative characteristic of the properties. - Requires a large number of transactions over a longer period of time. - Might suffer a sample selectivity issue: properties that sell more than once might not be representative of the entire population of properties. - Does not consider that properties might actually change their characteristics over time.

Table 4.2: Typical real estate price index models.

4.1 Smoothing procedure

In addition to the treatment described above, the Savitzky–Golay filter (Press et al. 1988) was applied to each time series to smooth the data, and thereby, to convey a better idea of the changes in quarterly prices. The filtered data were used for the heat maps, but not for the bubble diagnostic method, as the algorithm of the latter already introduces an internal filter.

The Savitzky–Golay filter makes a local polynomial regression on the adjacent values of each data point to determine their smoothed value. The filter has two parameters: 1) the degree of the polynomial d that is fitted; 2) the size of the window k, which corresponds to the number of points used for the regression. This project employed three different parameterizations depending on the number of available properties in each quarter, as this number impacted substantially the choppiness of the time series. Equation 4.1 shows the specific parameters used.

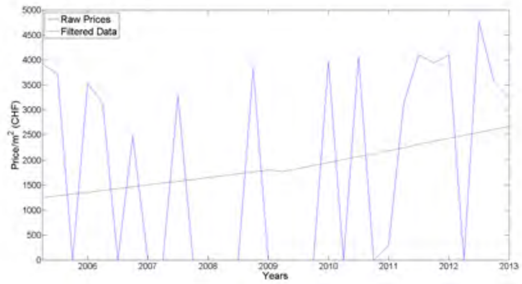
$$(d,k) = \begin{cases} (2,5), & \text{if } \hat{ad_j} \geq 50 \text{ and } zeros(\hat{ad_j}) = 0 \\ (2,11), & \text{if } 20 \leq \hat{ad_j} < 50 \text{ and } 0 < zeros(\hat{ad_j}) < 3 \\ (1,15), & \text{Otherwise: if } \hat{ad_j} < 20 \text{ and } zeros(\hat{ad_j}) \geq 3 \end{cases} \tag{4.1}$$

where $\hat{ad_j}$ is the average number of properties, and $zeros(ad_j)$ yields the total number of zeros in the analyzed period.

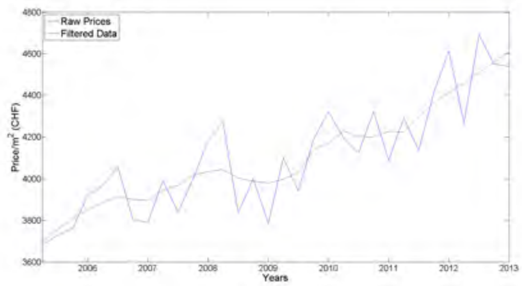
Series based on a low $\hat{ad_j}$ or with several missing values were smoothed using a linear fit and a window size that covered most of the period. Considering the nature of these series, they were unlikely to accurately capture the actual dynamics of the market, and their observed local minimum probably represented noise and not real volatility in the prices. Hence, we preferred to focus on the trend of the prices and to discard the local minimums. Figure 4.1a illustrates this effect.

On the contrary, we applied less aggressive parameterizations whenever more data were available. On one hand, the parameterization $(d, k) = (2, 11)$, which does maintain local minima, was used when $\hat{ad_j}$ suggested a more representative sample, but still not enough to attribute peaks and plunges to the actual development of the market. The case is shown in figure 4.1b, where the filtered data follows relatively well the raw prices, but deviates visibly from them.

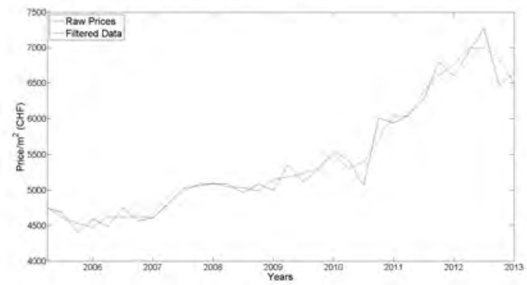
On the other hand, the parameterization $(d, k) = (2, 5)$ was applied when the size and nature of the data in a district suggested a representative sample. As showed in figure 4.1b, the filter under these parameters slightly alters the raw prices, mirroring closely each of their movements.



(a) $(d, k) = (1, 15)$.



(b) $(d, k) = (2, 11)$.



(c) $(d, k) = (2, 5)$.

Figure 4.1: Effects of the Savitzky–Golay filter.

Chapter 5

Overview of the real estate market

After applying the deduplication procedure to the comparis.ch database, there were 554'963 houses and 461'371 apartments advertised between 2005Q1 and 2012Q4, which amount to a total of 1'013'171 residential properties[1]. An overview of the market for apartments as of 2012Q4 is presented in figure 5.1. The apartments in 70.5 percent of the districts exhibit a median asking price per square meter between 3'000 and 6'000. Entremont, Saanen and Maloja are the most expensive districts.

A heat map for all houses is not shown as this would aggregate houses from very different sizes, which are hardly comparable.

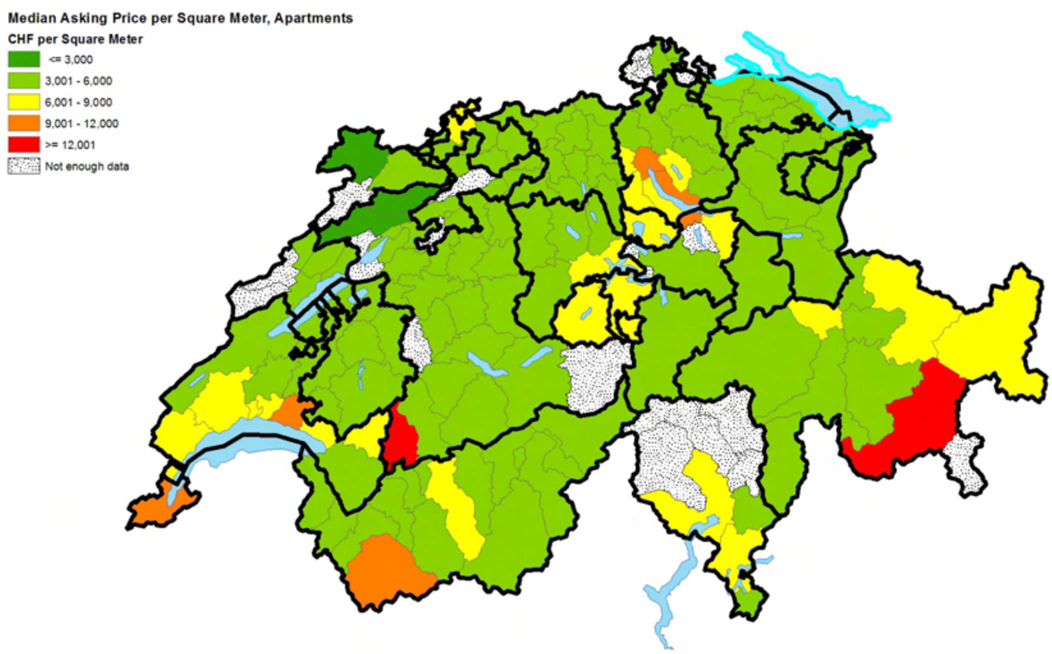


Figure 5.1: Median asking prices per square meter as of 2012Q4, apartments.

5.1 Disaggregation by property size

Figures 5.2, 5.3, and 5.4 present the disaggregation of apartments by number of rooms. As expected, the maps look reasonably similar since they are depicting the price per square meter, and thereby controlling for the quality of the properties. Although the districts of Entremont, Saanen and Maloja are still the most expensive ones, the disaggregation reveals two additional insights: first, the high price of large apartments in Zürich, Meilen, and Genève; second, the almost complete absence of these kind of apartments in the rest of the country.

[1]These figures only include properties that advertised their price and living space, as those attributes were essential for the deduplication procedure.

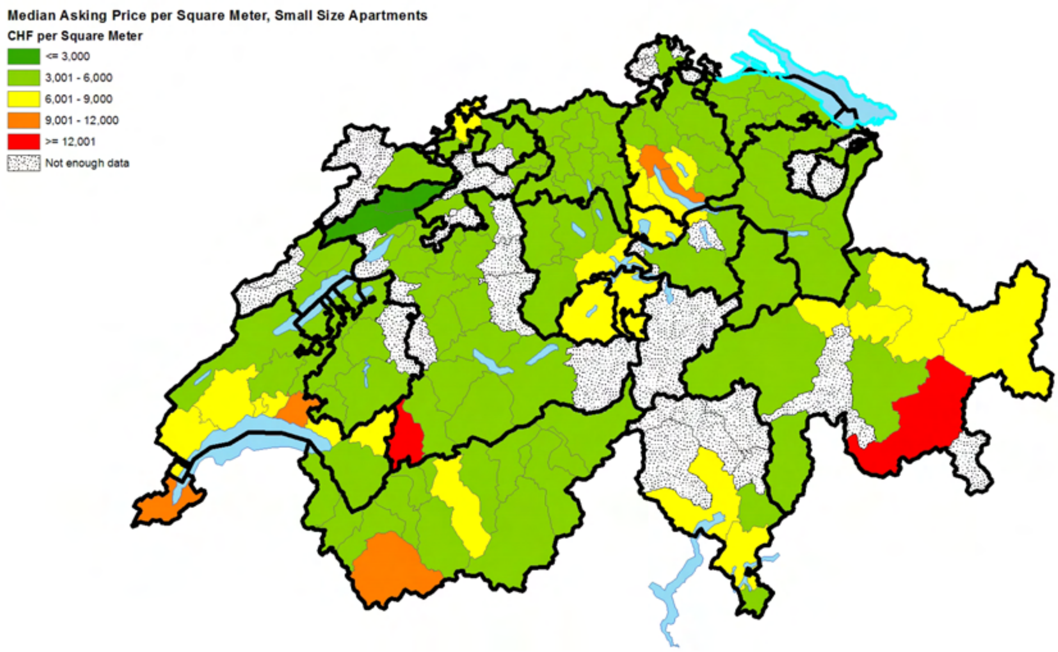


Figure 5.2: Median asking price per square meter, small apartments.

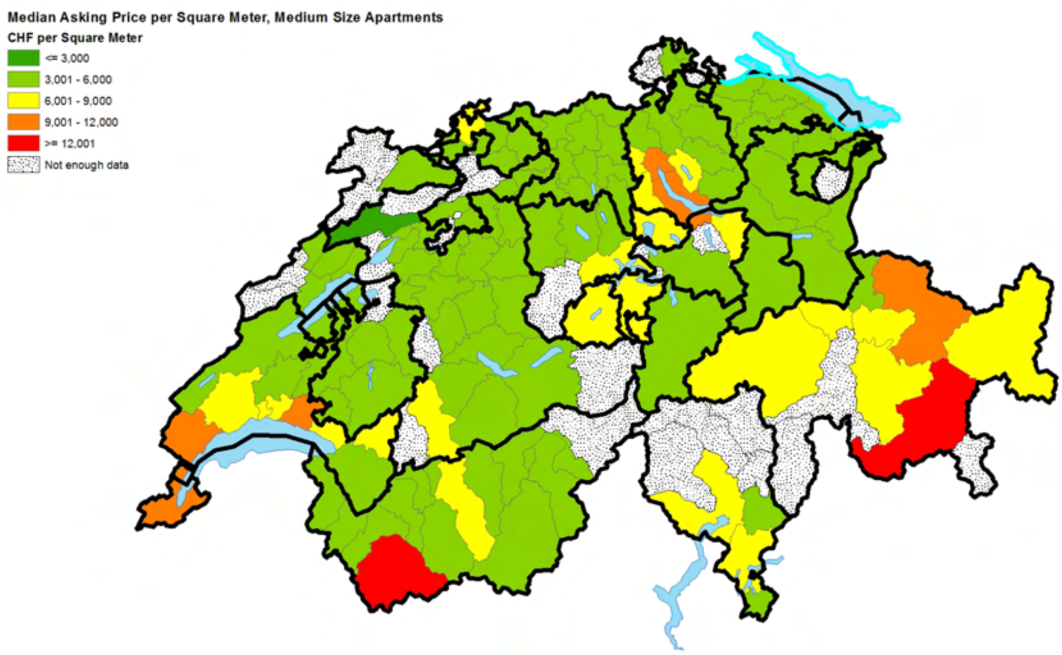


Figure 5.3: Median asking price per square meter, medium size apartments.

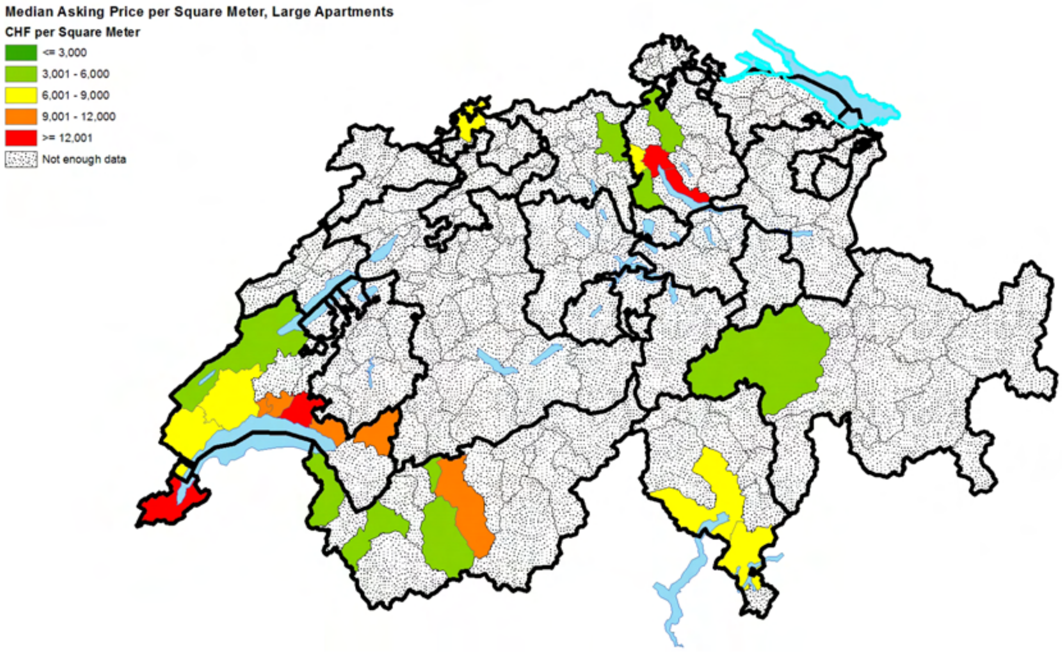


Figure 5.4: Median asking price per square meter, large apartments.

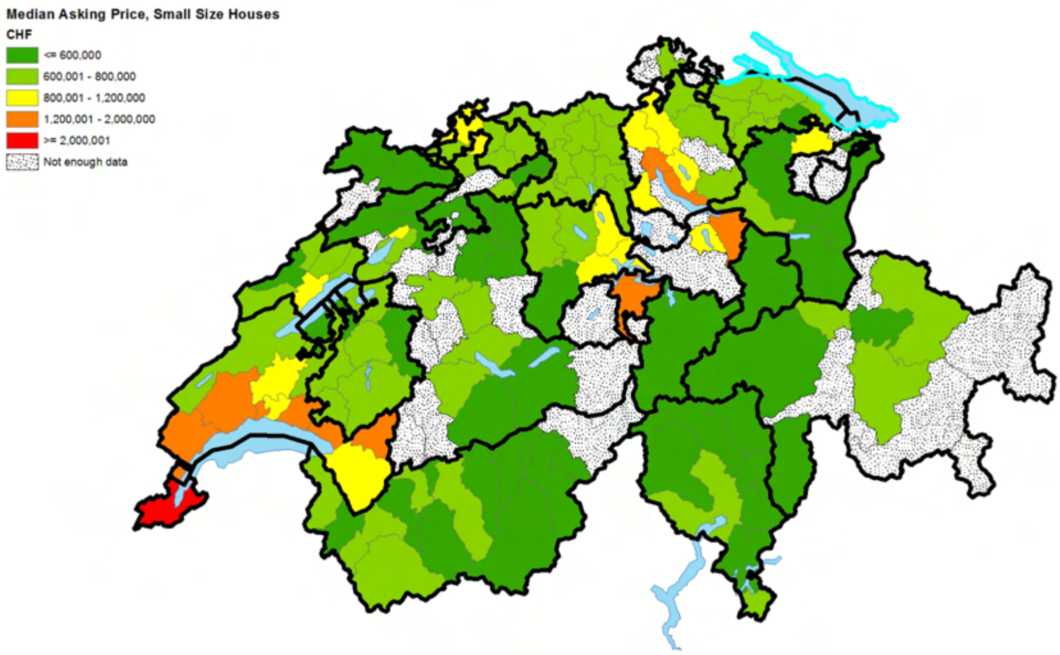


Figure 5.5: Median asking price, small houses.

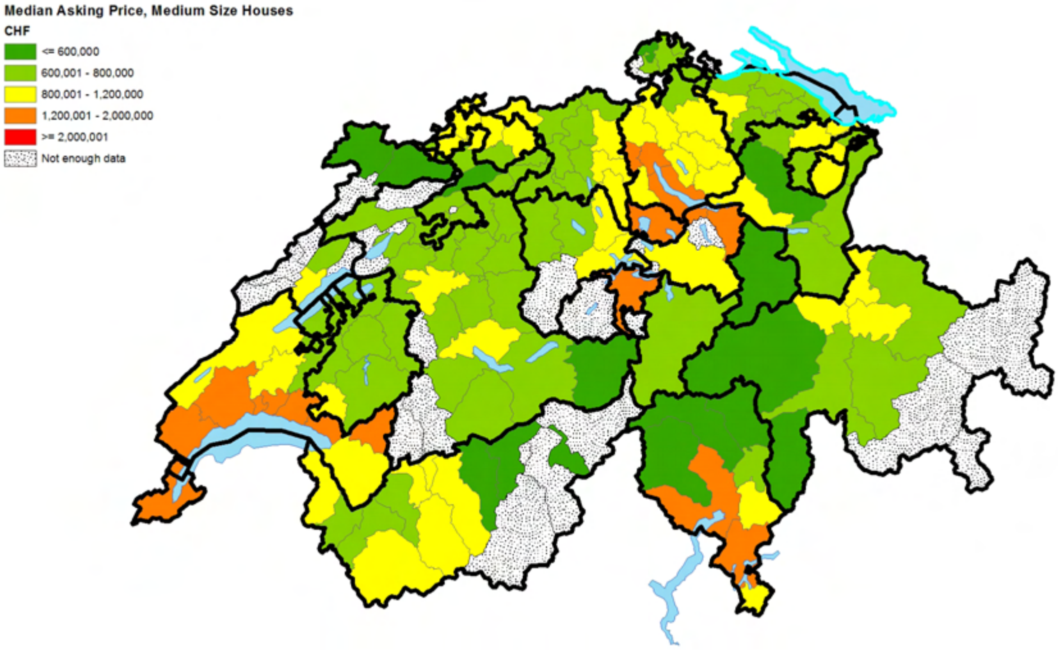


Figure 5.6: Median asking price, medium size houses.

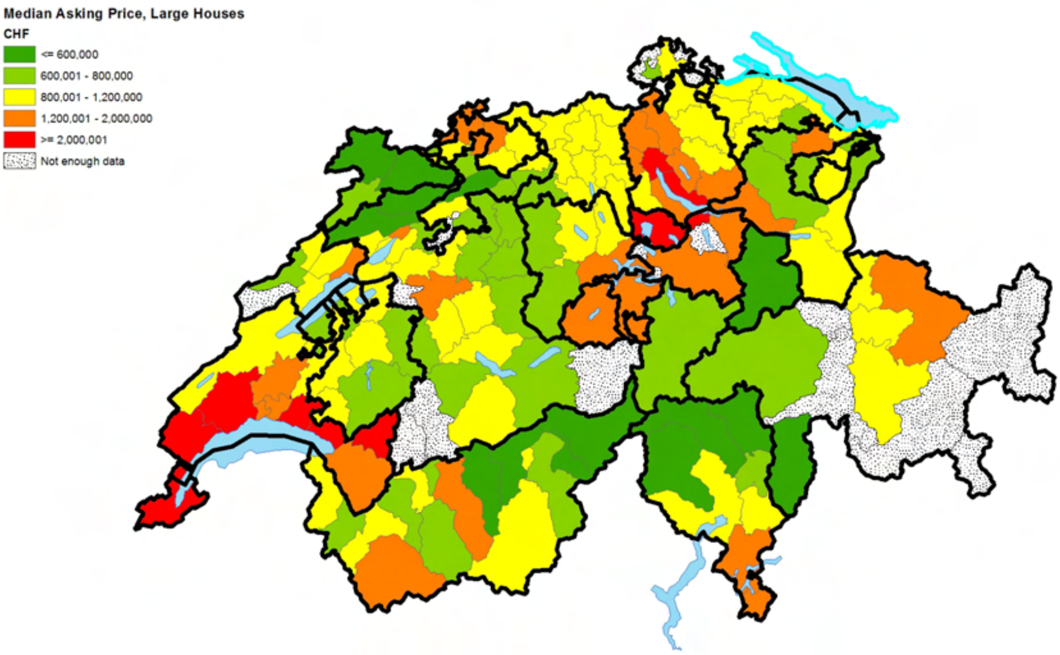


Figure 5.7: Median asking price, large Houses.

The corresponding disaggregation for houses is shown in figures 5.5, 5.6, and 5.7. The cantons of Genève, Zürich and Vaud are substantially pricier compared to the other cantons, regardless of the category considered. In particular:

- 92 percent of the districts in these cantons exhibit median asking price of small houses greater than 800'000 CHF, compared to a 14.7 percent when considering all the other cantons.
- 50 percent have median asking price of medium size houses greater than 1'200'000 CHF. This percentage falls to 8.4 in the rest of country.
- 41 percent have median asking price of large houses greater than 2'000'000 CHF. Grouping the other cantons, the percentage plunges to 4.2.

5.2 Development of prices

A heat map illustrating the price changes in apartments since 2007Q1 was developed to obtain a preliminary idea of the evolution of prices. The available data were not sufficient to generate maps for the other categories of properties. The map is presented in figure 5.8. The regions labeled "CM" represent the districts with not enough listings during the specified period (less than 10 ads in 2007Q1 or in 2012Q4). The cantonal median (CM) price change per square meter values are shown for those districts.

According to the data, 56 percent (93 out of 166) of the districts have undergone increases greater than 25 percent. The most notable has happened in Entremont, where the median asking price of apartments per square meter has more than doubled. The districts of Genève and Zürich along with the districts surrounding the lakes of Genève and Zürich, as well as the touristic destinations in canton Graubünden all show significant rise in asking price per square meter, mostly between 51 and 75 percent.

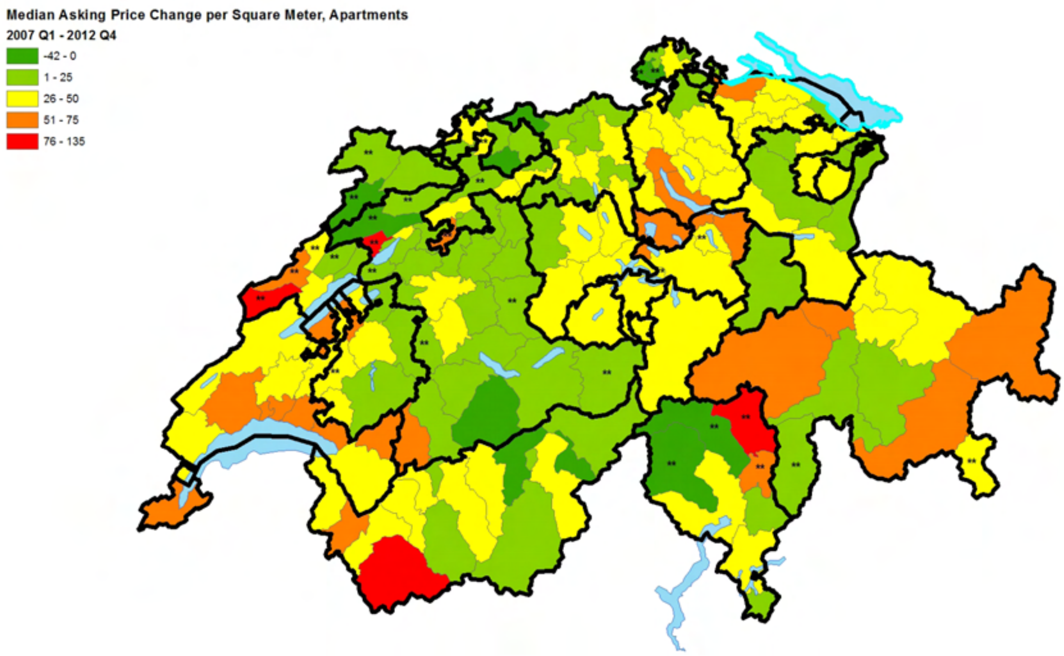


Figure 5.8: Change in median price per square meter of all apartments, 2007Q1 - 2012Q4.

A direct view to the most affected districts stresses the problems of analyzing specific price changes. The median asking price per square meter of Entremont, in figure 5.9a, has undergone extremely volatile changes, in which rapid increases are followed by similar movements in the opposite direction. This contrasts with the situation in Riviera-Pays-d'Enhaut (figure 5.9b) where prices have grown almost regularly since 2005. Meilen and Zürich in turn seem to exhibit different dynamics. On one hand, Meilen (figure 5.9c) has presented an increasing volatility after a period of consistent increments. On the other hand, Zürich (figure 5.9d) shows a belated price development that took off in 2008 and peaked at the beginning of 2012.

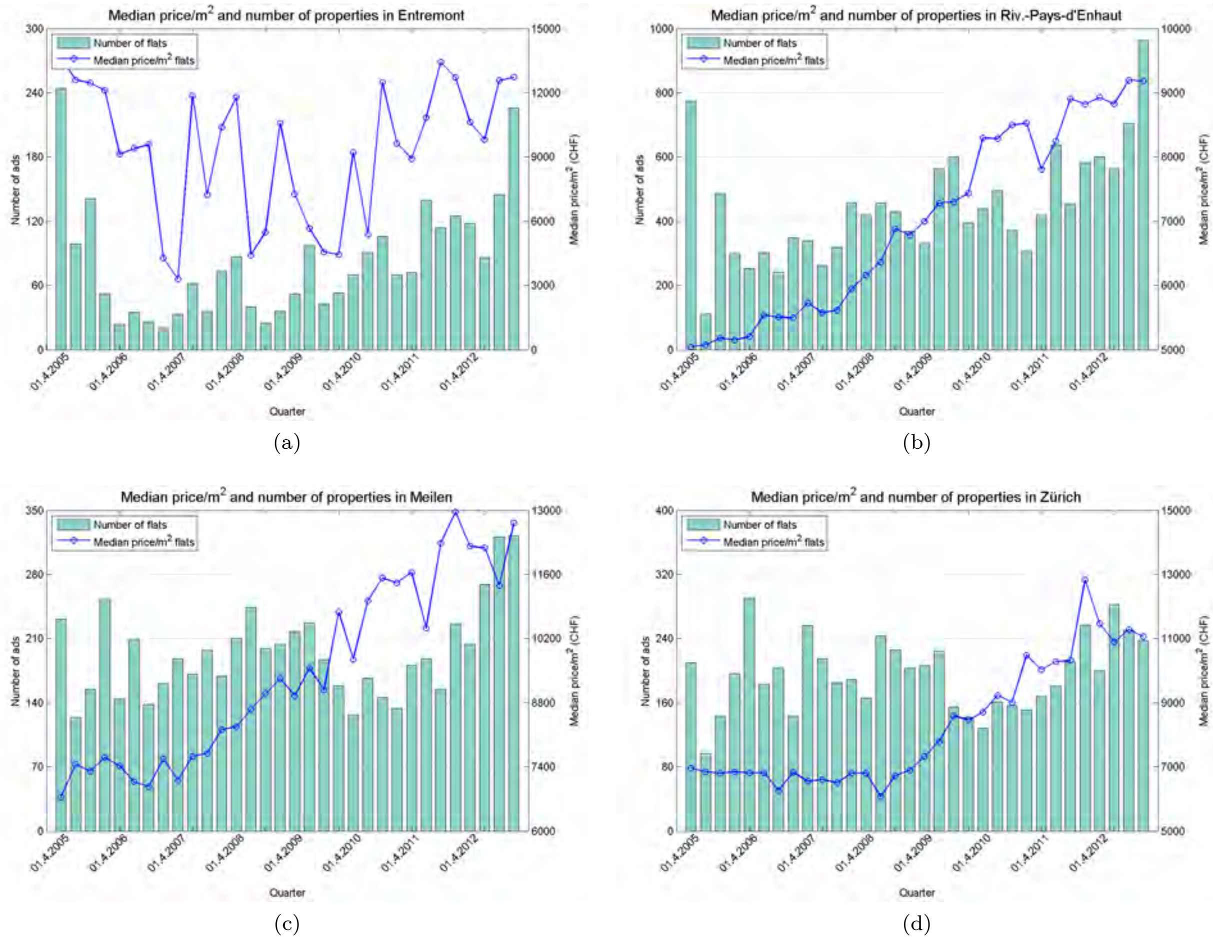


Figure 5.9: Development of prices, selected districts.

Chapter 6

Bubble diagnostic

6.1 Method: the Log-Periodic Power Law (LPPL) model

The term “bubble” refers to a situation in which excessive public expectations of future price increases cause prices to be temporarily elevated (K. E. Case and Shiller 2003). Didier Sornette and Ryan Woodard 2010, p. 21 illustrate the concept of housing price bubble as follows:

> "During a housing price bubble, homebuyers think that a home that they would normally consider too expensive for them is now an acceptable purchase because they will be compensated by significant further price increases. They will not need to save as much as they otherwise might, because they expect the increased value of their home to do the saving for them. First-time homebuyers may also worry during a housing bubble that if they do not buy now, they will not be able to afford a home later."

We employed the Log-Periodic Power Law (LPPL) model to diagnose the risk of real estate bubbles in Switzerland. The LPPL model states that a bubble is a transient faster than exponential growth process, decorated with ever-increasing oscillations. In its microeconomic formulation, the model assumes a hierarchical organization of the market, comprised of two groups of agents: a group with rational expectations, and a group of "noise" agents, who are irrational and exhibit herding behavior. The herding creates price-to-price positive feedback loops that yields an accelerated growth process. The tension and competition between the rational agents and the noise traders produces deviations around the growing prices that take the form of oscillations, which increase in frequency as the time of crash gets closer.

In the LPPL model, a crash signals a change of regime, in which the prices stop rising, and take a different dynamic. This can be a swift correction, but also a slow deflation or stagnation. Moreover, a crash is not a particular event but is characterized by a probability distribution. This is an essential ingredient for the bubble to exist as it is only rational for financial agents to continue investing, because the risk of the crash to happen is compensated by the positive return generated by the financial bubble, and there exists a small probability for the bubble to disappear smoothly. In other words, the bubble is only possible when the public opinion is not certain about its end.

Many examples of calibrations of financial bubbles with LPPLs are reported in Jiang et al. 2010. For example, the LPPL has been successfully used to diagnose in advance the US real estate market bubble that burst in 2007, the oil bubble that crashed in 2008, and the Shanghai Composite index crashes in 2007 and 2009.

6.2 Fitting procedure

The LPPL estimation procedure fits the so-called log-periodic power law (LPPL) (equation 6.1). The best known fitting procedure slaves the linear parameters (A, B, C) to the non-linear ones t_c, w, m, ϕ in order to reduce the effective number of parameters from 7 to 4 (Filimonov and D. Sornette 2011). Thereafter, a combination of the Levenberg-Marquart algorithm (Davis 1993) and a preliminary taboo search (Cvijovic and Klinowski 1995) - or other metaheuristics such as genetic algorithm - is employed. A valid fit must satisfy the constraints listed in equation 6.2, which are extensively discussed in D. Sornette et al. 2011.

$$\lg p_t = A + (t_c - t)^m [B + C \cos(\omega \lg(t_c - t) - \phi)] \tag{6.1}$$

$$\begin{gathered} 0 \leq m \leq 1 \\ 5 \leq \omega \leq 25 \\ \#oscillations \geq 2.5 \\ |B| * m/(|C|\omega) \geq 1 \end{gathered} \tag{6.2}$$

The typical applications of the model varies the length of the data set to estimate confidence intervals. However, this approach was not feasible in this project since the time series had at most 32 quarters. Thus, a mixed algorithm that combines this procedure with a bootstrapping algorithm was implemented as an alternative approach. This algorithm is presented in below.

Data: $(p_1, p_2, ..., p_j, ...p_n)$ `// Observed prices`
$(\hat{p_1}, \hat{p_2}, ..., \hat{p_j}, ...\hat{p_n})$ `// Fitted values`
Result: quantiles
for $i \leftarrow 1$ **to** 3 **do**
  Attempt LPPL fits with $(p_i, ..., p_j, ...p_n)$. Save valid fit if any;
end
foreach *valid fit* **do**
  Obtain residuals $e_j = \lg p_j - \lg \hat{p_j}$;
  Create synthetic response variables $\lg(\tilde{p_j}) = \lg p_j + e_k$, where k is selected randomly from $(1...n)$ for every $j \in (1...n)$;
  Refit the model using the artificial response variables $\lg \tilde{p_j}$, and retain t_c;
  Repeat steps 2 and 3 a statistically significant number of times (1000 iterations were used in this project);
end
Obtain the quantiles based on all t_cs;

Algorithm 2: Pseudo-code of the bootstrapping algorithm.

6.3 Application of the method

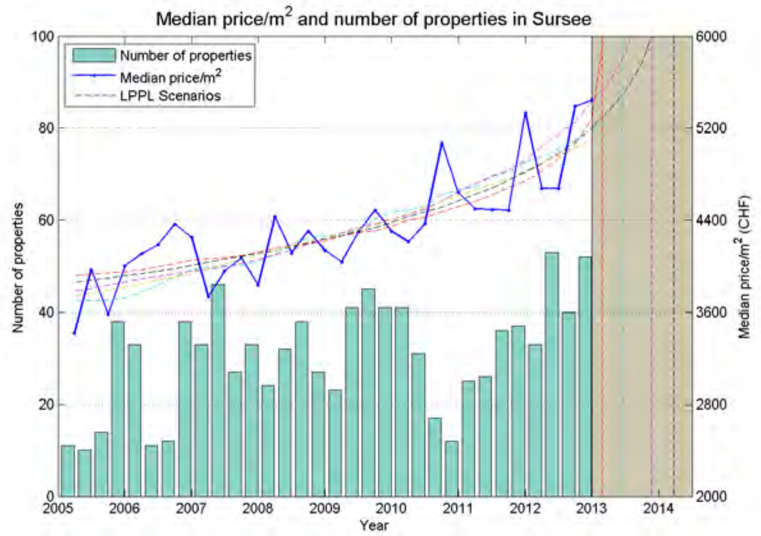
We applied the method to all subcategories of properties as well as to the aggregated index for apartments over the period 2005Q1-2012Q4. In addition, fits were also attempted using a subset of the time series that only covered the period 2005Q1-2011Q4 (i.e. 28) in order to identify districts where regime changes have already occurred (i.e. they had bubbles that already burst). We discarded fits beyond the third quarter of 2014 (inclusive) not to search for crashes too far into future. In the end, 58 complying LPPL fits were found, out of which only 18 were accepted when analyzed closely.

The reasons to discard the other 40 fits were diverse:

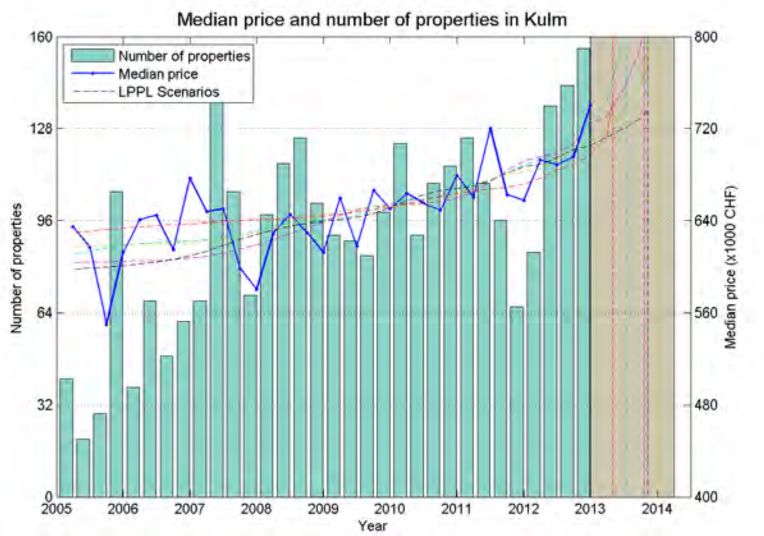
- Lack of data: 13 were not accepted as there were not enough ads in the sample to build a reliable index.
- Noise or choppiness: 13 were based on extremely choppy time series that describe implausible dynamics in light of the current state of the market. The large volatility in these series was interpreted as noise.
- Invalid aggregation: 7 fits were identified among all houses on sale, which is a category deemed invalid.
- Parent category already included: 3 were not considered as a fit in the parent category was also found. For example, a fit among small apartments, found along with one among all apartments.

- Lack of evidence: 3 fits of the 2005Q1-2011Q4 fits were not taken in account because the predicted crash could not be verified or denied in light of the observations available at the time when this thesis was written.
- No change of regime: 1 fit of the 2005Q1-2011Q4 fits was not taken in account because the predicted crash did not happened. The median asking price per square meter of all apartments in Münchwilen continued rising, and in fact, the district appeared again as a critical region when all the dataset was used.

Figure 6.1 illustrates each of these cases, whereas tables 6.1 and 6.2 provide the list of all discarded fits.

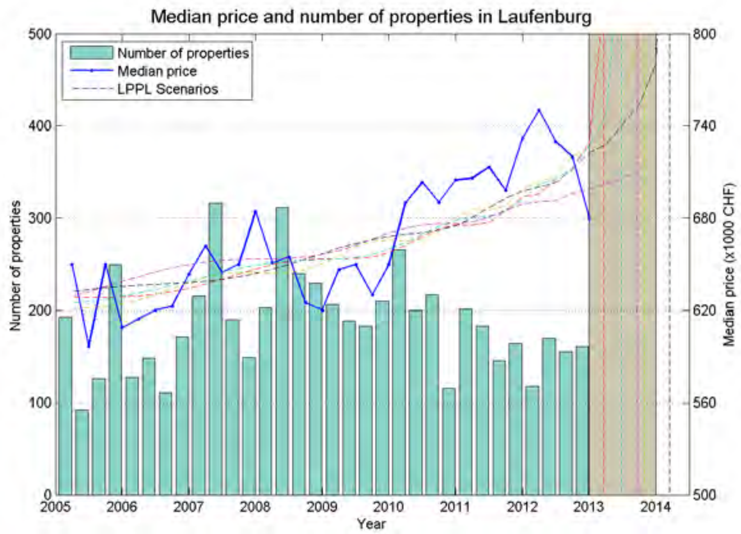


(a) Lack of data. Sursee, small apartments.

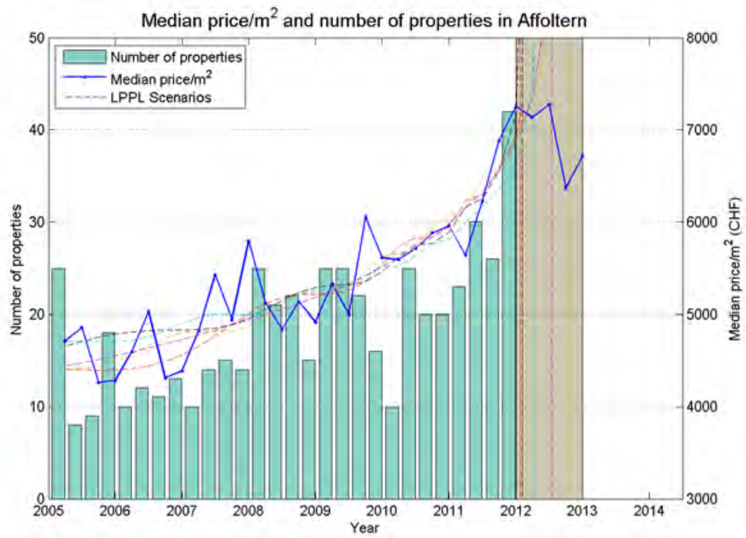


(b) Noise or choppiness. Kulm, medium size houses.

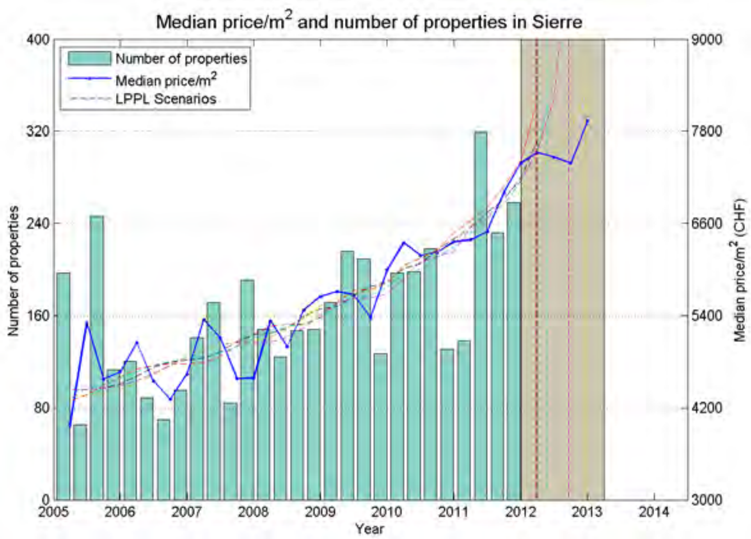
Figure 6.1: Discarded fits, illustrative examples.



(c) Invalid aggregation. Laufenburg, all houses.

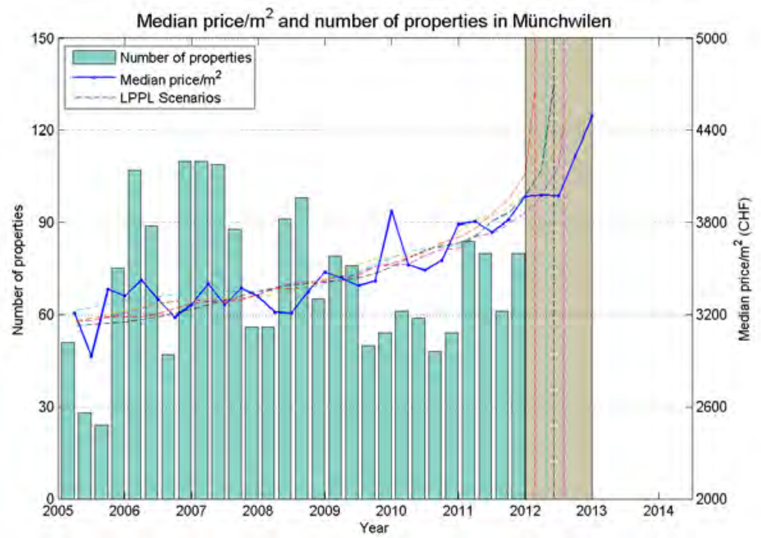


(d) Parent category already included. Affoltern, small apartments.



(e) Lack of evidence. Sierre, small apartments.

Figure 6.1: Discarded fits, illustrative examples (cont).



(f) No change of regime. Münchwilen, all apartments.

Figure 6.1: Discarded fits, illustrative examples (cont).

District ID	District	Property type	Size	Reason
101	Affoltern	Apartments	Medium-size	Noise or choppiness
103	Bülach	Houses	Large	Noise or choppiness
106	Horgen	Apartments	Small	Parent category already included
224	Thun	Houses	All	Invalid aggregation
302	Hochdorf	Apartments	Small	Noise or choppiness
304	Sursee	Apartments	Small	Lack of data
1003	Gruyère	Apartments	Small	Lack of data
1007	Veveyse	Houses	All	Invalid aggregation
1502	Mittelland	Apartments	All	Lack of data
1723	Rheintal	Houses	Medium-size	Lack of data
1901	Aarau	Houses	All	Invalid aggregation
1904	Brugg	Houses	Medium-size	Noise or choppiness
1905	Kulm	Houses	Medium-size	Noise or choppiness
1906	Laufenburg	Houses	All	Invalid aggregation
2104	Locarno	Apartments	Small	Parent category already included
2302	Conthey	Apartments	All	Noise or choppiness
2307	Martigny	Houses	Small	Lack of data

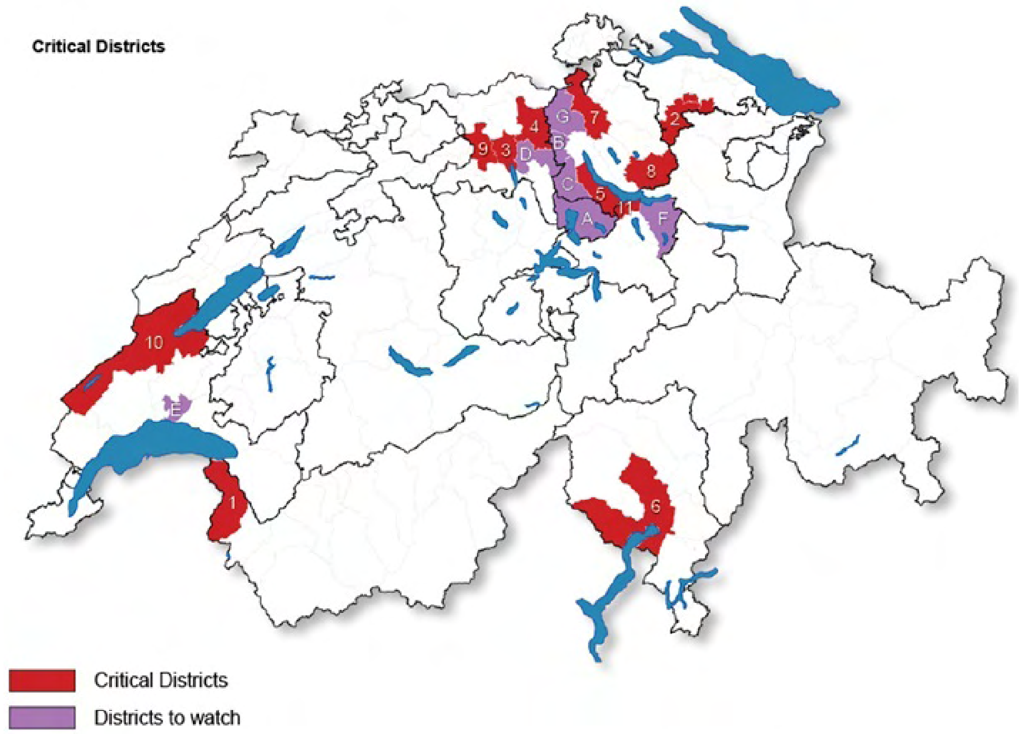
Table 6.1: LPPL fits for 2005Q1-2012Q4 period.

District ID	District	Property type	Size	Reason
101	Affoltern	Apartments	Small	Parent category already included
104	Dielsdorf	Apartments	All	Lack of evidence
108	Pfäffikon	Houses	All	Invalid aggregation
212	Konolfingen	Apartments	Small	Lack of data
216	Nidau	Apartments	All	Noise or choppiness
506	Schwyz	Houses	All	Invalid aggregation
900	Kanton Zug	Houses	Medium-size	Lack of data
1001	Broye	Houses	Medium-size	Lack of data
1003	Gruyère	Apartments	All	Lack of data
1108	Olten	Apartments	Small	Lack of data
1303	Liestal	Houses	Medium-size	Noise or choppiness
1821	Albula	Apartments	Small	Noise or choppiness
1901	Aarau	Apartments	All	Lack of evidence
1904	Brugg	Apartments	All	Noise or choppiness
1905	Kulm	Houses	Large houses	Noise or choppiness
1911	Zurzach	Houses	Medium-size	Noise or choppiness
2006	Münchwilen	Apartments	All	Lack of evidence
2224	Jura-Nord vaudois	Houses	Medium-size	Lack of data
2227	Morges	Houses	All	Invalid aggregation
2230	Riv.-Pays-d'Enhaut	Apartments	All	Lack of data
2311	Sierre	Apartments	All	Noise or choppiness
2311	Sierre	Apartments	Small	Lack of evidence
2313	Visp	Apartments	Medium-size	Lack of data

Table 6.2: LPPL fits for 2005Q1-2011Q4 period.

Chapter 7

Critical regions



Critical Districts

ID	District	Property Type	Size	Critical Time
1	Monthey	Apartments	Medium	2013 Q1 – 2014 Q1
2	Münchwilen	Apartments	Medium	2013 Q1 – 2013 Q4
3	Lenzburg	Houses	Medium	2013 Q1 – 2014 Q1
4	Baden	Apartments	All	2013 Q1 – 2014 Q1
5	Horgen	Apartments	All	2013 Q1 – 2014 Q2
6	Locarno	Apartments	All	2013 Q1 – 2014 Q1
7	Bülach	Apartments	Medium	2013 Q1 – 2013 Q4
8	Hinwil	Houses	Medium	2013 Q1 – 2014 Q1
9	Aarau	Houses	Medium	2013 Q1 – 2014 Q1
10	Jura-Nord vaudois	Houses	Medium	2013 Q1 – 2014 Q1
11	Höfe	Apartments	Medium	2013 Q1 – 2014 Q1

Districts to watch

A	B	C	D	E	F	G
Zug	Dietikon	Affoltern	Bremgarten	Lausanne	March	Dielsdorf

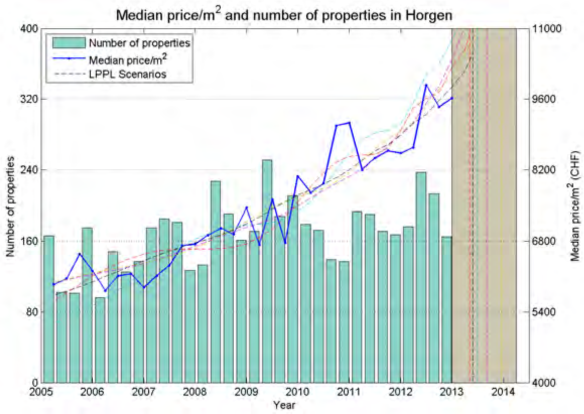
Figure 7.1: Critical districts and districts to watch.

The consolidated group of districts with recent or possible future change of regimes is shown in figure 7.1. The districts labeled from 1 through 11 show signs of speculative bubbles with critical times between the first quarter of 2013 and the second quarter of 2014. As it was described above, the districts to watch in figure 7.1 correspond to regions where the model has predicted critical times in the year 2012, and the observed prices during the year suggest that this has actually happened. The bubble in the latter has been diagnosed among all the apartments, except in the district of Dietikon where the bubble covered only small apartments.

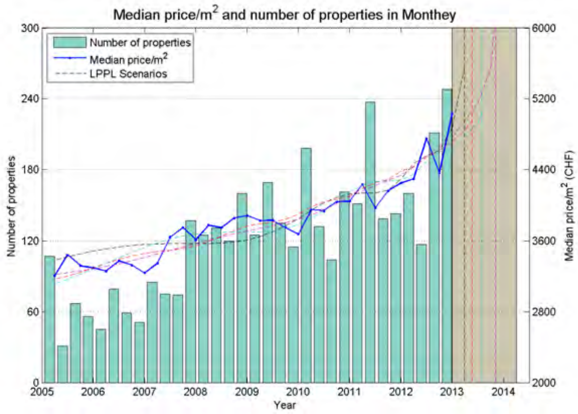
Some fits are presented in figure 7.2, in which the 80 percent confidence interval of the critical time is depicted in gray. The dotted lines represent possible LPPL scenarios.

Figures 7.2a and 7.2b show the development of the median asking price per square meter for all apartments in Horgen and Monthey. Both regions exhibit the signals of the bubbles modeled by the LPPL method: a super-exponential growth, accompanied by decorating oscillations.

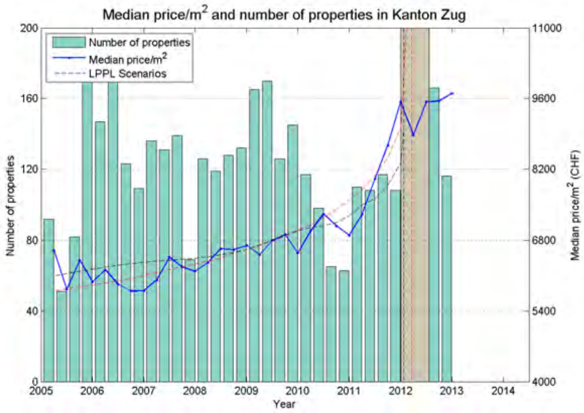
Figures 7.2c and 7.2d in turn correspond to examples where a change of regime have already occurred. Although this is very difficult to assess at the present time due to the slow dynamics of real estate, the recent development of prices in these regions suggest that the prices have in fact stagnated. For example, the apartments of Zug (figure 7.2c) experienced a mild year-on-year increase of 6.9 percent, compared to the 31.2 percent that took place in 2011. Likewise, the median asking price per square meter of small apartments in Dietikon (figure 7.2d) remained almost constant in 2012, growing at a 2.5 percent rate on a year-on-year basis. This contrasts with the 10.5 percent yearly increase that was observed in 2011.



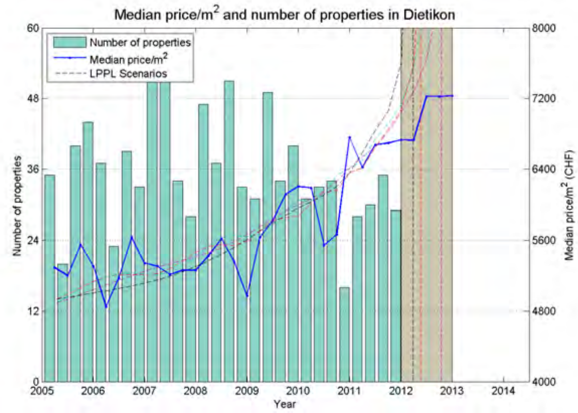
(a) Bubble in Horgen, all apartments.



(b) Bubble in Monthey, all apartments.



(c) A bubble that burst in the canton of Zug, all apartments.



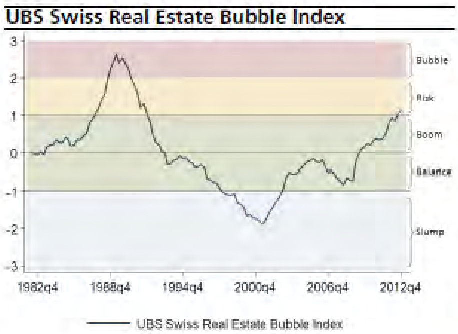
(d) A bubble that burst in the canton of Dietikon, all apartments.

Figure 7.2: Development of prices in some critical and to watch districts.

Chapter 8

Comparison to other studies

We compared our results with the UBS Bubble Index (UBS 2012). The index is based on a fundamental analysis, which comprises six different sub-indices such as the relationship between purchase and rental prices, the relationship between house prices and household income, and the proportion of credit applications for residential property not intended for owner occupancy by UBS clients. The selection of exposed regions is further conducted using a multi-level process that considers the size of the regional population and the property price data. In its 20012Q4 report, the index rose to 1.11 from 1.02, and highlighted 17 exposed districts (14 regions), and nine monitored ones (seven regions). The performance of the index and the risk map of exposed regions are shown in figures 8.1 and 8.2.



Performance of the UBS Swiss Real Estate Bubble Index

		Index
2009	Quarter 1	-0.24
	Quarter 2	-0.05
	Quarter 3	0.10
	Quarter 4	0.15
2010	Quarter 1	0.25
	Quarter 2	0.21
	Quarter 3	0.33
	Quarter 4	0.39
2011	Quarter 1	0.35
	Quarter 2	0.40
	Quarter 3	0.52
	Quarter 4	0.79
2012	Quarter 1	0.93
	Quarter 2	0.82
	Quarter 3	1.02
	Quarter 4	1.11

Figure 8.1: Performance of the UBS Bubble Index. Source: UBS 2012.

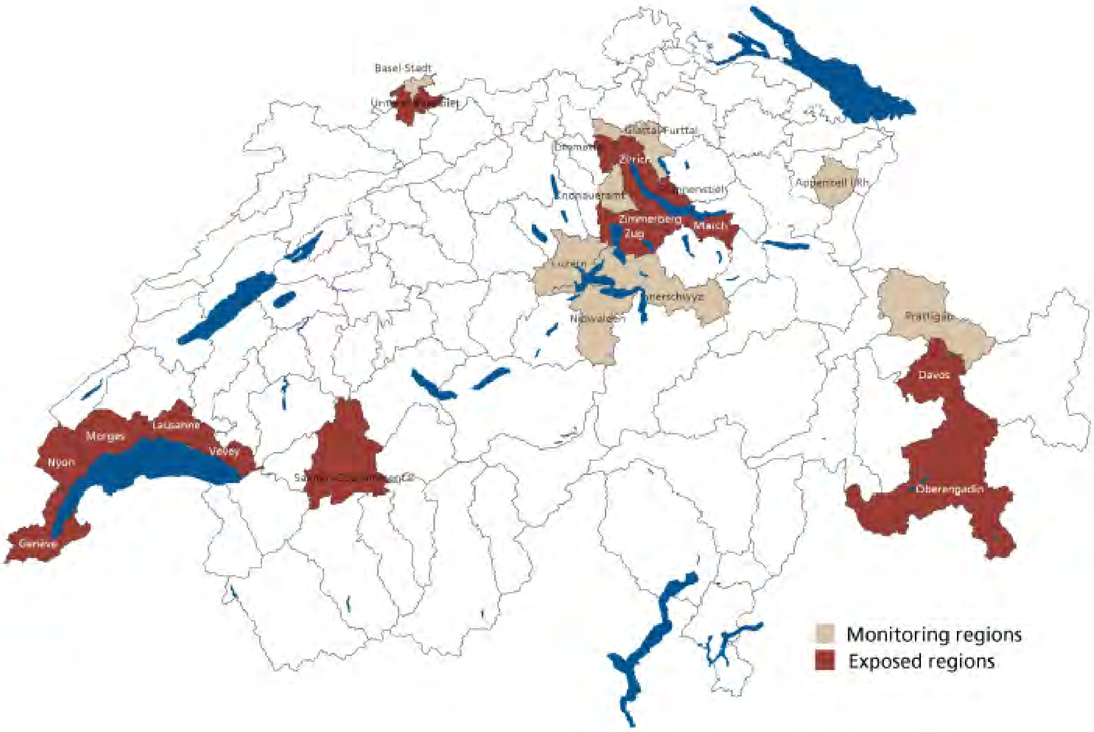


Figure 8.2: Regional risk map of the UBS Bubble Index. Source: UBS 2012.

A comprehensive comparison with the index is not possible as the UBS index does not make any claim regarding the future development of prices, and even defines some regions differently. However, table 8.1 presents a simplified parallel, in which the districts highlighted by the LPPL model and the UBS Bubble Index are directly contrasted[1]. The LPPL model provides completely new information about nine districts (eight critical districts, and one to watch district), but does not report a critical situation in 19 districts, where UBS points current exposure or need for monitoring.

We looked closely at the exposed districts reported by the UBS Bubble Index that were not identified by the LPPL model, as this could imply an overlook of latent threats. Among these discrepancies, arguably, the most prominent is the absence of the cantons of Geneva, Vaud, and Graubünden, consistently reported by the UBS Bubble Index as risky zones. Our assessment found moderately or did not find at all, bubble signatures in these regions. An explanation for this has methodological and data reasons.

First of all, the method applied by UBS compares the values of a region with those of all the country to determine the extent of a regional exposure. As a result, overpopulated regions or those that have historically exhibited above average prices will tend to be reported. In contrast, the LPPL model prioritizes the dynamics of the price developments, requiring a faster than exponential growth to diagnose a price development as a bubble.

The latter condition is essential, and is not fulfilled in the cantons of Geneva and Vaud nor in the district of Arlesheim. In these regions, the development of prices resembles a linear growth. For example, the median asking price per square meter of apartments in the district of Morges (figure 8.12a), has grown on average about 100 CHF per quarter since 2005. Likewise, the median asking price per square meter of apartments in the canton of Geneva (figure 8.13a) has increased on average about 156 CHF per quarter during the same period. Thus, these cantons do not show the typical signals of the bubbles identified by the LPPL model, though a different overpricing cannot be discarded.

A similar situation seemed to have occurred among apartments of Zürich (figure 8.4a) and Meilen (8.3a), with the extra consideration that the growth period started belatedly, at about the third quarter of 2008 for the former, and at about the second quarter of 2007 for the latter.

The differences in Obersimmental and the two districts of Graubünden are bound to other reasons. The number of advertised properties that were available in the comparis.ch database for these districts

[1] In the table, whenever the name of a UBS region does not coincide with a district, the original name is shown between parenthesis. Districts are *partially monitored* or *partially exposed* when they are not fully covered by a UBS region.

	UBS exposed districts	UBS monitored districts	Not reported by UBS
LPPL critical districts	Horgen(Zimmerberg) Höfe (March)	Bülach(partially in Glattal-Flurttal)	Monthey Müchwillen Lenzburg Baden Hinwil Locarno Aarau Jura-Nord valudois
LPPL to watch districts	Zug Dietikon(Limmatal) March Lausanne	Affoltern(Knonaueramt) Dielsdorf (partially in Glattal-Flurttal)	Bremgarten
Not reported by the LPPL model	Prättigau-Davos Bernina (Oberengadin) Maloja (Oberengadin) Geneve Nyon Morges Lavaux-Oron (Vevey) Arlesheim (Unteres Basielbieg) Saanen(Saanen-Obersimmental) Zürich Meilen(Pfannestiel)	Basel Stadt Luzern Appenzell-Innerhoden Nidwalden Uster Gersau (Innerschvyz) Kussnacht (Innerschvyz) Schvyz (Innerschvyz)	

Table 8.1: Comparison between the LPPL results and the UBS Bubble Index.

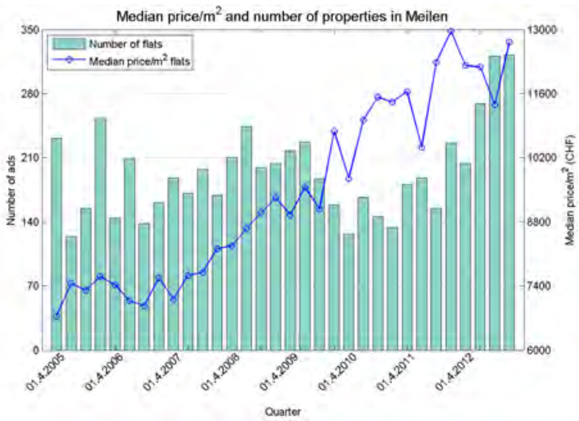
District ID	District	Comment of price development
107	Meilen(Pfannestiel)	Linear growth with belated takeoff
112	Zürich	Linear growth with belated takeoff
220	Saanen(Saanen-Obersimmental)	Lack of data
1301	Arlesheim (Unteres Basielbieg)	Linear growth
1822	Bernina (Oberengadin)	Lack of data
1827	Maloja (Oberengadin)	Lack of data
1830	Prättigau-Davos	Additional monitoring is required. Short acceleration
2226	Lavaux-Oron	Linear growth
2227	Morges	Linear growth
2228	Nyon	Linear growth
2500	Geneve	Linear growth

Table 8.2: Comments on price development in UBS exposed districts.

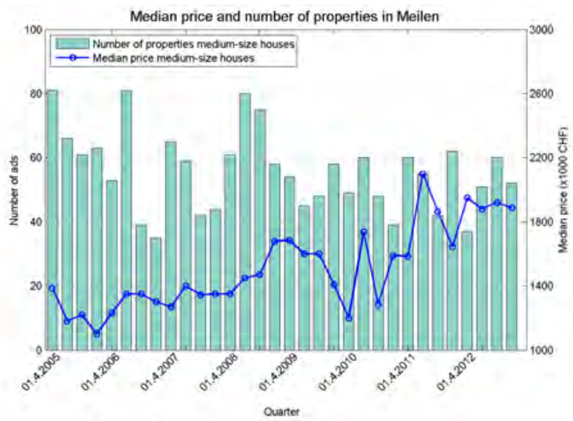
is small or zero over several quarters (see for example figure 8.9b). Hence, it is not possible to draw any statistical conclusion about their prices, and the results of this study should not undermine the alarms raised by the other index. Having mentioned this, it is also worth noting that the low number of properties might not be an issue specific to our dataset, but rather a predominant characteristic of these locations, which serve mainly as luxurious or tourist destinations. If this were the case, the consequences of a bubble in these region would be marginal as very few people would be affected.

The exception in Graubünden is the apartments of Davos in figure 8.9b, which have had a very liquid market. There the situation needs further monitoring as the prices grew sharply during two years, starting from the beginning of 2010, and then stabilized. That is, although there were notable price increases, they occurred during a very short period of time.

A summary of this discussion is presented in table 8.2.

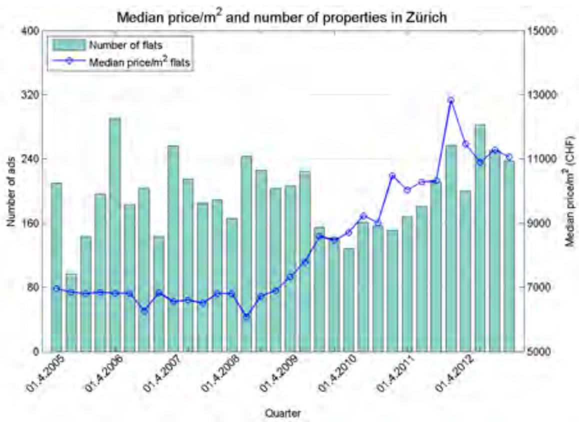


(a) All apartments.

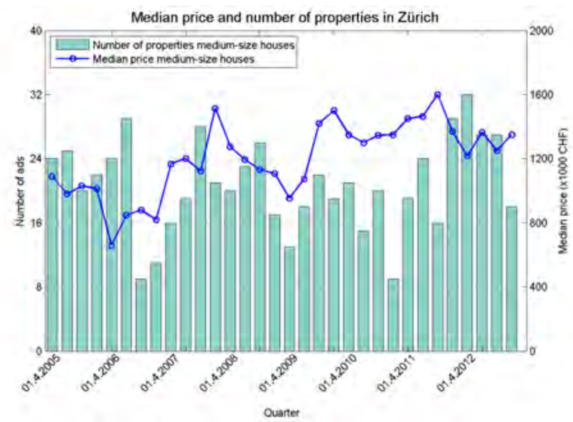


(b) Medium Size Houses.

Figure 8.3: Development of prices in Meilen (Zürich).

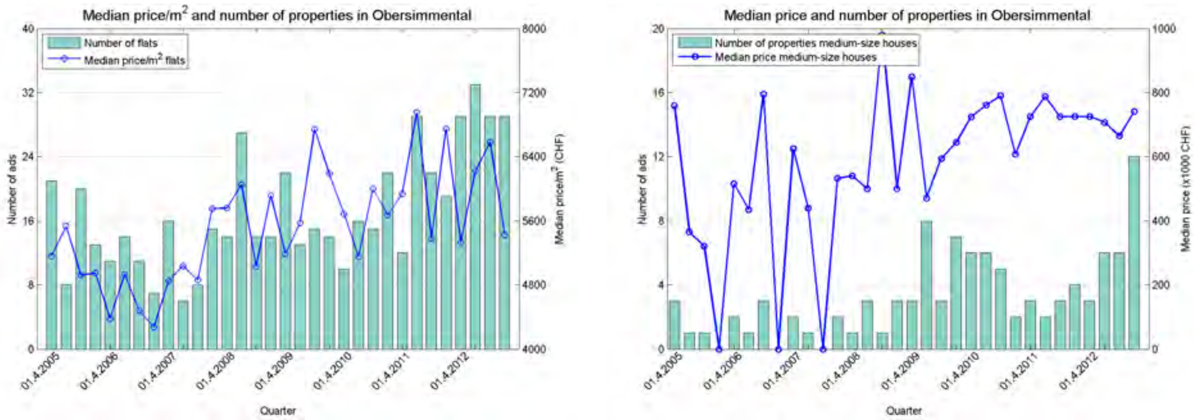


(a) All apartments.



(b) Medium Size Houses.

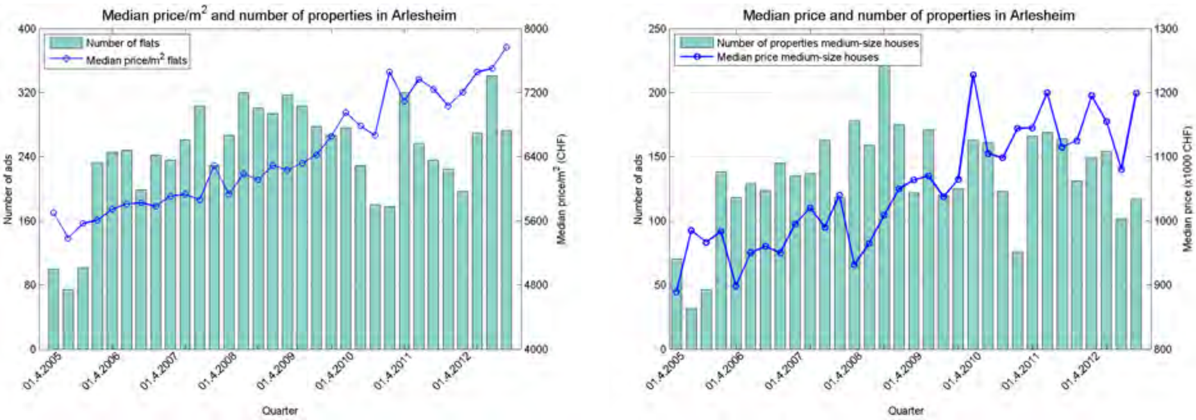
Figure 8.4: Development of prices in Zürich (Zürich).



(a) All apartments.

(b) Medium size houses.

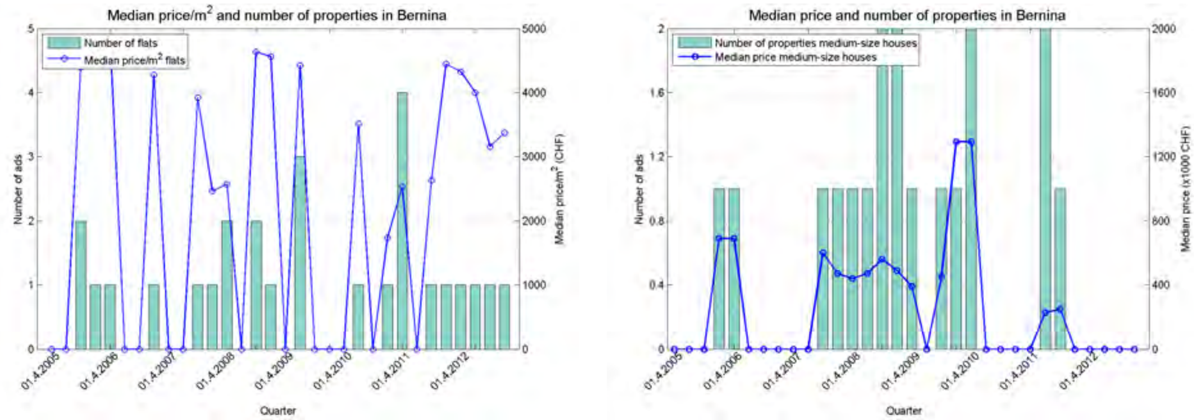
Figure 8.5: Development of prices in Obersimmental.



(a) All apartments.

(b) Medium size houses.

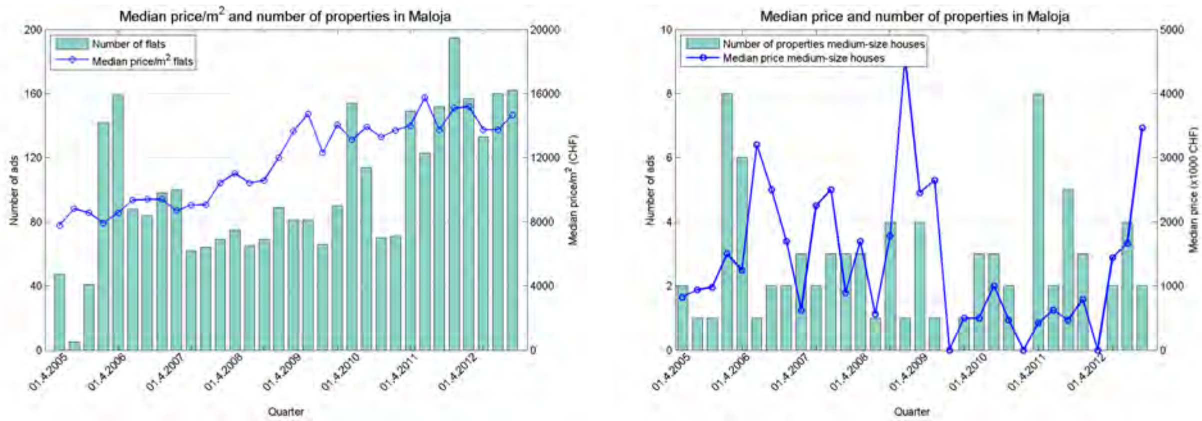
Figure 8.6: Development of prices in Arlesheim.



(a) All apartments.

(b) Medium size houses.

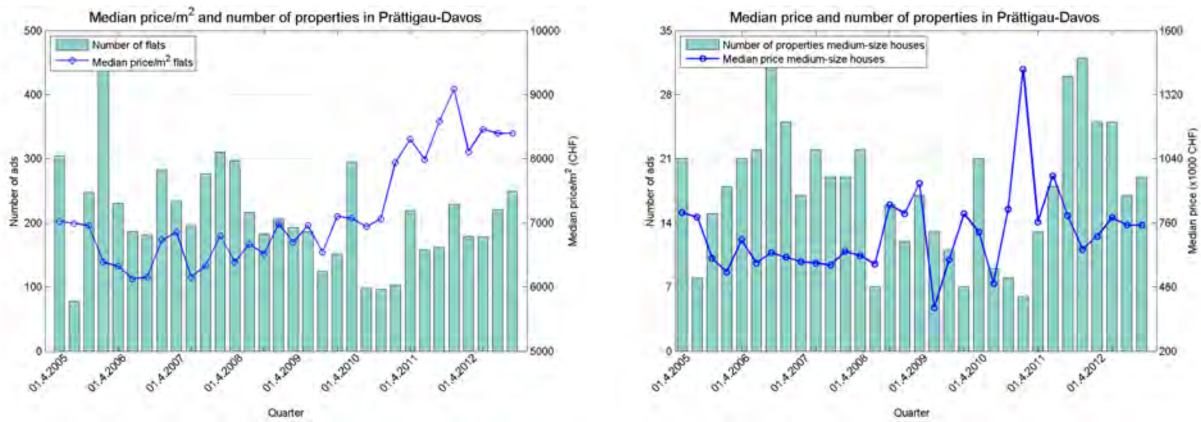
Figure 8.7: Development of prices in Bernina (Graubünden).



(a) All apartments.

(b) Medium size houses.

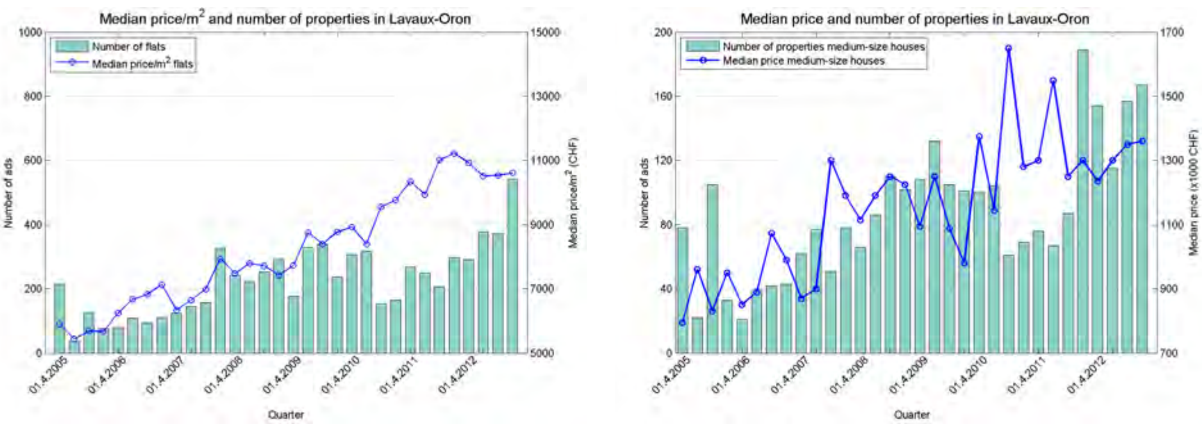
Figure 8.8: Development of prices in Maloja (Graubünden).



(a) All apartments.

(b) Medium size houses.

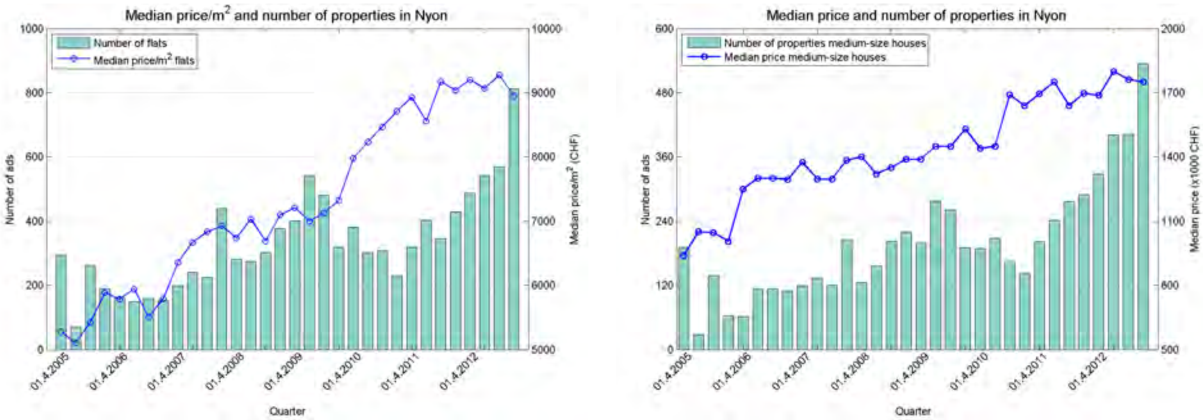
Figure 8.9: Development of prices in Davos (Graubünden).



(a) All apartments.

(b) Medium Size Houses.

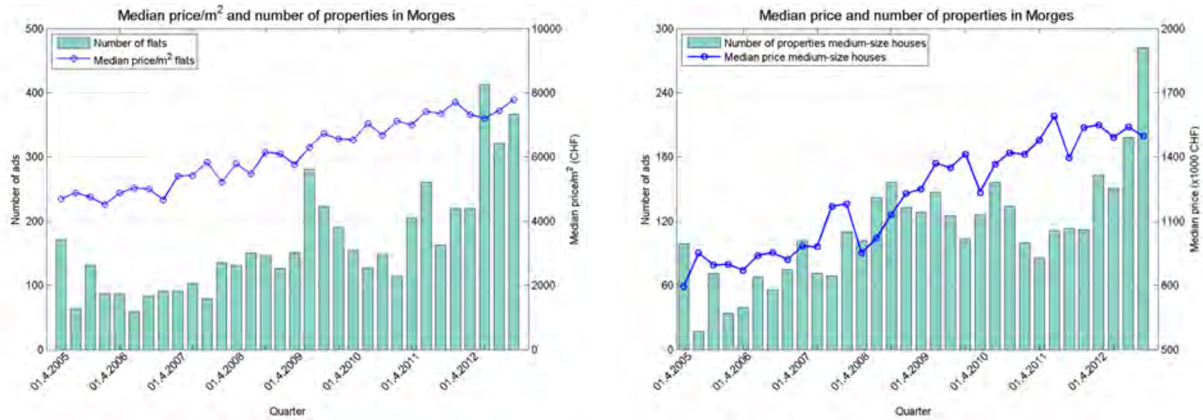
Figure 8.10: Development of prices in Lavaux-Oron (Vaud).



(a) All apartments.

(b) Medium size houses.

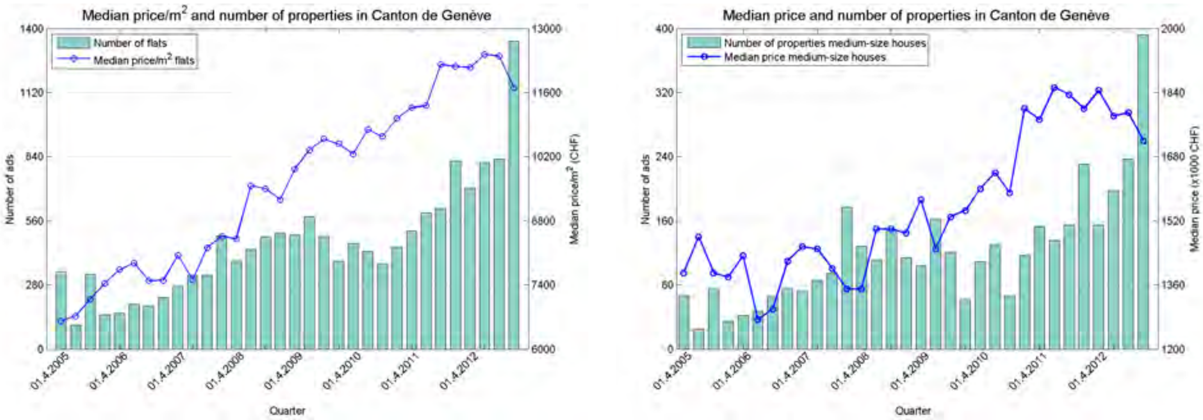
Figure 8.11: Development of prices in Nyon (Vaud).



(a) All apartments.

(b) Medium size houses.

Figure 8.12: Development of prices in Morges (Vaud).



(a) All apartments.

(b) Medium size houses.

Figure 8.13: Development of prices in Genève.

Chapter 9

Final discussion

Despite the finding of strong bubbles signals in several districts, there is no reason to panic. The current economic environment suggests that a soft landing of prices instead of a sharp correction can be expected.

First, the rising property prices in Switzerland has not been accompanied by a boom in the construction sector as those that occurred during the bubbles in US, Ireland and Spain. In these countries, high supply sensitivity introduced a construction boom that contributed to a stronger reverse of high prices ((Allen and Carletti 2010), (Duca, Muellbauer, and Murphy 2010)). On the contrary, the construction sector in Switzerland keeps moving slowly, and stays below historic averages (see figure 2.10c). The vacancy rate in turn has stagnated at a low level, presenting a marginal increase of only one percent during the last year: from 38'420 empty apartments in June 2011 to 38'920 empty apartments in June 2012 (FSO 2012).

Second, the SNB is already issuing measures to control the market. In February 2013, it ordered banks to hold a countercyclical capital buffer amounting to one percent of their risk-weighted, direct or indirect mortgage-backed positions secured by residential property in Switzerland (SNB 2013a, p. 1). With this policy, the central bank is directly aiming to reduce the exposure of banks to real estate, which has proved a key amplifier of previous crashes (Hilbers, Lei, and Zacho 2001). It is estimated that the new policy will impact as much as 25 percent of the country's total mortgage volume (Bloomberg 2013), affecting especially regional and Raiffeisen banks, as most of their assets are mortgages.

Third, unlike the burst of the real-estate market bubble in Switzerland during the 80s, which was fueled by extensive mortgage lending practices (Westernhagen et al. 2004), Swiss banks are seeking to implement more conservative practices. The Swiss Financial Market Supervisory Authority FINMA approved a new set of minimum requirements for mortgage financing, drawn up by the Swiss Bankers Association (SBA). The new self-regulatory regime, which came into effect from July 2012, for the first time requires a minimum 10 percent down payment from the own borrower's funds when purchasing a property and demands mortgages to be paid down to two thirds of the lending value within a maximum of 20 years (SBA 2012). The new self-regulatory scheme should prevent households from taking greater risks, as they will be unable to overuse the money from their pension funds to make the down payment and will be pressed to reduce the burden of the debt.

In light of this reasoning, a severe crash in the districts analyzed in this project is unlikely, and a soft landing of prices turns a more probable scenario. Yet, as the vigorous demand in 2013 is an economic reality, the possible change of regime in the critical districts might arguably be accompanied by increasing price pressures in their adjacent districts. This is plausible, not only because contagious effects have been observed in other housing market bubbles ((Roehner 1999), (Fry 2009)), but also because immigrants, which represent an important driver of the current demand, are traditionally more flexible and willing to travel farther distances when looking for a place to live.

Having said this, it is also important to keep in mind that the impact of the preventive measures is yet to be seen. Not only there are still debates concerning the role that central banks should play during bubble regimes (see (Roubini 2006) and (Posen 2006) for the main arguments), but also there is uncertainty regarding the strength and appropriate calibration of the measures (Central Banking Newsdesk 2013). The fact that the monetary policy is anchored to the international milieu only makes harder to maintain the stability of the market as interest rates cannot be revised upwards.

Moreover, the overall economic situation remains challenging and an exogenous shock cannot be discarded. Nonetheless, the results of this thesis extend only to endogenous crashes. Thus, possible shocks such as the adverse scenario contemplated by the Financial Stability Report of the SNB (SNB

2012), which includes a sharp escalation of the European debt crisis that leads to a deep recession in Switzerland, are beyond the scope of this study.

The analysis hereby presented can be improved in several ways. Further research should develop a more robust index, probably incorporating a Hedonic regression methodology that takes into account the sensibilities inherent to a bubble regime. In addition, fundamental factors, such as the dynamic of the construction sector, demographics, and geographic considerations could directly be introduced to complement the LPPL model. It is also important to make an explicit comparison between asking prices and transaction prices in order to assess the impact of using the formers in the analysis. Finally, the market conditions of the critical and to watch districts should be closely monitored in the forthcoming months as this constitutes the ultimate test of this study.

Appendix A

Districts of Switzerland

Figure A.1: Districts of Switzerland. Source: SFSO

ID	District	ID	District	ID	District
101	Affoltern	111	Dietikon	209	Fraubrunnen
102	Andelfingen	112	Zürich	210	Frutigen
103	Bülach	201	Aarberg	211	Interlaken
104	Dielsdorf	202	Aarwangen	212	Konolfingen
105	Hinwil	203	Bern	213	Laupen
106	Horgen	204	Biel	214	Moutier
107	Meilen	205	Büren	215	La Neuveville
108	Pfõffikon	206	Burgdorf	216	Nidau
109	Uster	207	Courtelary	217	Niedersimmental
110	Winterthur	208	Erlach	218	Oberhasli

Table A.1: Districts of Switzerland.

ID	District	ID	District	ID	District
219	Obersimmental	1305	Waldenburg	2006	Münchwilen
220	Saanen	1401	Oberklettgau	2007	Steckborn
221	Schwarzenburg	1402	Reiat	2008	Weinfelden
222	Seftigen	1403	Schaffhausen	2101	Bellinzona
223	Signau	1404	Schleitheim	2102	Blenio
224	Thun	1405	Stein	2103	Leventina
225	Trachselwald	1406	Unterklettgau	2104	Locarno
226	Wangen	1501	Hinterland	2105	Lugano
301	Entlebuch	1502	Mittelland	2106	Mendrisio
302	Hochdorf	1503	Vorderland	2107	Riviera
303	Luzern	1600	Appenzell Innerrhoden	2108	Vallemaggia
304	Sursee	1721	St. Gallen	2221	Aigle
305	Willisau	1722	Rorschach	2222	Broye-Vully
400	Uri	1723	Rheintal	2223	Gros-de-Vaud
501	Einsiedeln	1724	Werdenberg	2224	Jura-Nord vaudois
502	Gersau	1725	Sarganserland	2225	Lausanne
503	Büren	1726	See-Gaster	2226	Lavaux-Oron
504	Küssnacht (SZ)	1727	Toggenburg	2227	Morges
505	March	1728	Wil	2228	Nyon
506	Schwyz	1821	Albula	2229	Ouest lausannois
600	Obwalden	1822	Bernina	2230	Riviera-Pays-d'Enhaut
700	Nidwalden	1823	Hinterrhein	2301	Brig
800	Glarus	1824	Imboden	2302	Conthey
900	Zug	1825	Inn	2303	Entremont
1001	La Broye	1826	Landquart	2304	Goms
1002	La Glâne	1827	Maloja	2305	Hérens
1003	La Gruyère	1828	Moesa	2306	Leuk
1004	La Sarine	1829	Plessur	2307	Martigny
1005	See	1830	Prättigau/Davos	2308	Monthey
1006	Sense	1831	Surselva	2309	Raron
1007	La Veveyse	1901	Aarau	2310	Saint-Maurice
1101	Gäu	1902	Baden	2311	Sierre
1102	Thal	1903	Bremgarten	2312	Sion
1103	Bucheggberg	1904	Brugg	2313	Visp
1104	Dorneck	1905	Kulm	2401	Boudry
1105	Gösgen	1906	Laufenburg	2402	La Chaux-de-Fonds
1106	Wasseramt	1907	Lenzburg	2403	Le Locle
1107	Lebern	1908	Muri	2404	Neuchâtel
1108	Olten	1909	Rheinfelden	2405	Val-de-Ruz
1109	Solothurn	1910	Zofingen	2406	Val-de-Travers
1110	Thierstein	1911	Zurzach	2500	Genève
1200	Basel-Stadt	2001	Arbon	2601	DelÚmont
1301	Arlesheim	2002	Bischofszell	2602	Les Franches-Montagnes
1302	Laufen	2003	Diessenhofen	2603	Porrentruy
1303	Liestal	2004	Frauenfeld		
1304	Sissach	2005	Kreuzlingen		

Table A.2: Districts of Switzerland (cont).

Appendix B

All critical regions

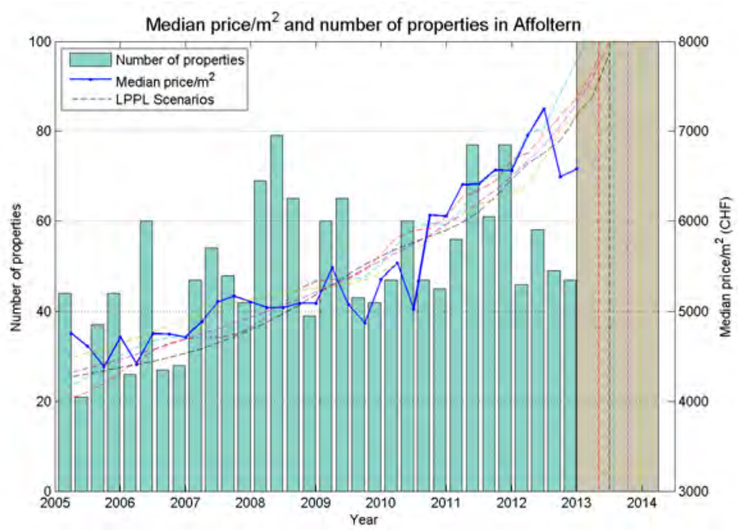


Figure B.1: Affoltern, medium size apartments. Rejected because of *noise or choppiness*.

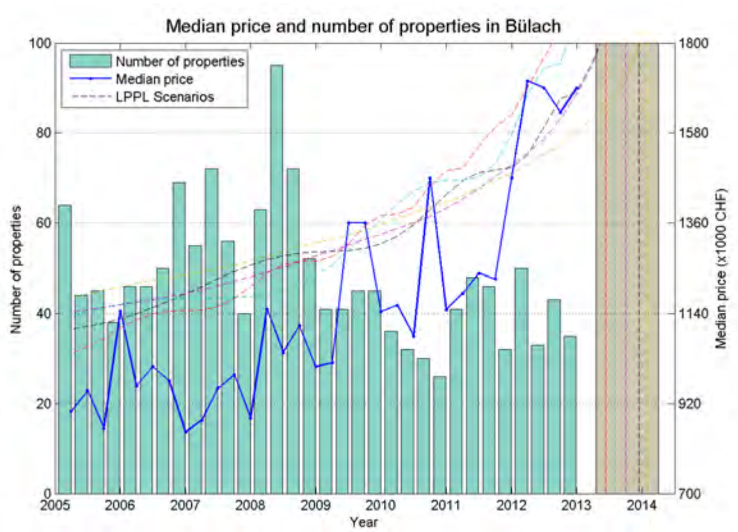


Figure B.2: Bülach, all houses. Rejected because of *noise or choppiness*.

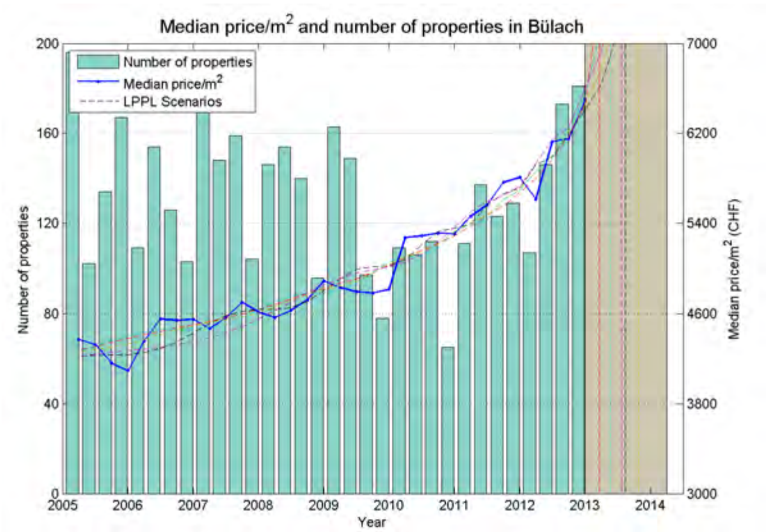


Figure B.3: Bülach, medium size apartments. Accepted.

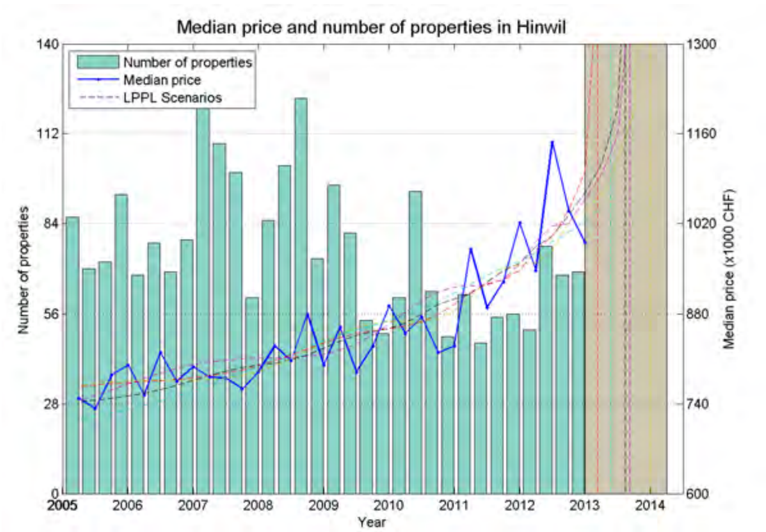


Figure B.4: Hinwil, medium size houses. Accepted.

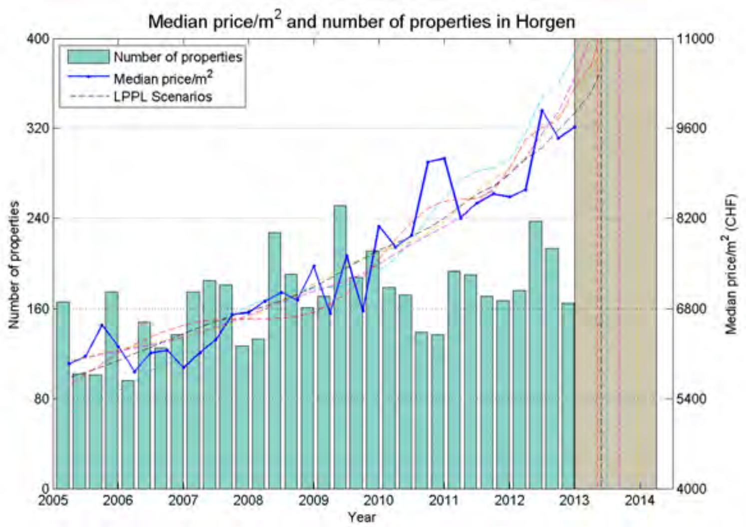


Figure B.5: Horgen, all apartments. Accepted

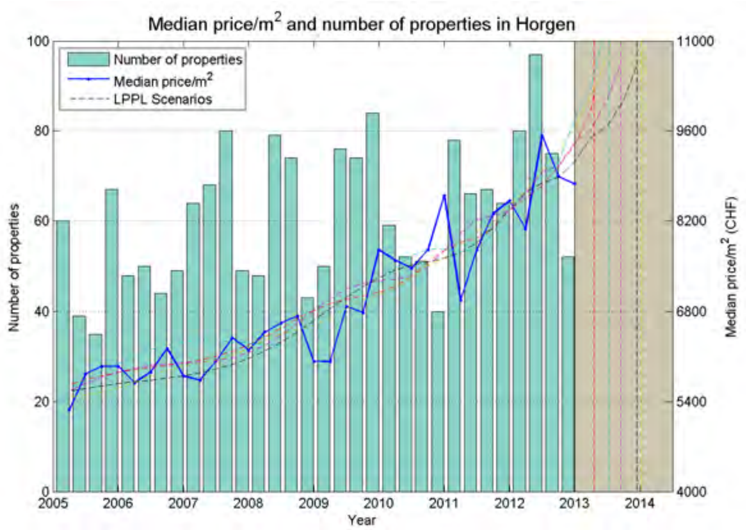


Figure B.6: Horgen, small apartments. Rejected because of *parent category already included.*

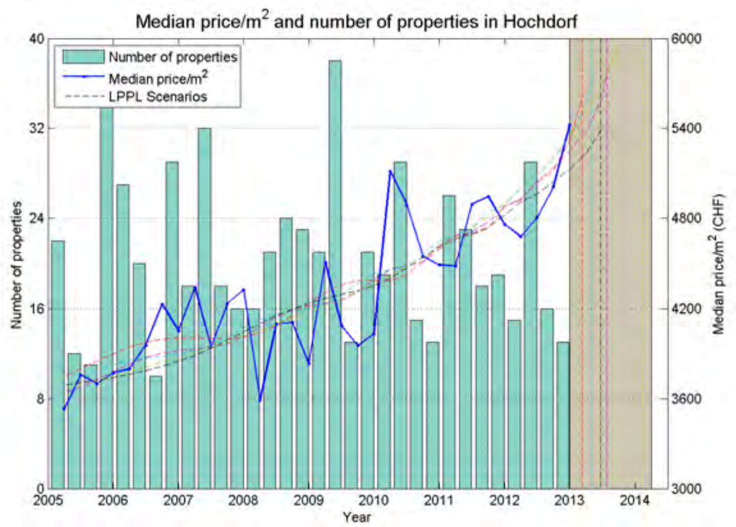


Figure B.7: Hochdorf, small apartments. Rejected because of *noise or choppiness*.

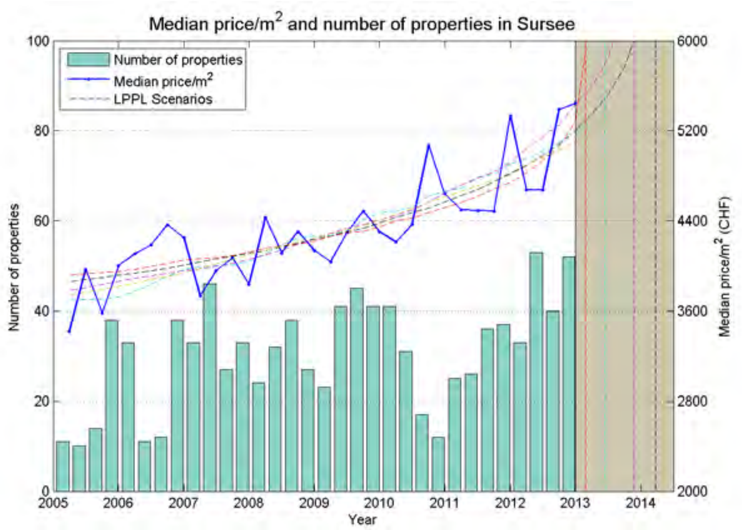


Figure B.8: Sursee, small apartments. Rejected because of *lack of data*.

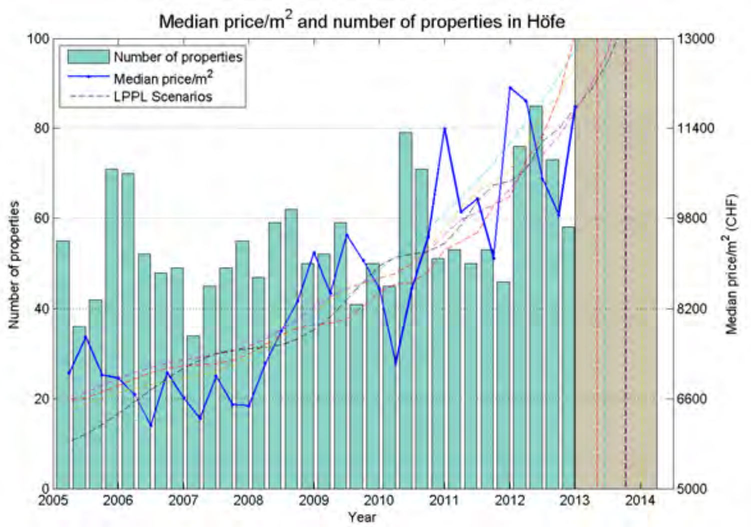


Figure B.9: Höfe, medium size apartments. Accepted.

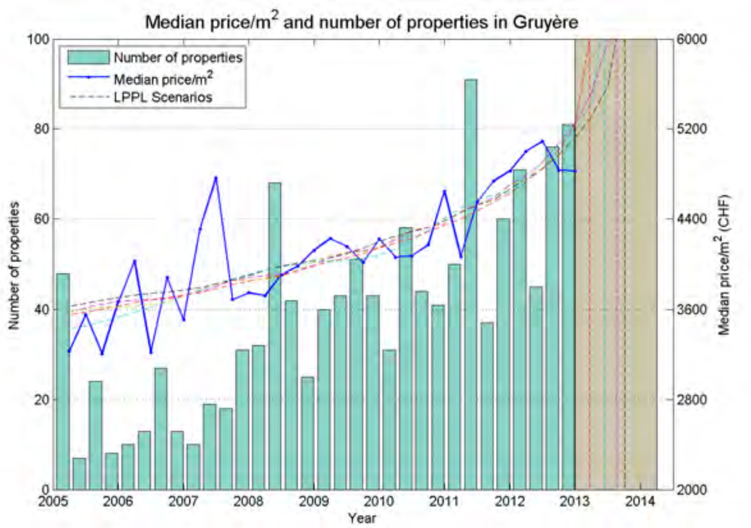


Figure B.10: Gruyère, small apartments. Rejected because of *lack of data*.

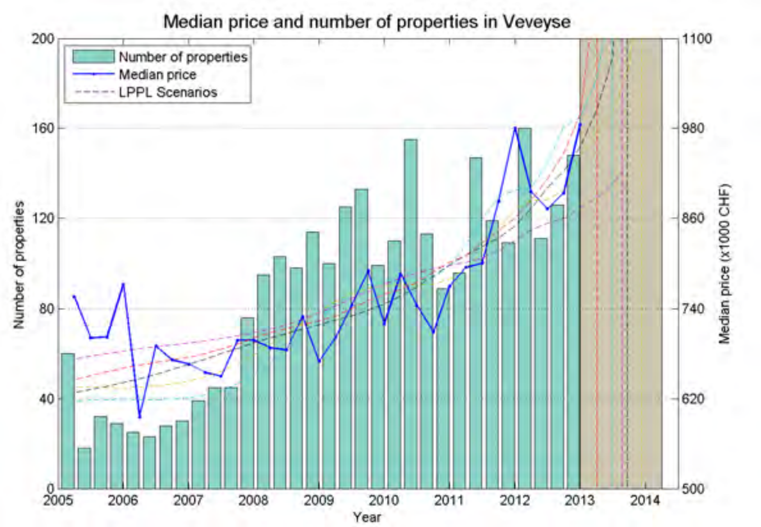


Figure B.11: Veveyse, all houses. Rejected because of *invalid aggregation*.

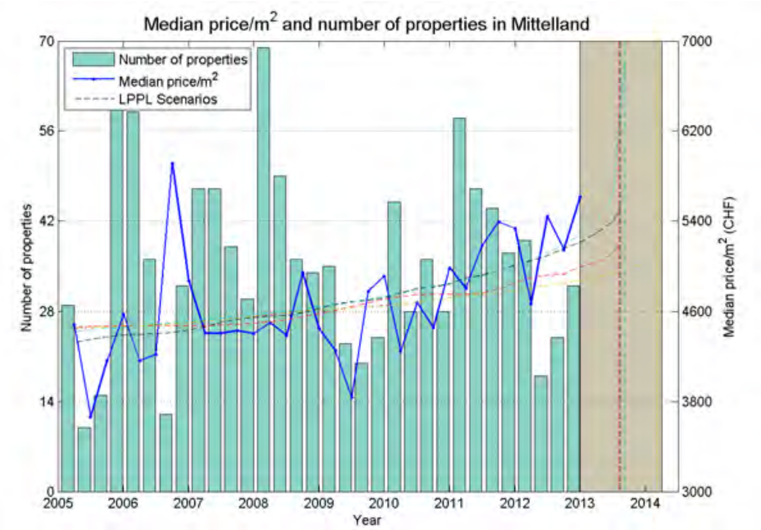


Figure B.12: Mittelland, all apartments. Rejected because of *lack of data*.

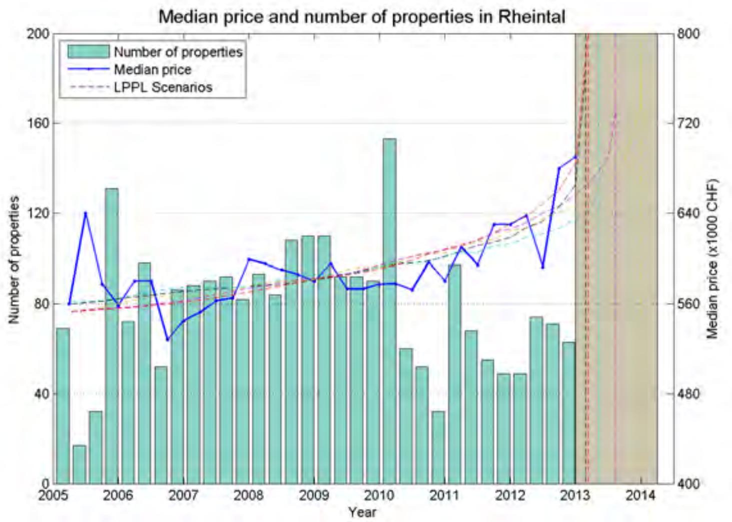


Figure B.13: Rheintal, medium size houses. Rejected because of *lack of data*.

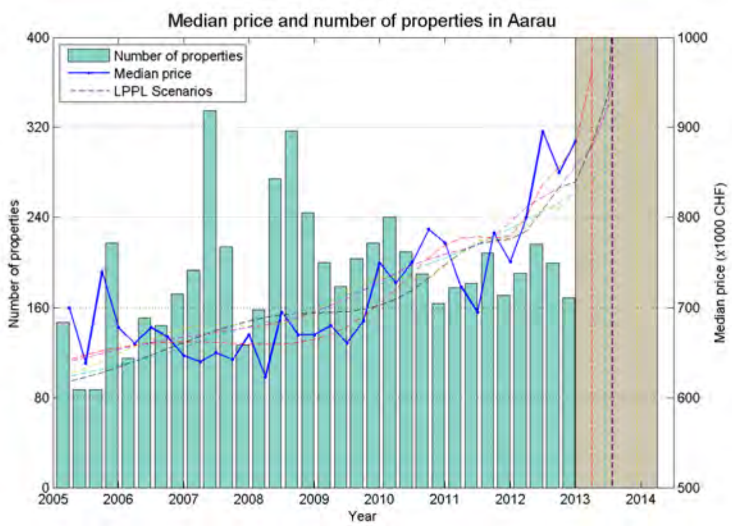


Figure B.14: Aarau, all houses. Rejected because of *invalid aggregation*.

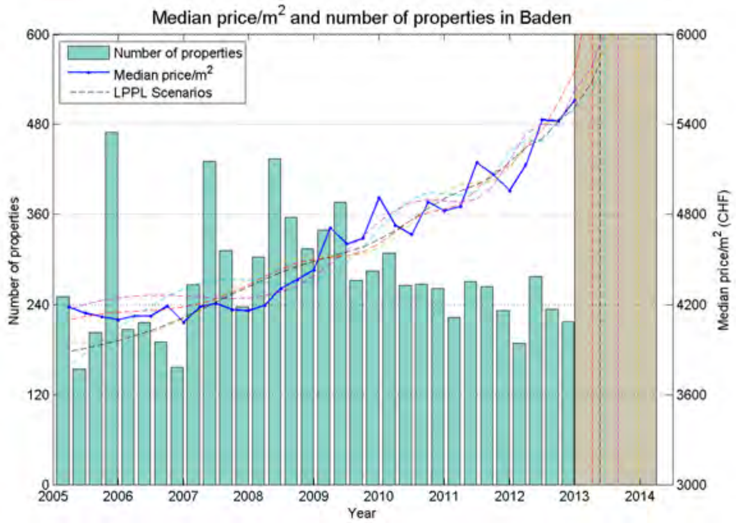


Figure B.15: Baden, all apartments. Accepted.

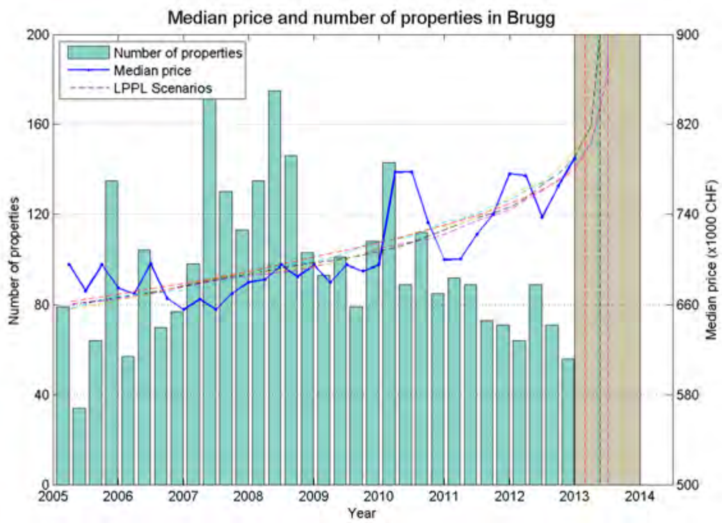


Figure B.16: Brugg, medium size houses. Rejected because of *noise or choppiness*.

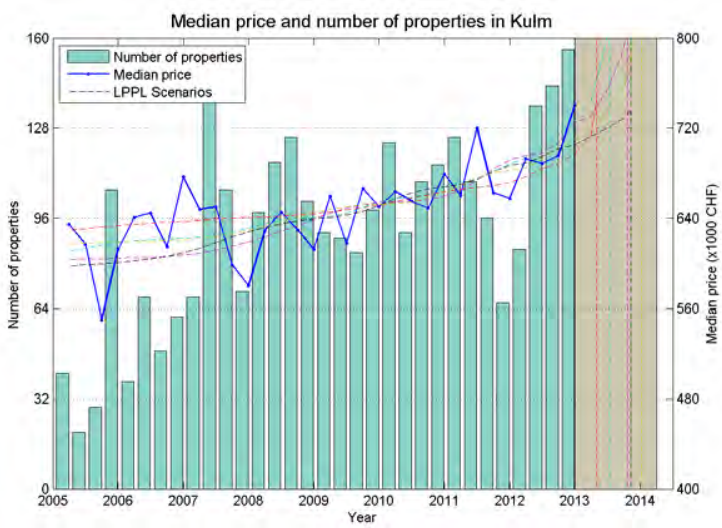


Figure B.17: Kulm, medium size houses. Rejected because of *noise or choppiness*.

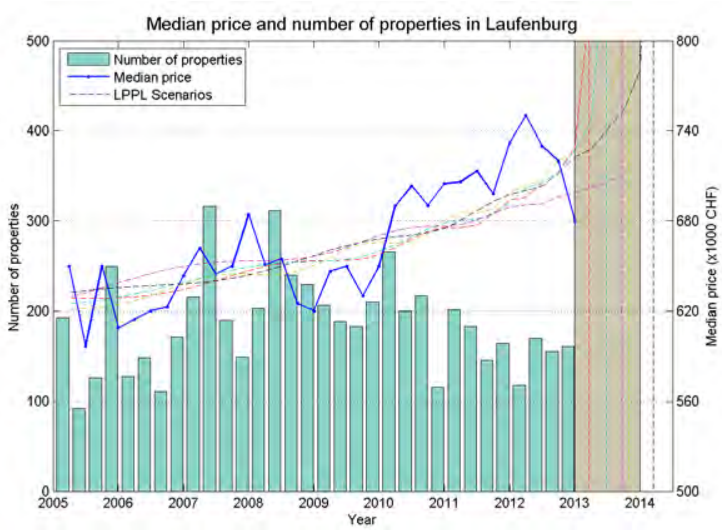


Figure B.18: Laufenburg, all houses. Rejected because of *invalid aggregation*.

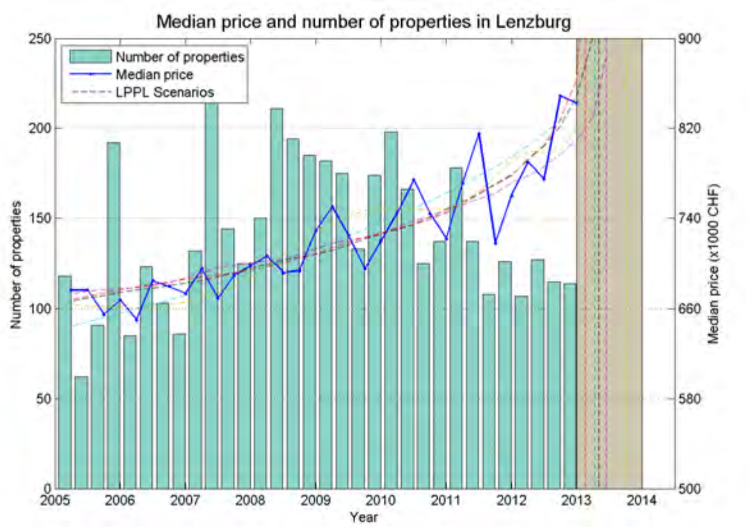


Figure B.19: Lenzburg, medium size houses. Accepted.

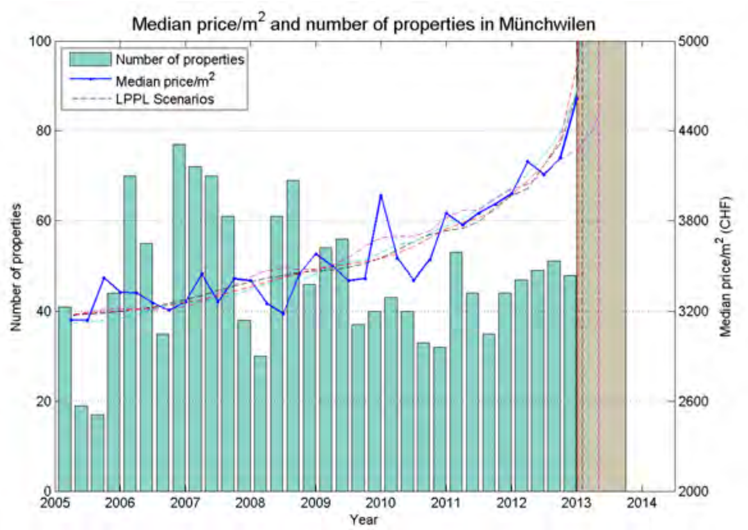


Figure B.20: Münchwilen, medium size apartments. Accepted.

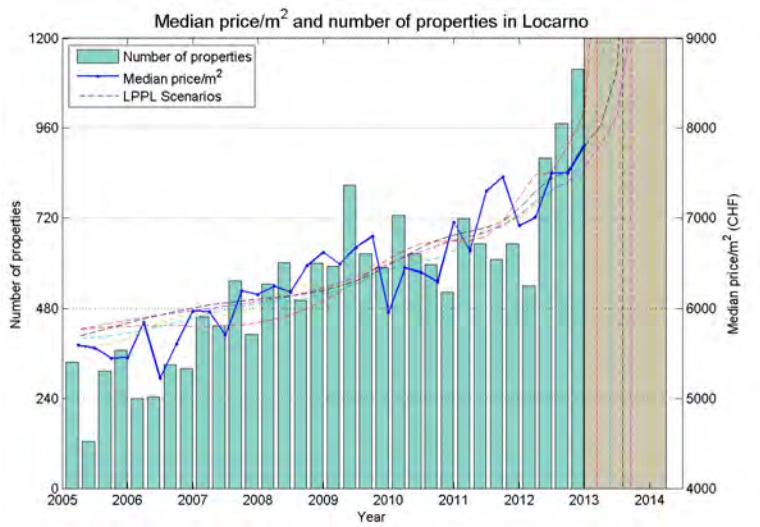


Figure B.21: Locarno, all apartments. Accepted.

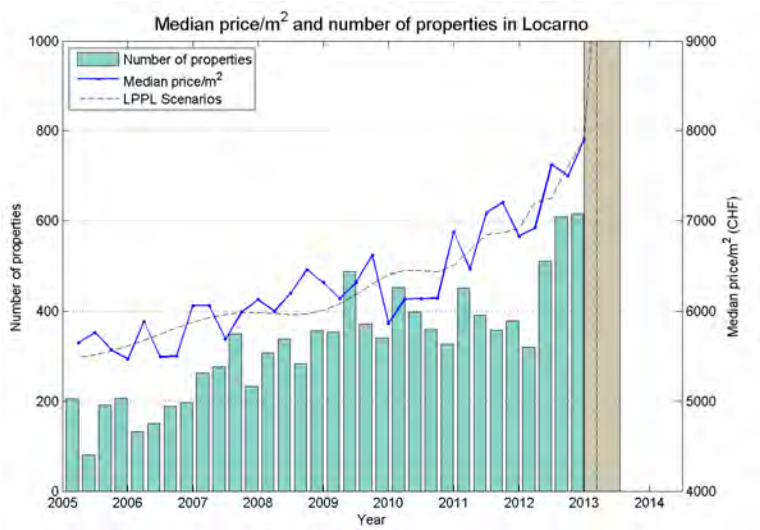


Figure B.22: Locarno, small apartments. Rejected because of *parent category already included*.

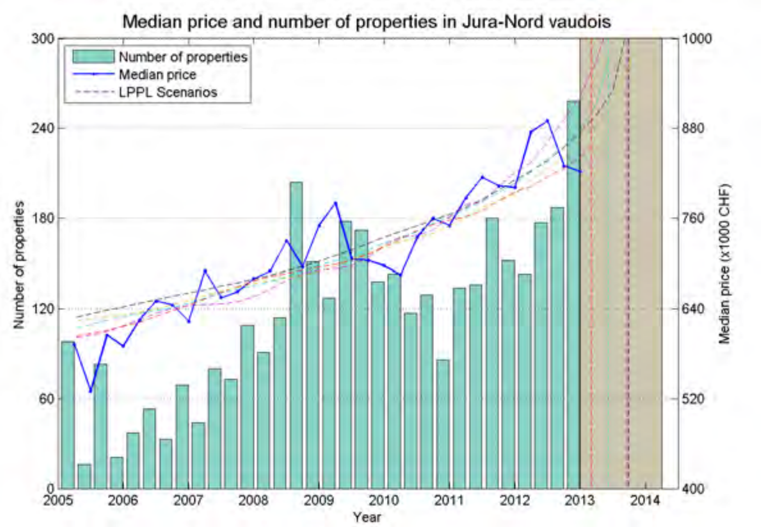


Figure B.23: Jura-Nord vaudois, medium size houses. Accepted.

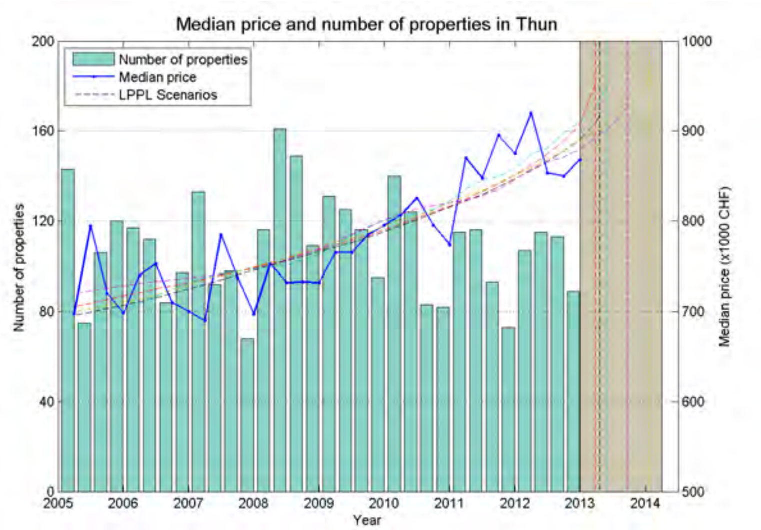


Figure B.24: Thun, all houses. Rejected because of *invalid aggregation*.

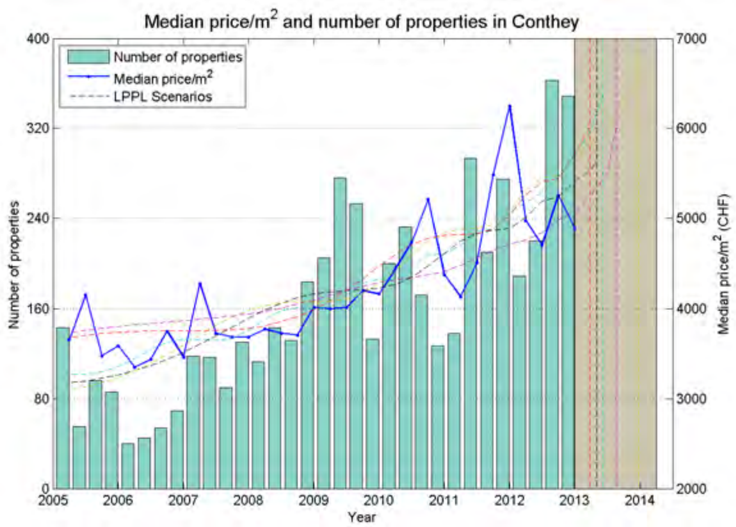


Figure B.25: Conthey, all apartments. Rejected because of *noise or choppiness.*

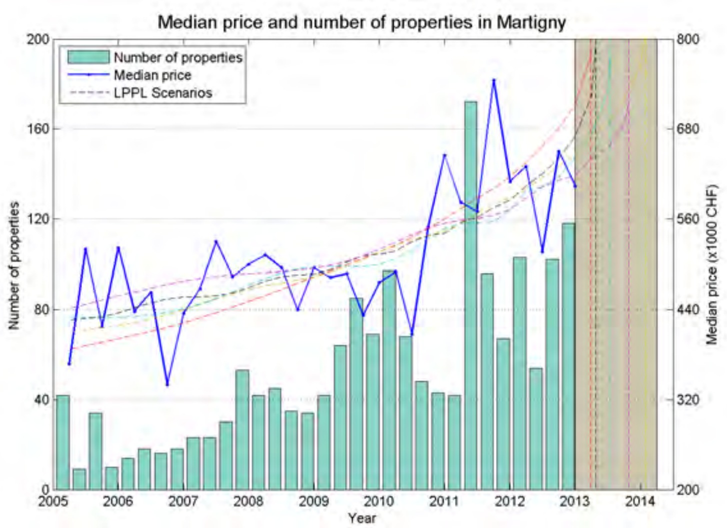


Figure B.26: Martigny, small houses. Rejected because of *lack of data.*

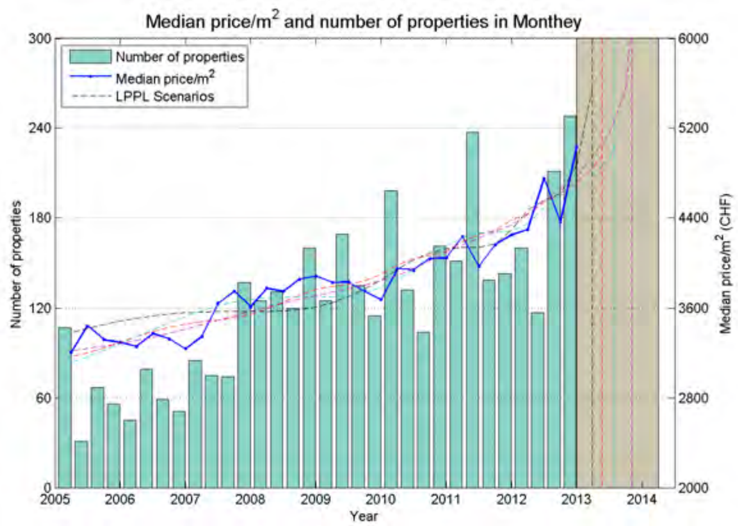


Figure B.27: Monthey, medium size apartments. Accepted.

Appendix C

All to watch regions

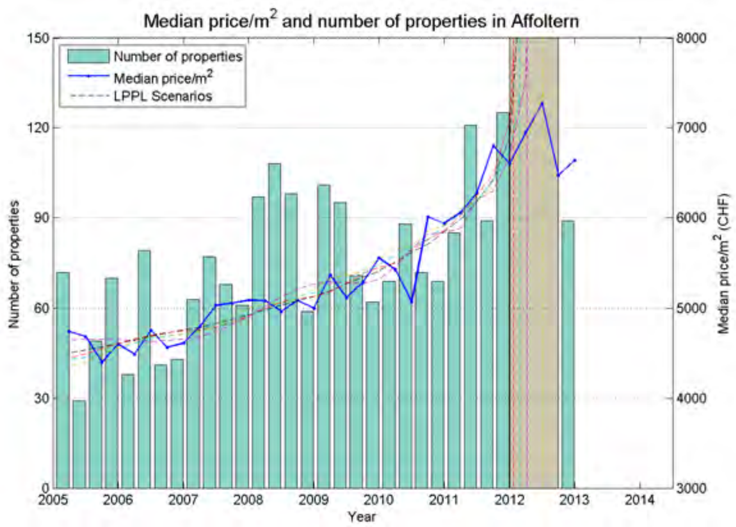


Figure C.1: Affoltern, all apartments. Accepted.

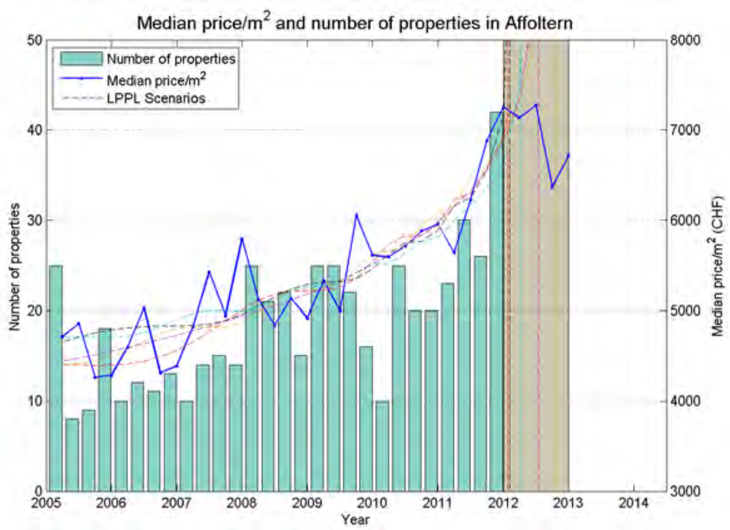


Figure C.2: Affoltern, small apartments. Rejected because of *parent category already included.*

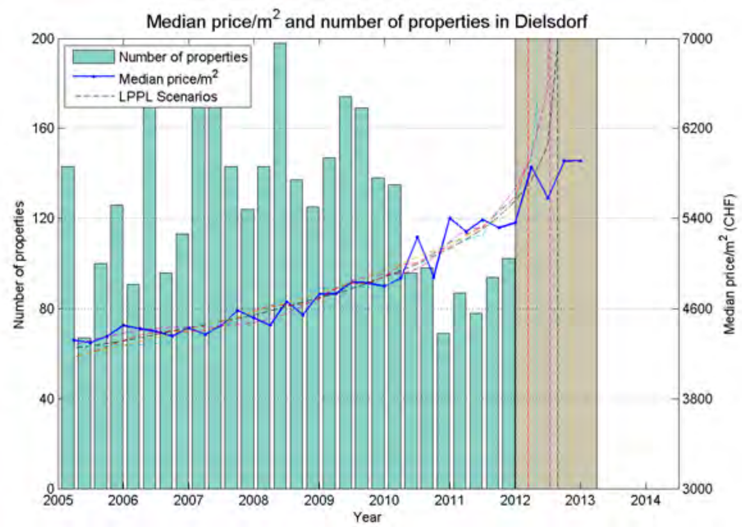


Figure C.3: Dielsdorf, all apartments. Accepted.

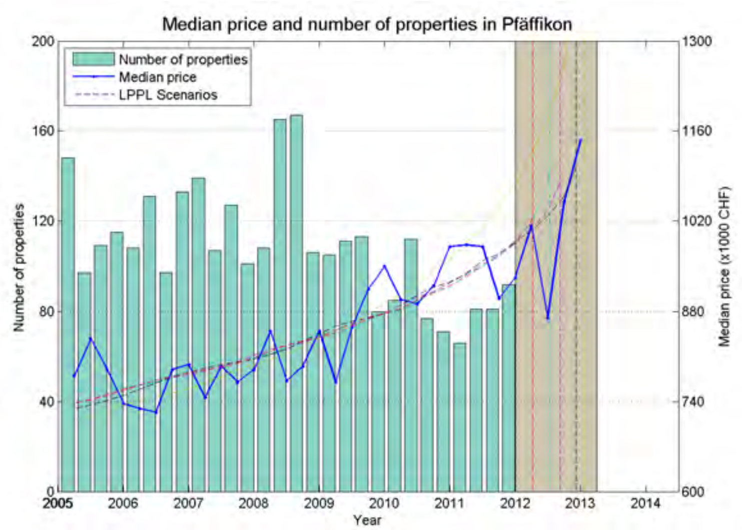


Figure C.4: Pfäffikon, all houses. Rejected because of *invalid aggregation*.

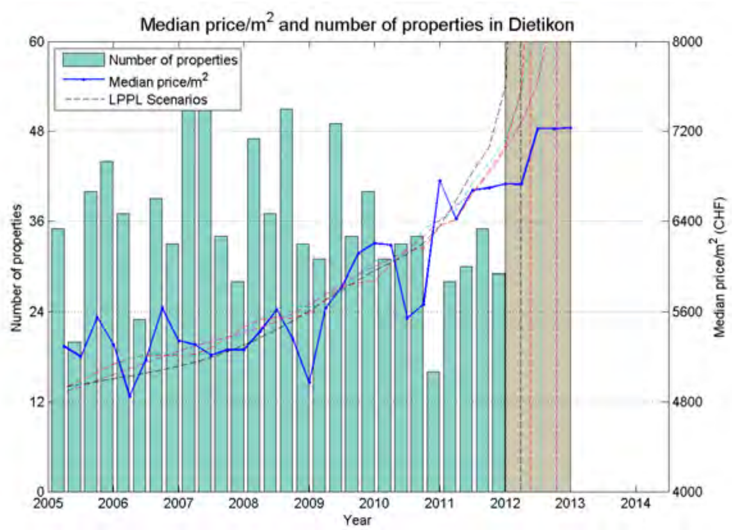


Figure C.5: Dietikon, small apartments. Accepted.

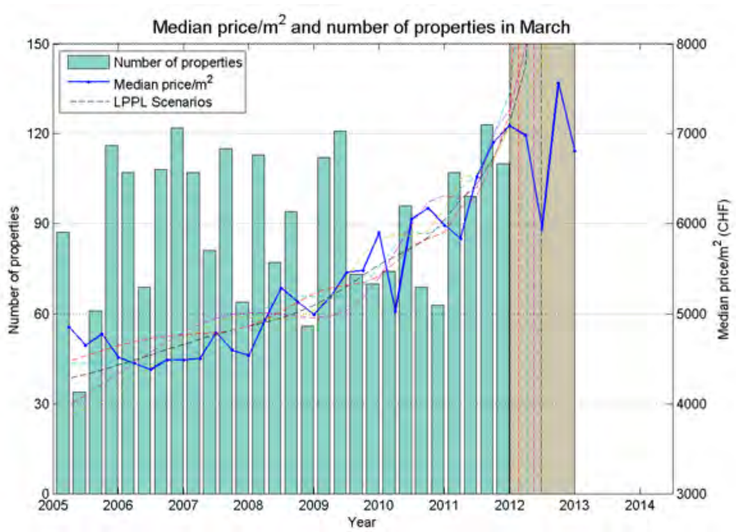


Figure C.6: March, all apartments. Accepted.

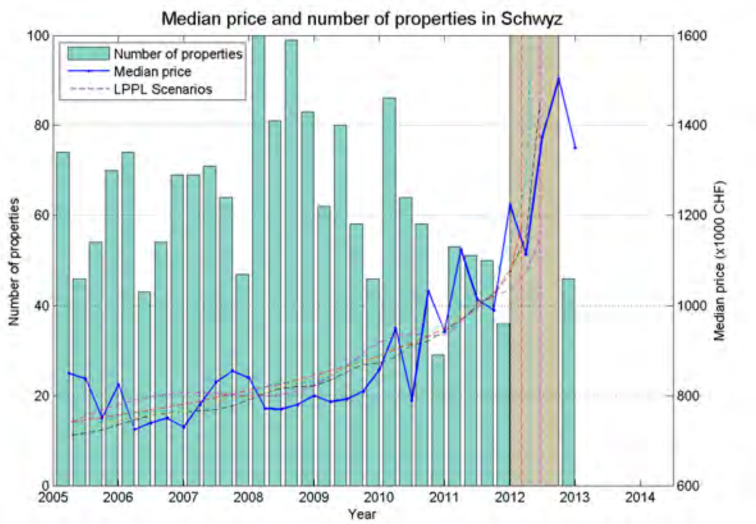


Figure C.7: Schwyz, all houses. Rejected because of *invalid aggregation*.

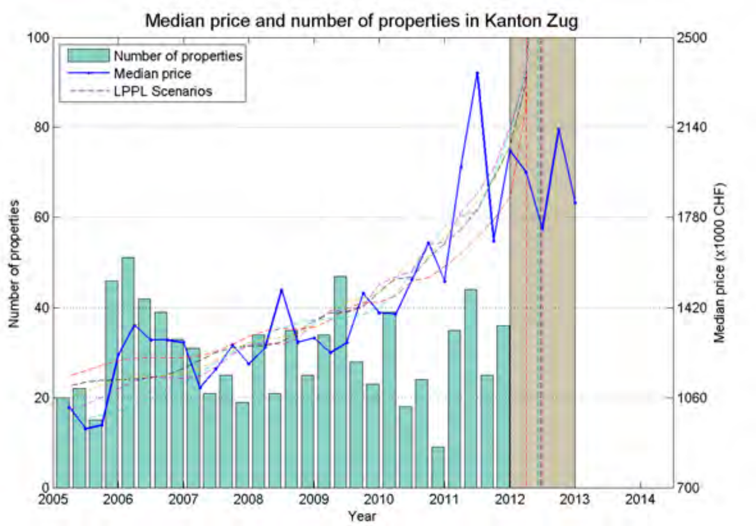


Figure C.8: Kanton Zug, medium size houses. Rejected because of *lack of data*.

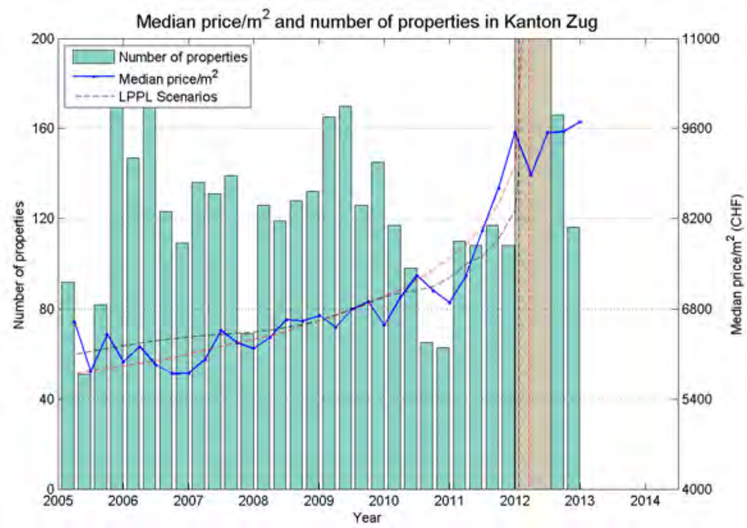


Figure C.9: Kanton Zug, all apartments. Accepted.

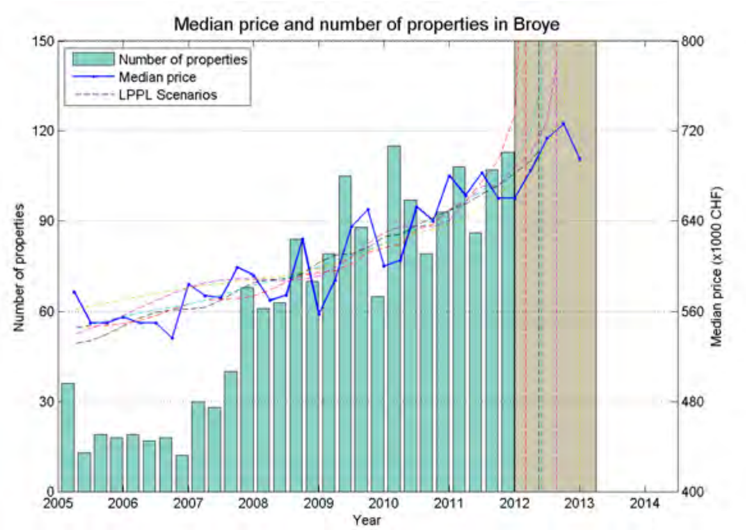


Figure C.10: Broye, medium size houses. Rejected because of *lack of data*.

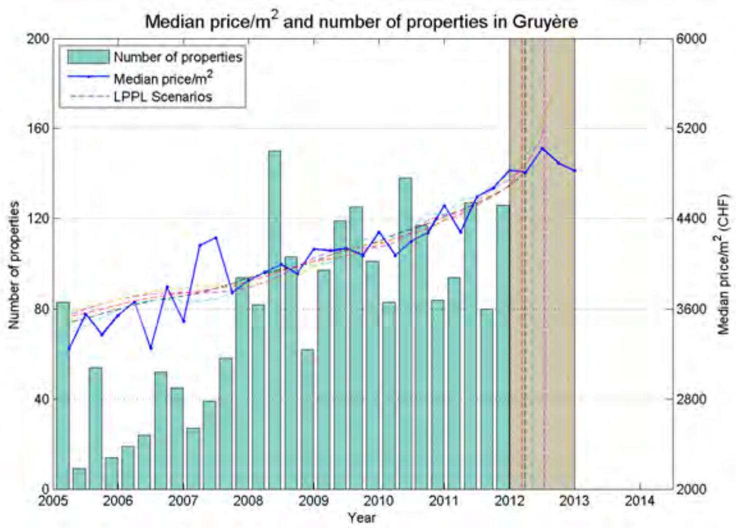


Figure C.11: Gruyère, all apartments. Rejected because of *lack of data*.

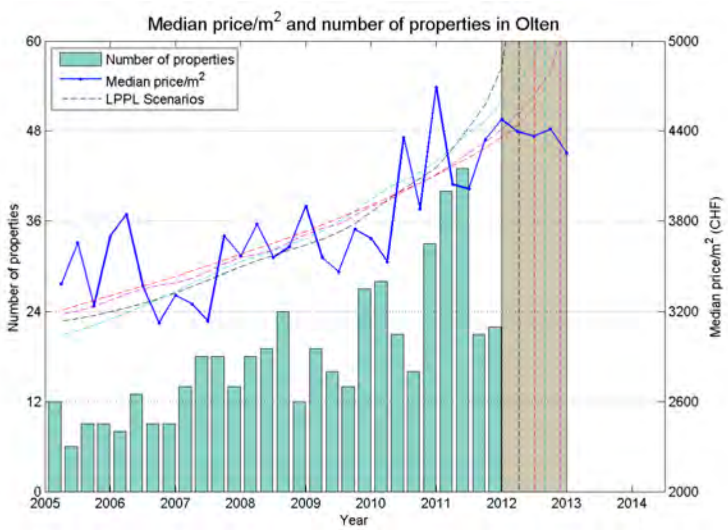


Figure C.12: Olten, small apartments. Rejected because of *lack of data*.

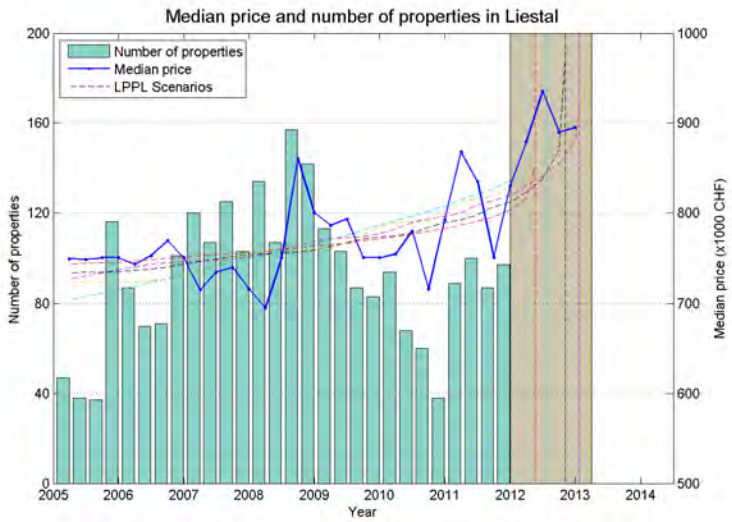


Figure C.13: Liestal, medium size houses. Rejected because of *noise or choppiness*.

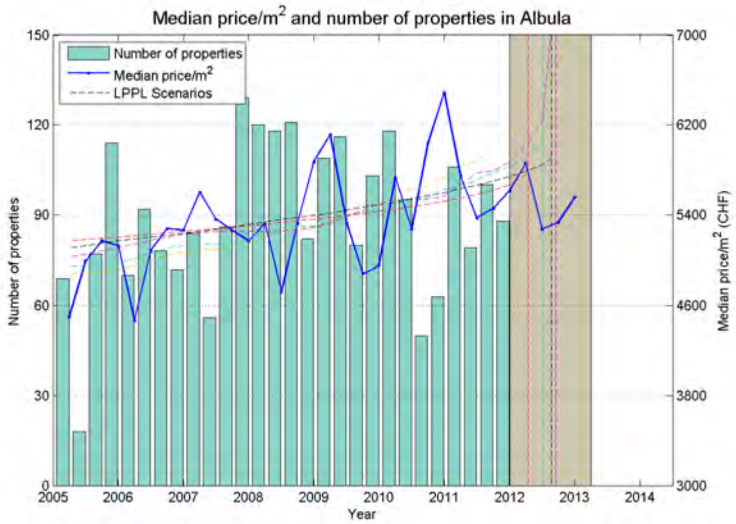


Figure C.14: Albula, small apartments. Rejected because of *noise or choppiness*.

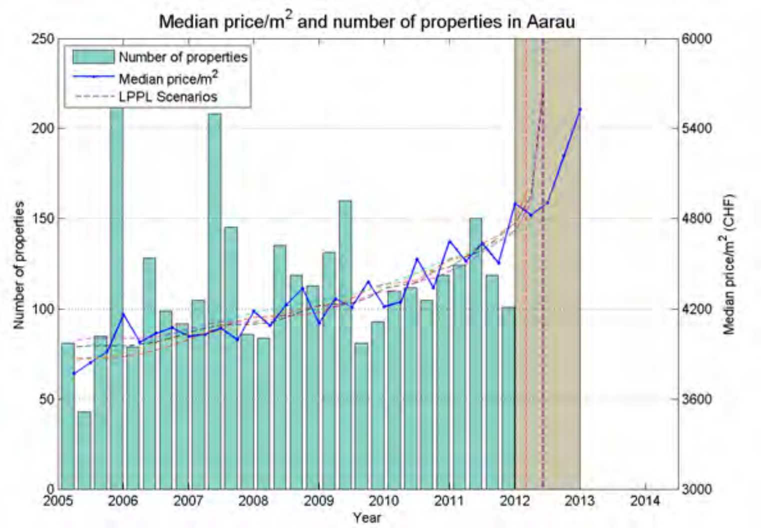


Figure C.15: Aarau, all apartments. Rejected because of *lack of evidence*.

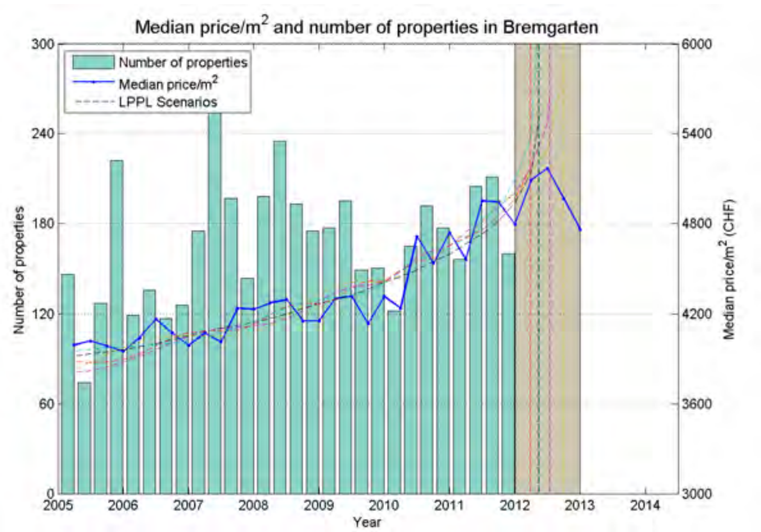


Figure C.16: Bremgarten, all apartments. Accepted.

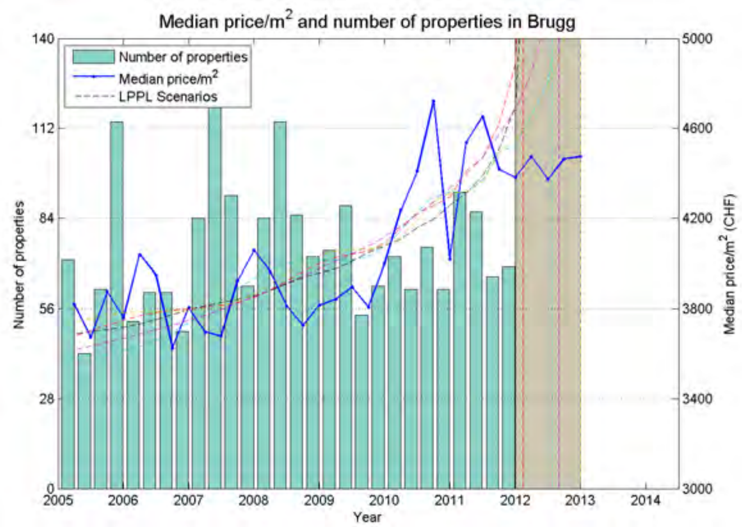


Figure C.17: Brugg, all apartments. Rejected because of *noise or choppiness*.

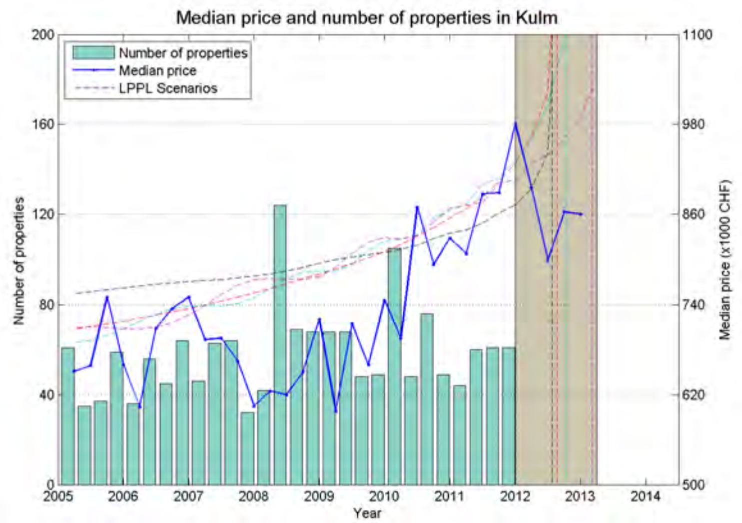


Figure C.18: Kulm, large houses. Rejected because of *noise or choppiness*.

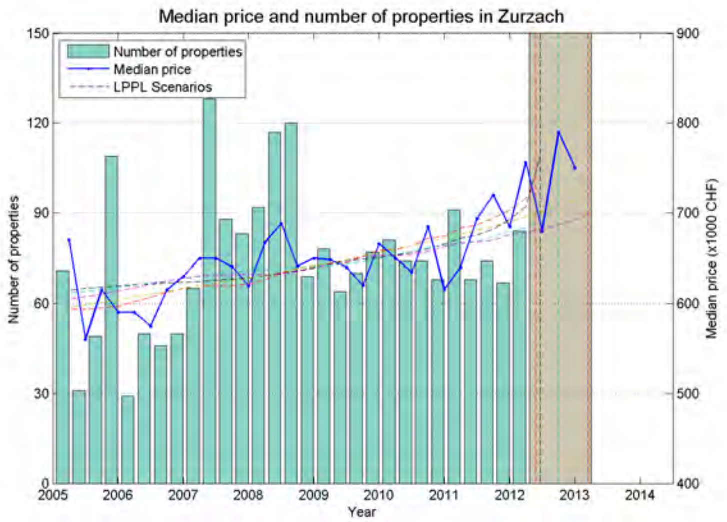


Figure C.19: Zurzach, medium size houses. Rejected because of *noise or choppiness.*

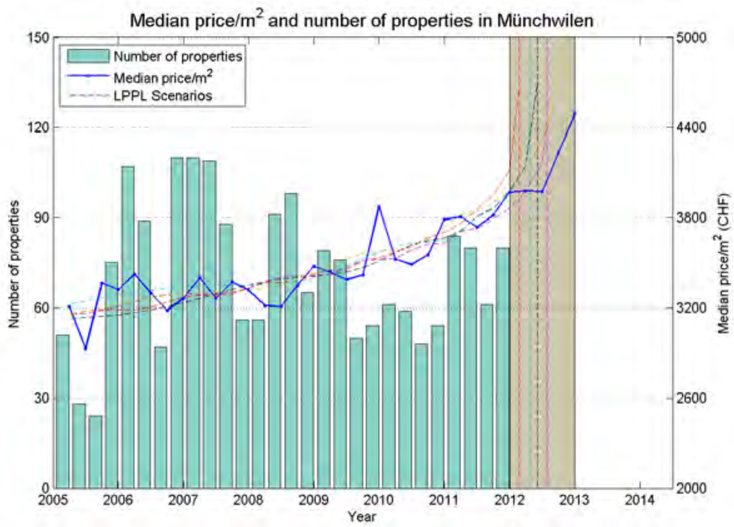


Figure C.20: Münchwilen, all apartments. Rejected because of *lack of evidence.*

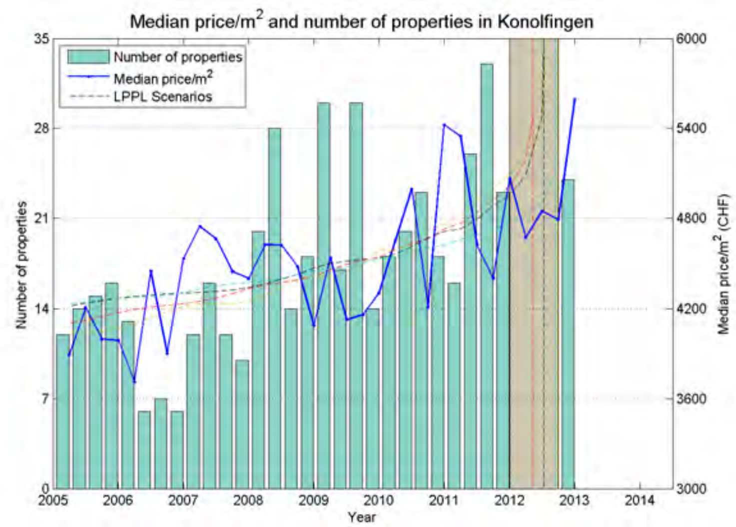


Figure C.21: Konolfingen, small apartments. Rejected because of *lack of data*.

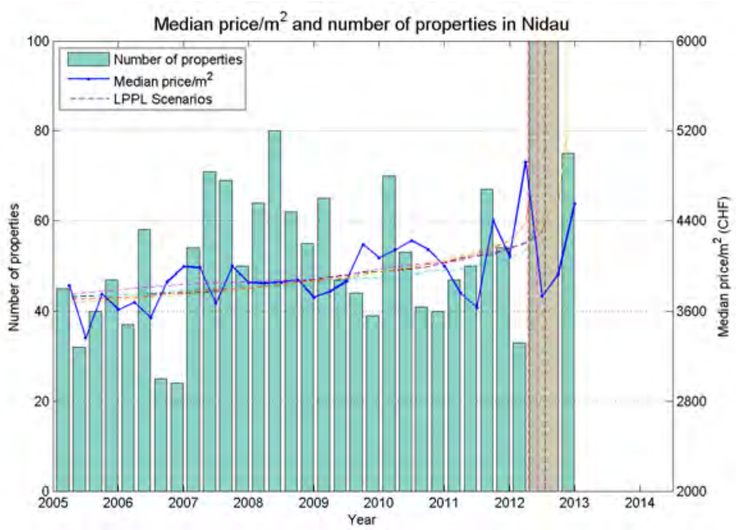


Figure C.22: Nidau, all apartments. Rejected because of *noise or choppiness*.

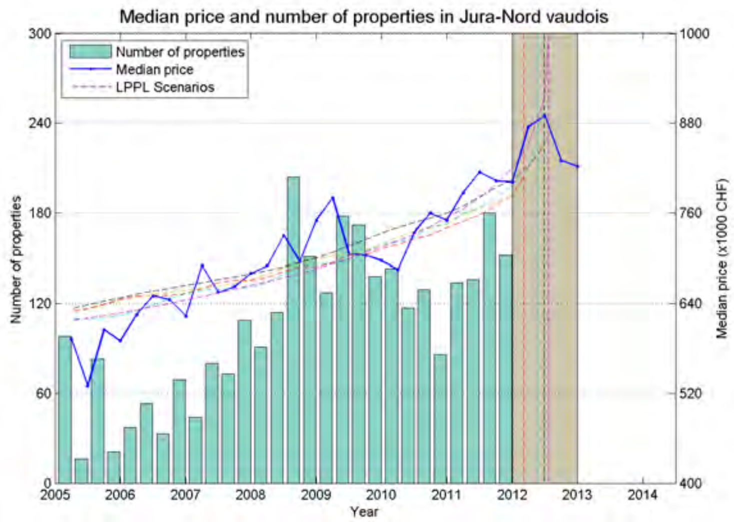


Figure C.23: Jura-Nord vaudois, medium size apartments. Rejected because of *lack of data*.

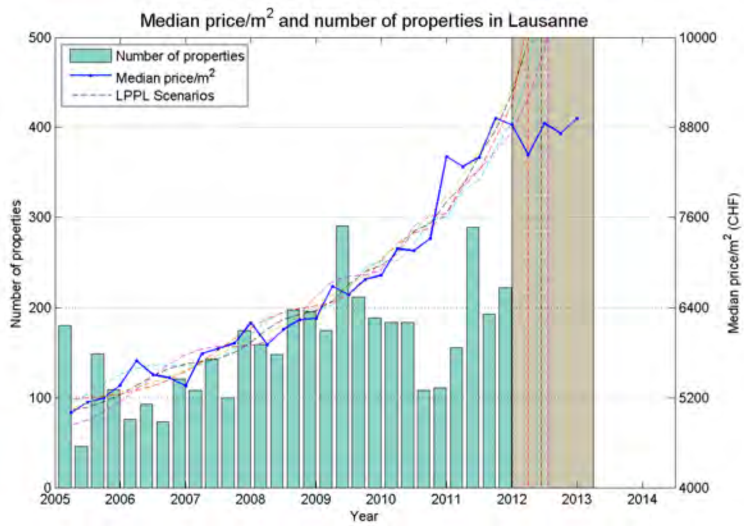


Figure C.24: Lausanne, all apartments. Accepted.

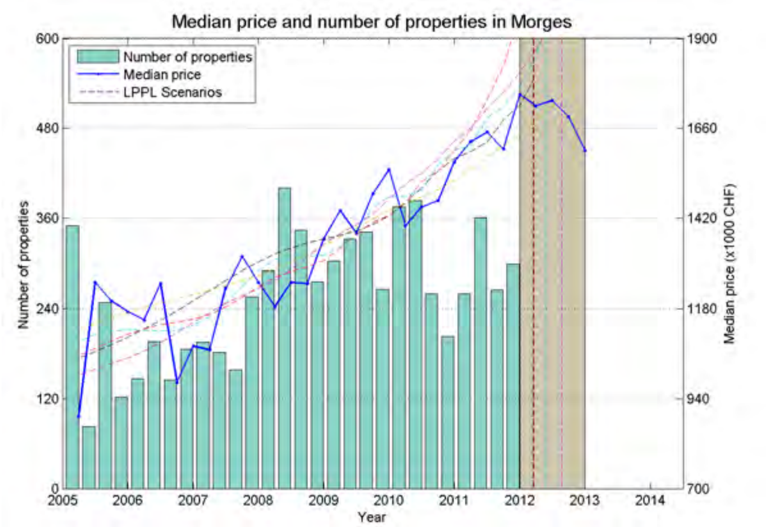


Figure C.25: Morges, all houses. Rejected because of *invalid aggregation*.

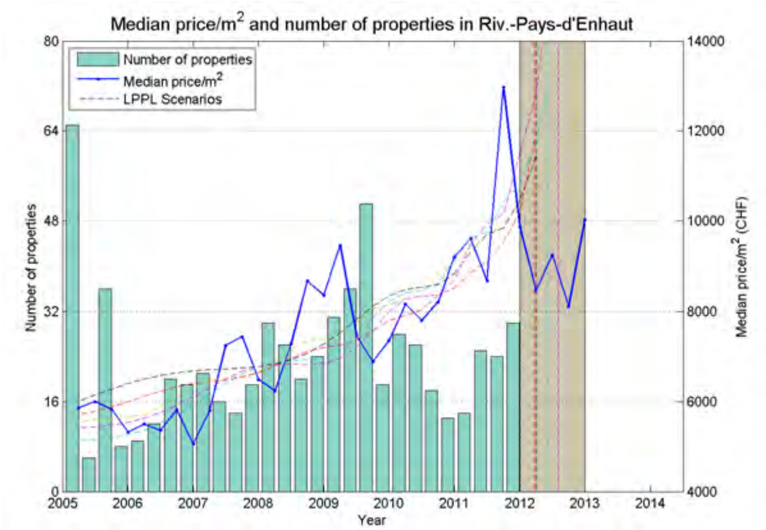


Figure C.26: Riv.-Pays-d'Enhaut, all apartments. Rejected because of *lack of data*.

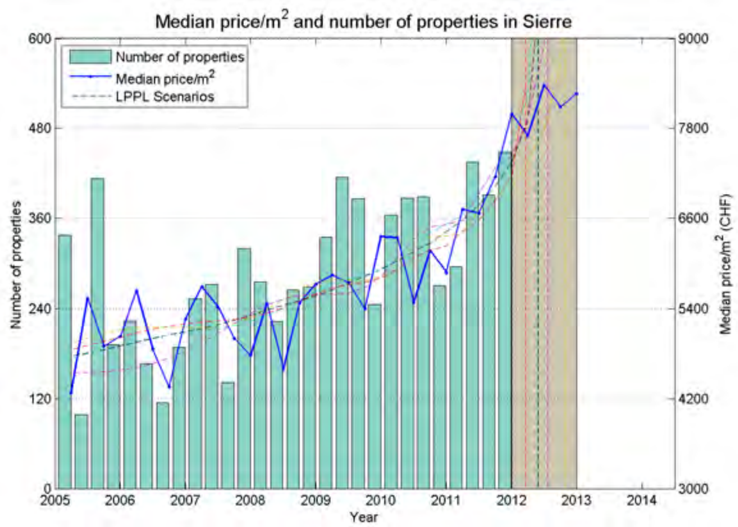


Figure C.27: Sierre, all apartments. Rejected because of *noise of choppiness*.

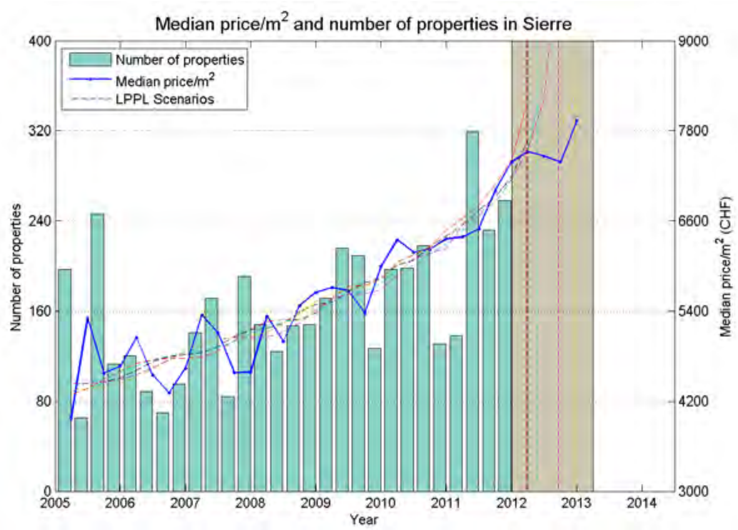


Figure C.28: Sierre, small apartments. Rejected because of *lack of evidence*.

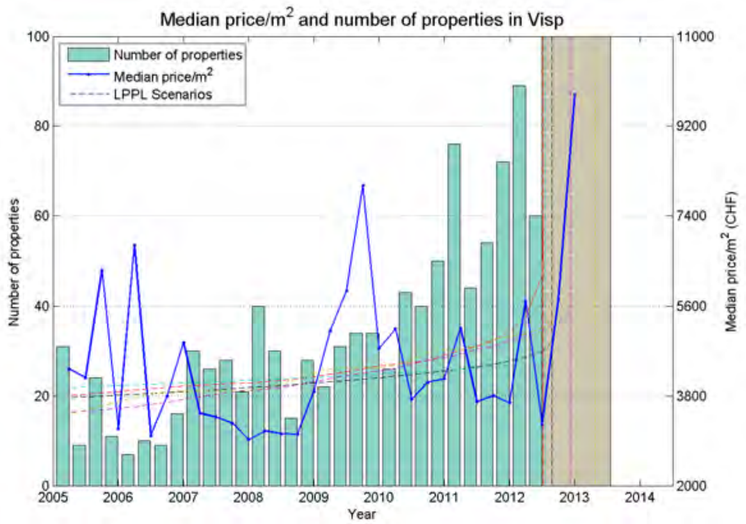
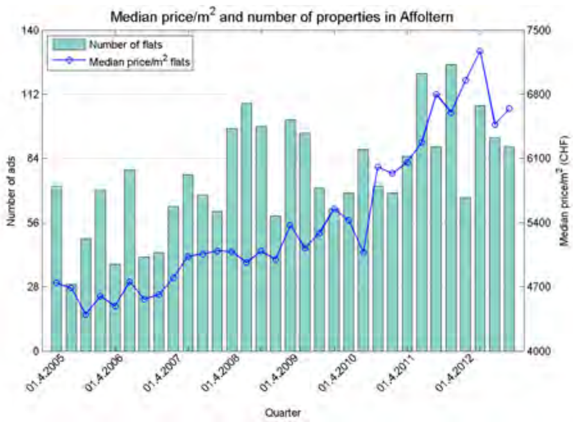


Figure C.29: Visp, medium size apartments. Rejected because of *lack of data*.

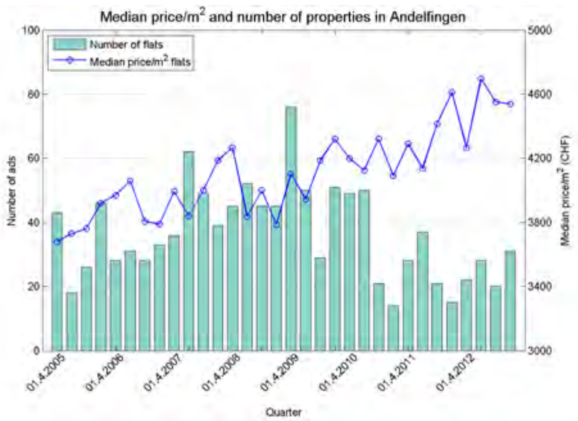
Appendix D

Development of prices by district

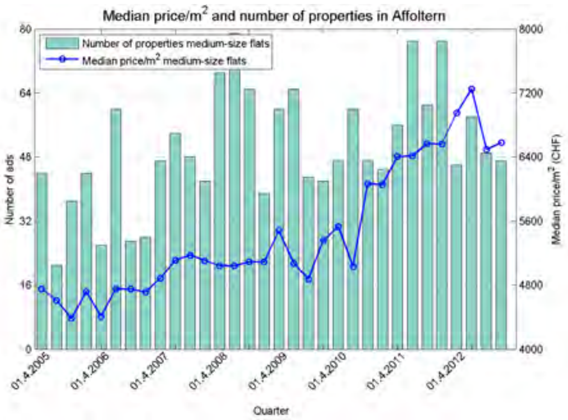
This appendix presents the price development of apartments, medium size apartments and medium size houses of each of the 166 districts of Switzerland for the period 2005-2012.



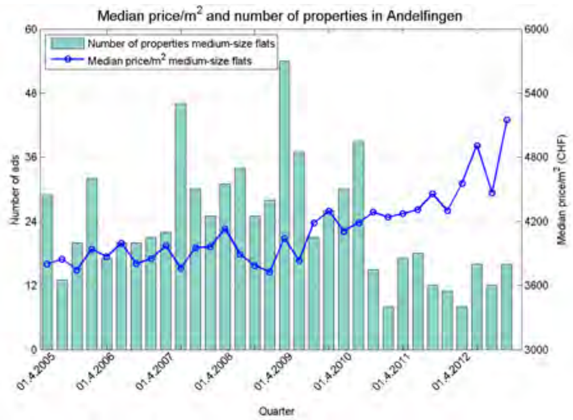
(a) All apartments.



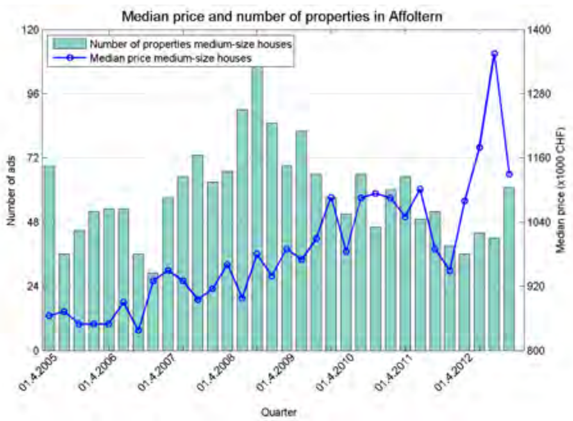
(a) All apartments.



(b) Medium size apartments.



(b) Medium size apartments.

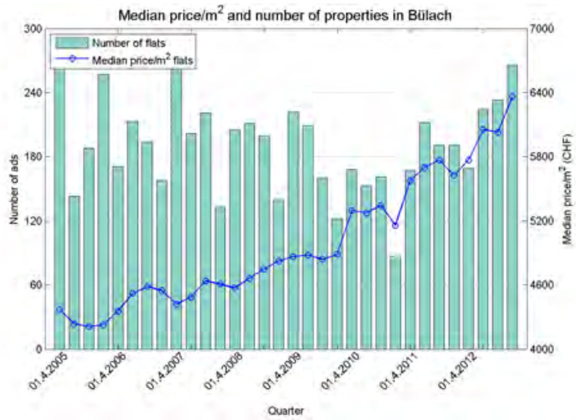


(c) Medium size houses.

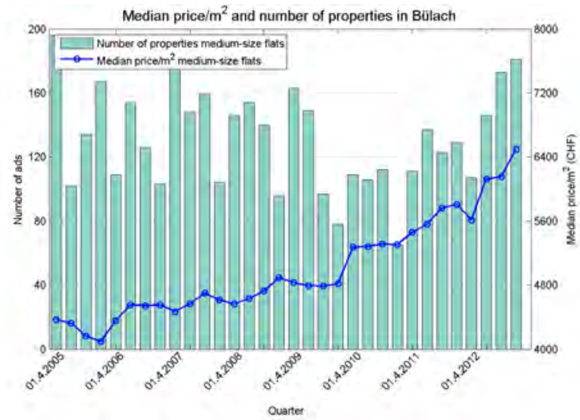
(c) Medium size houses.

Figure D.1: Development of prices in Affoltern.

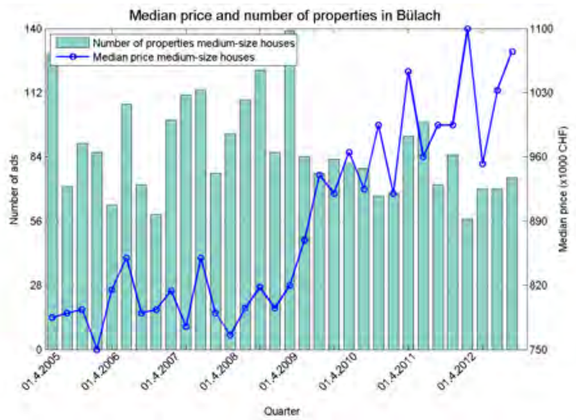
Figure D.2: Development of prices in Andelfingen.



(a) All apartments.

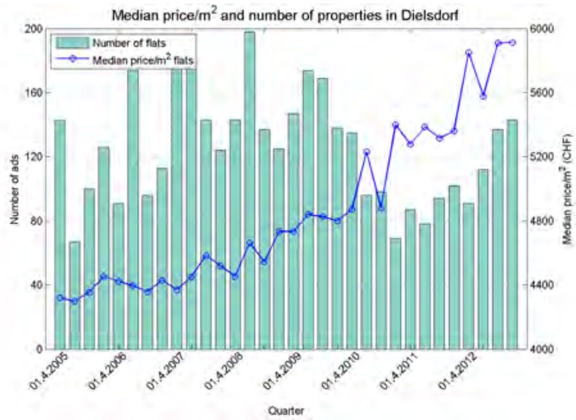


(b) Medium size apartments.

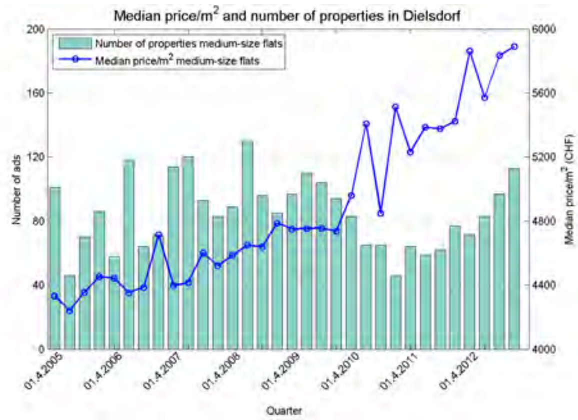


(c) Medium size houses.

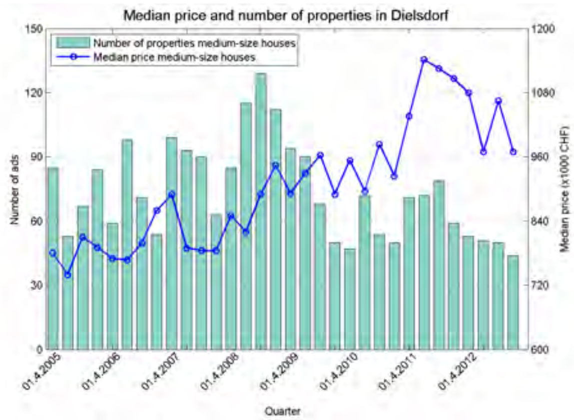
Figure D.3: Development of prices in Bülach.



(a) All apartments.

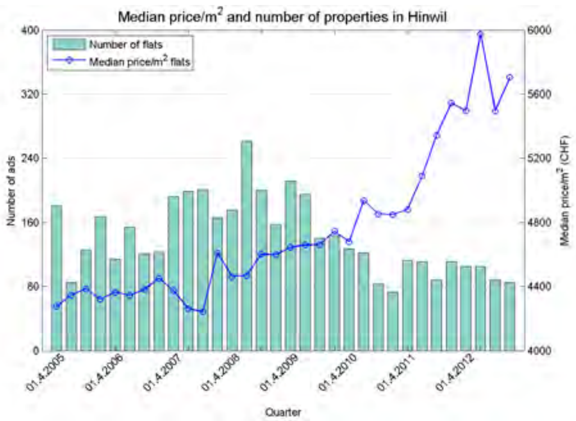


(b) Medium size apartments.

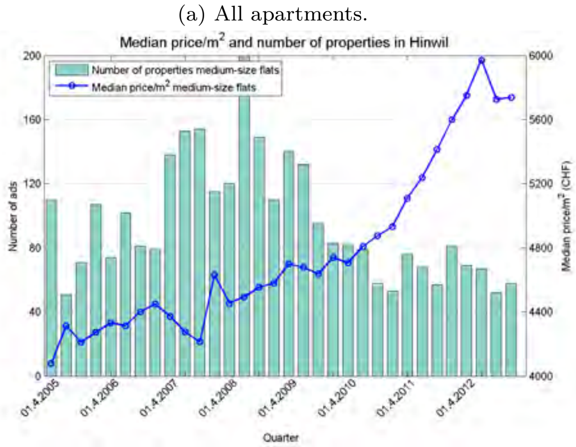


(c) Medium size houses.

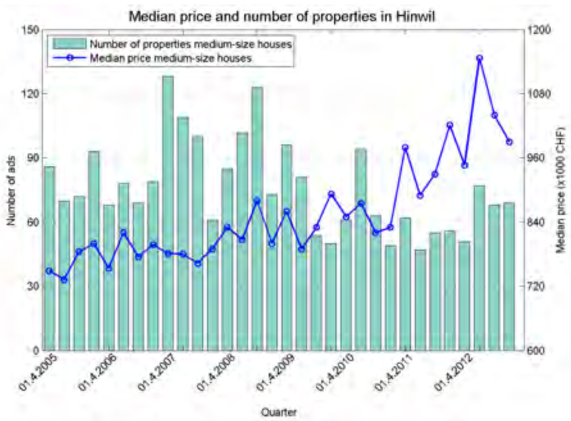
Figure D.4: Development of prices in Dielsdorf.



(a) All apartments.

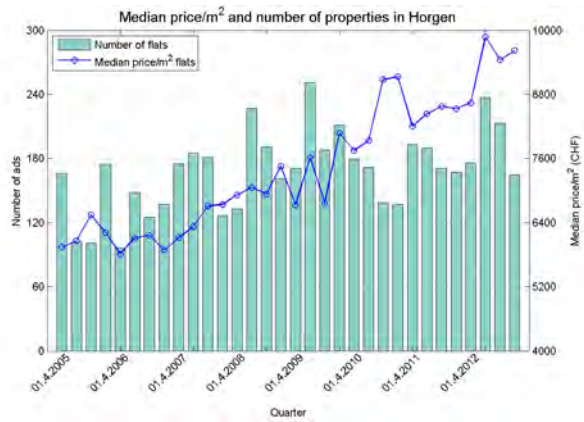


(b) Medium size apartments.

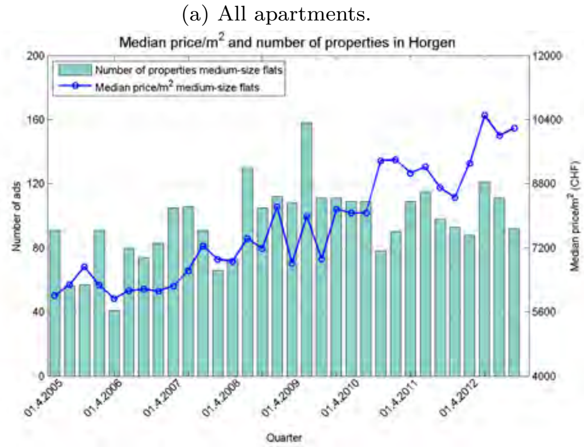


(c) Medium size houses.

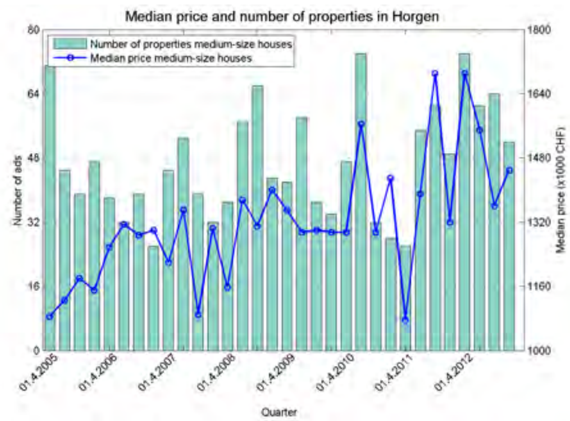
Figure D.5: Development of prices in Hinwil.



(a) All apartments.

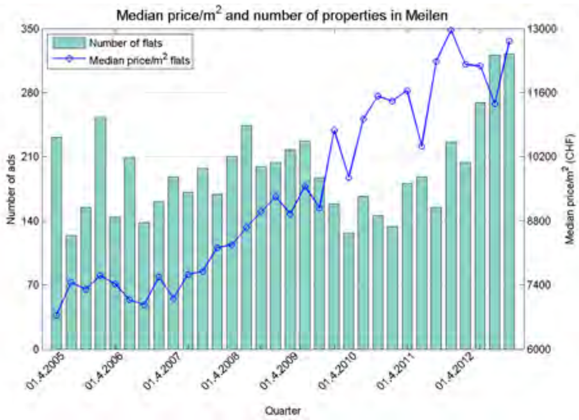


(b) Medium size apartments.

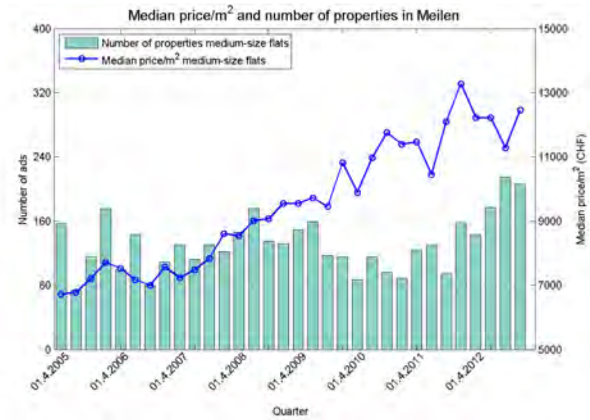


(c) Medium size houses.

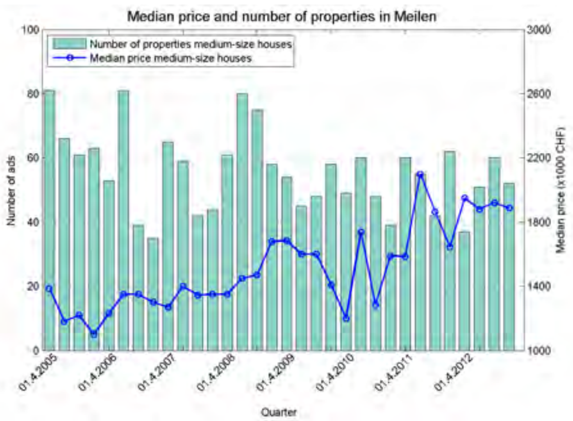
Figure D.6: Development of prices in Horgen.



(a) All apartments.

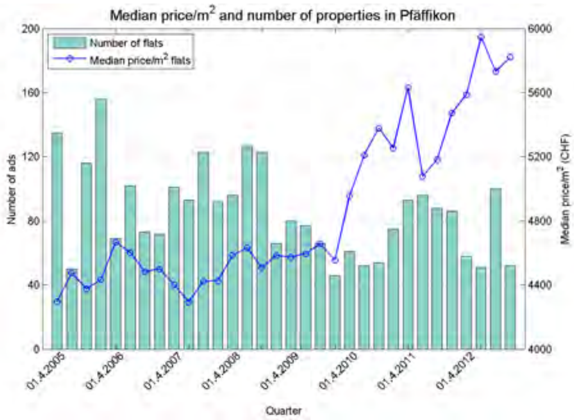


(b) Medium size apartments.

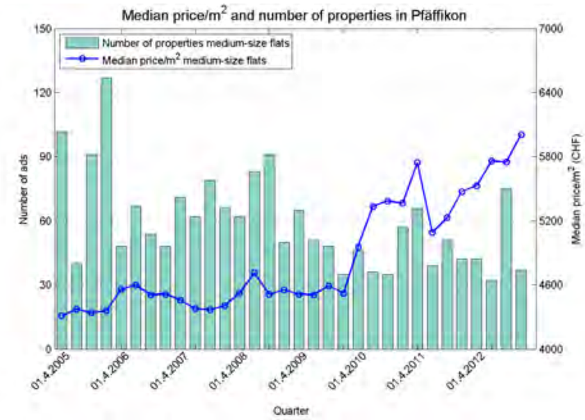


(c) Medium size houses.

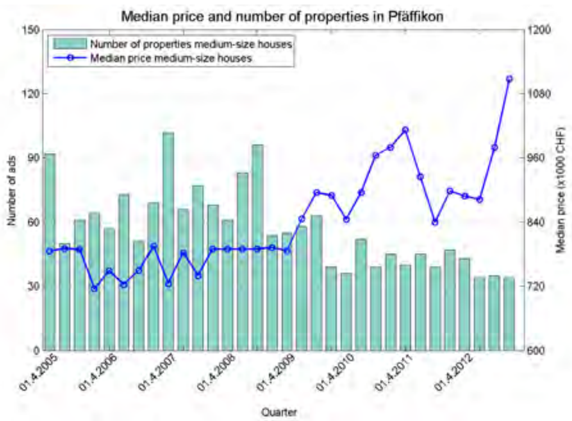
Figure D.7: Development of prices in Meilen.



(a) All apartments.

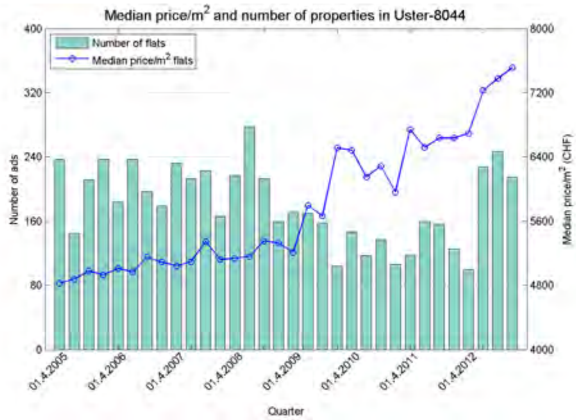


(b) Medium size apartments.

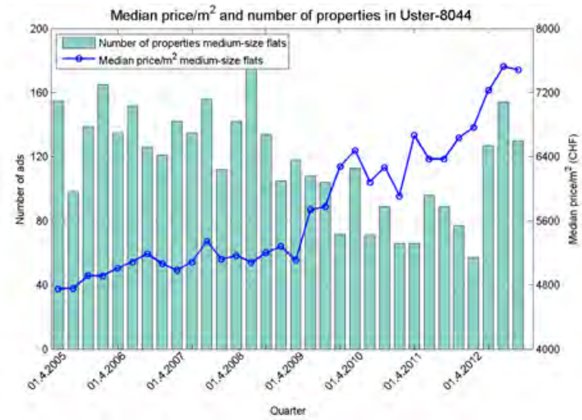


(c) Medium size houses.

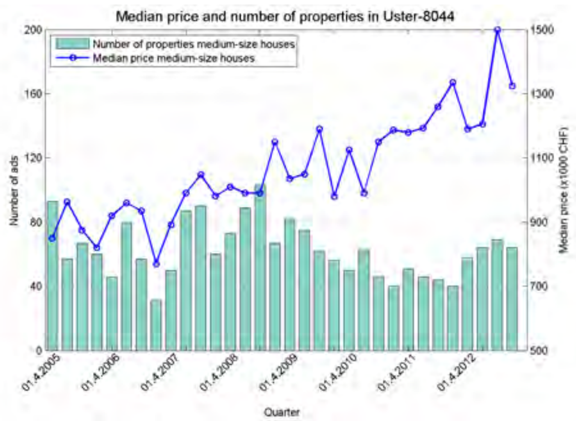
Figure D.8: Development of prices in Pfäffikon.



(a) All apartments.

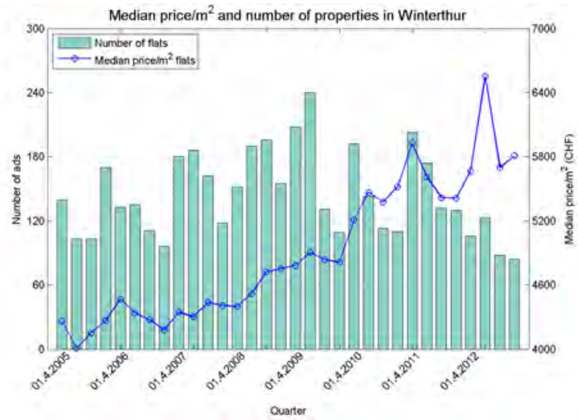


(b) Medium size apartments.

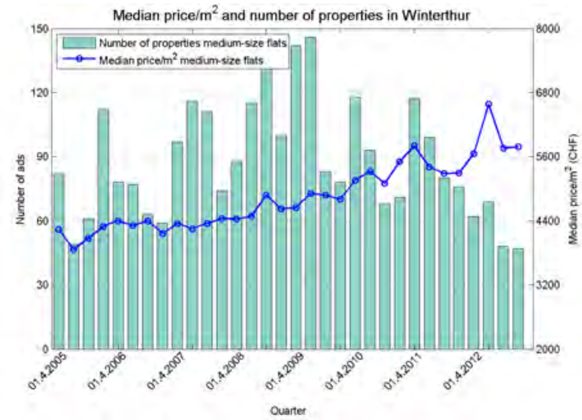


(c) Medium size houses.

Figure D.9: Development of prices in Uster.



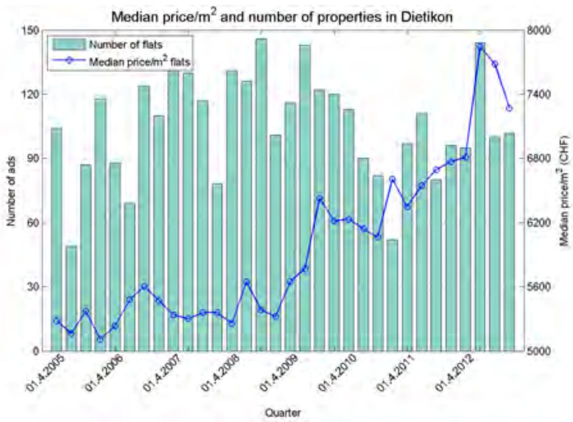
(a) All apartments.



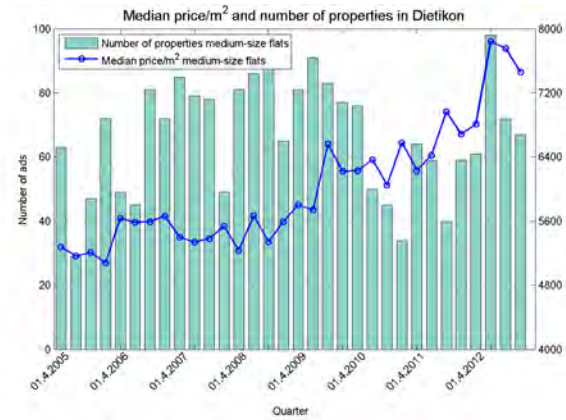
(b) Medium size apartments.

(c) Medium size houses.

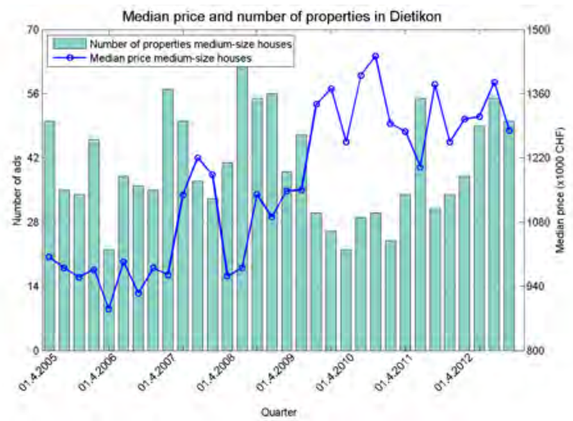
Figure D.10: Development of prices in Winterthur.



(a) All apartments.

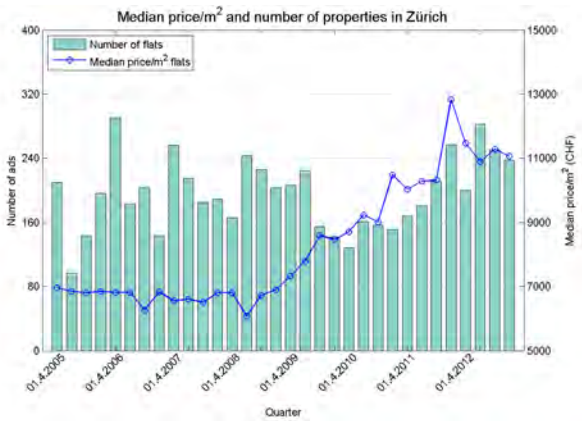


(b) Medium size apartments.

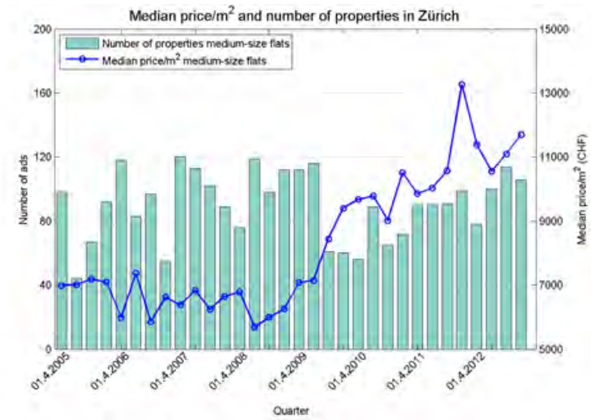


(c) Medium size houses.

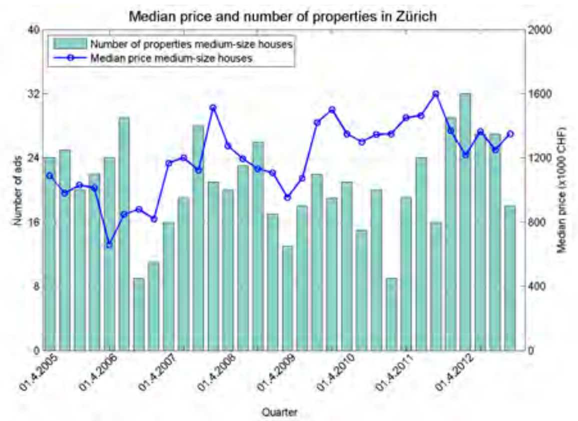
Figure D.11: Development of prices in Dietikon.



(a) All apartments.

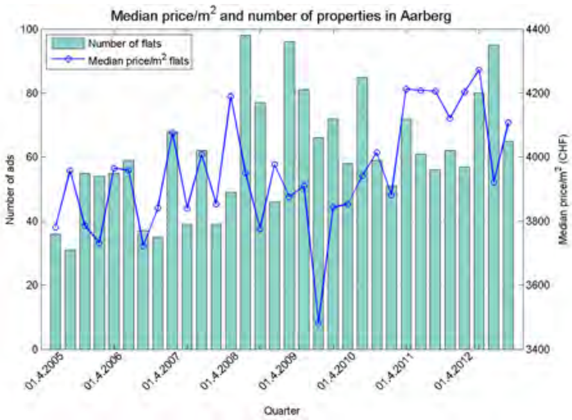


(b) Medium size apartments.

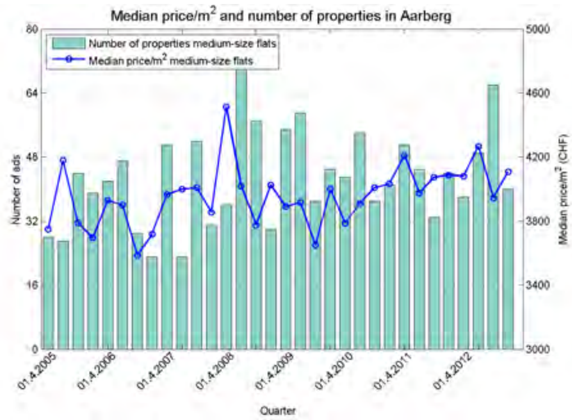


(c) Medium size houses.

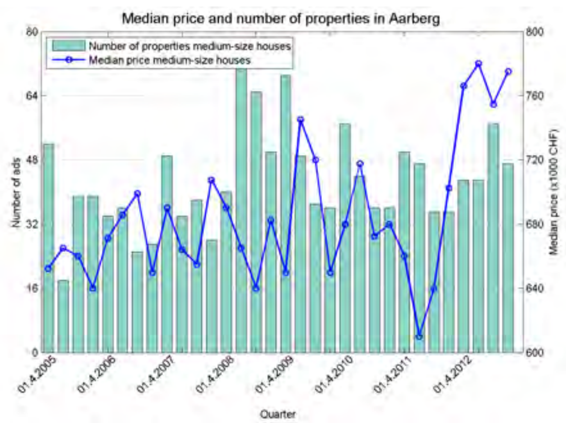
Figure D.12: Development of prices in Zürich.



(a) All apartments.

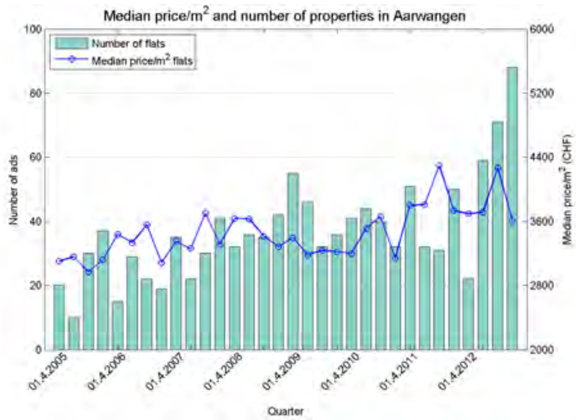


(b) Medium size apartments.

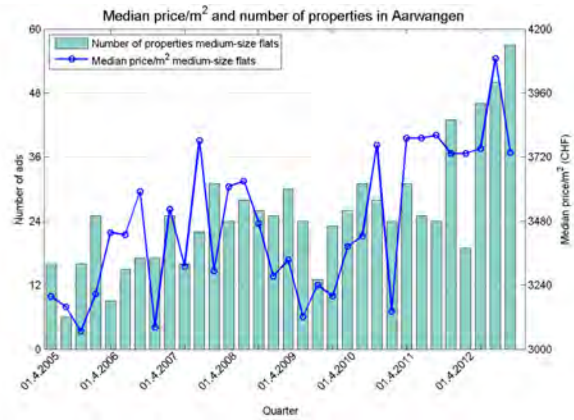


(c) Medium size houses.

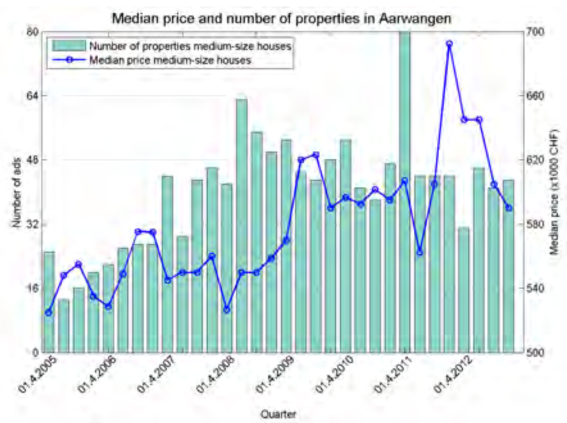
Figure D.13: Development of prices in Aarberg.



(a) All apartments.

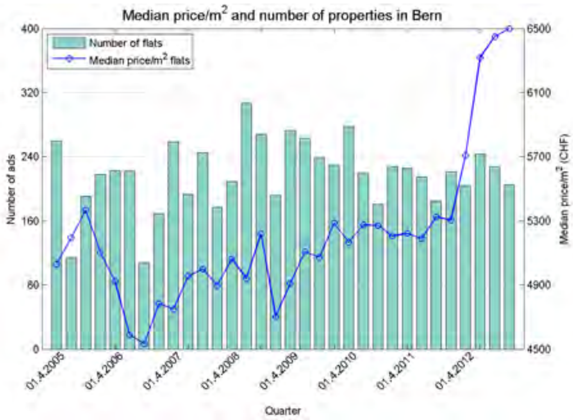


(b) Medium size apartments.

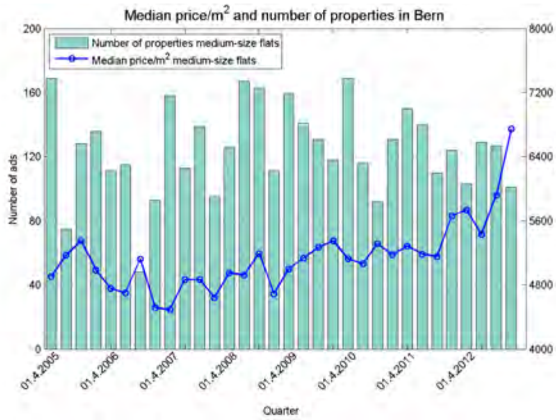


(c) Medium size houses.

Figure D.14: Development of prices in Aarwangen.



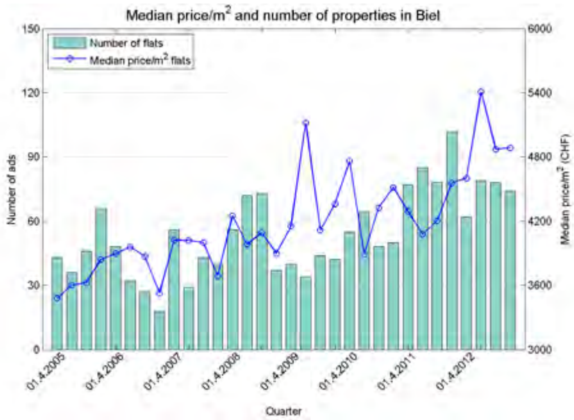
(a) All apartments.



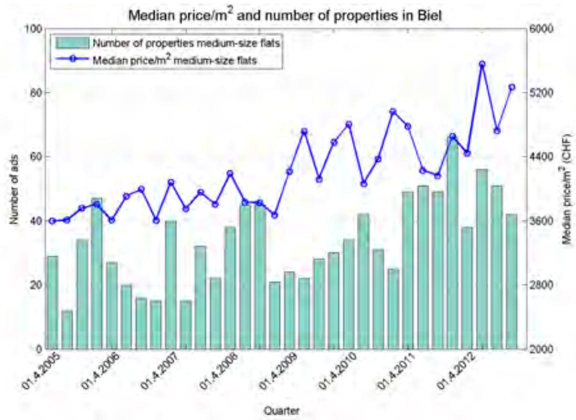
(b) Medium size apartments.

(c) Medium size houses.

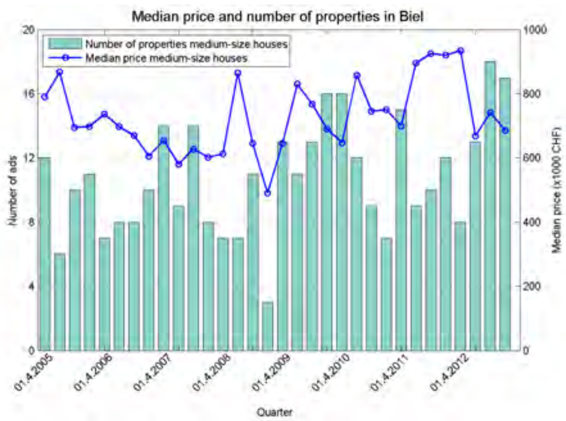
Figure D.15: Development of prices in Bern.



(a) All apartments.

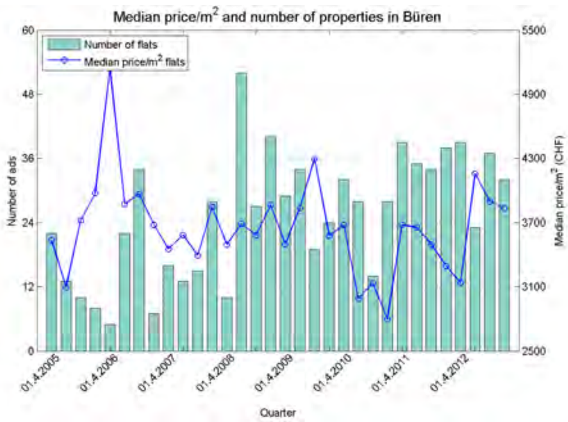


(b) Medium size apartments.

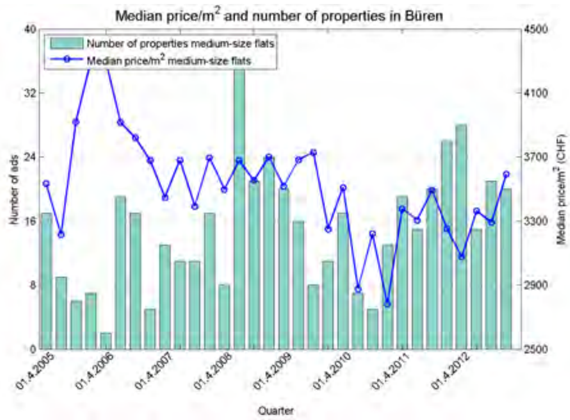


(c) Medium size houses.

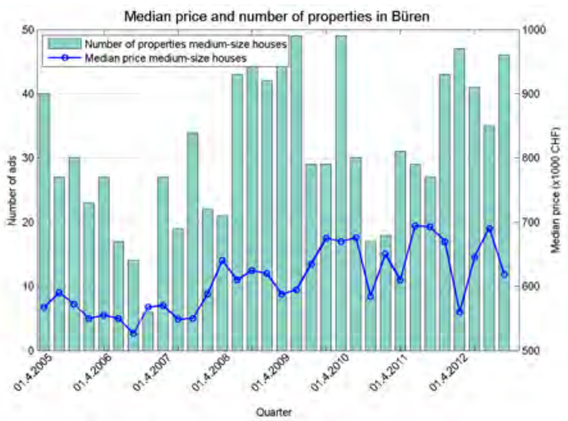
Figure D.16: Development of prices in Biel.



(a) All apartments.

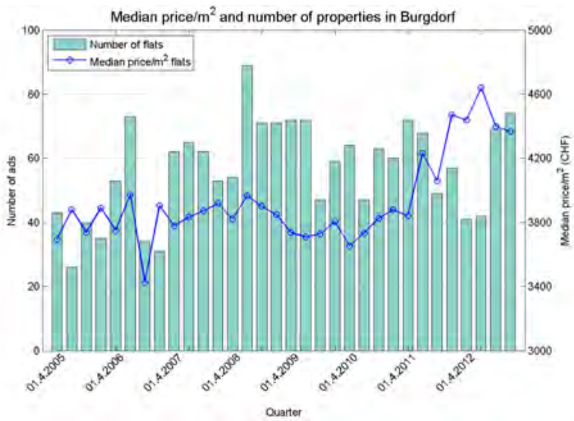


(b) Medium size apartments.

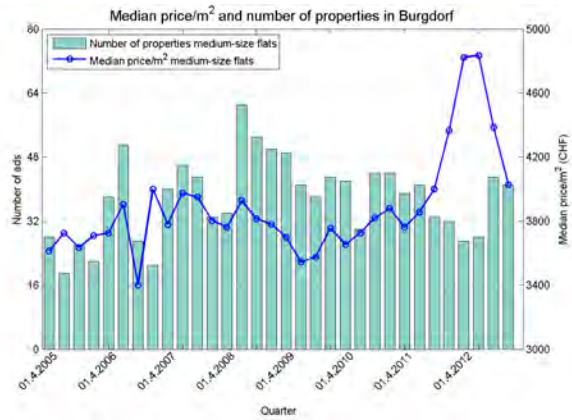


(c) Medium size houses.

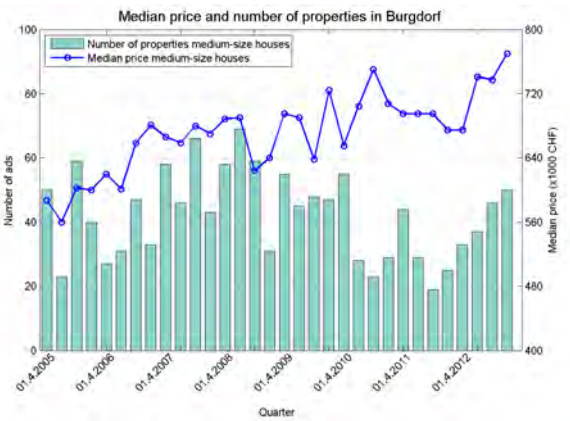
Figure D.17: Development of prices in Büren.



(a) All apartments.

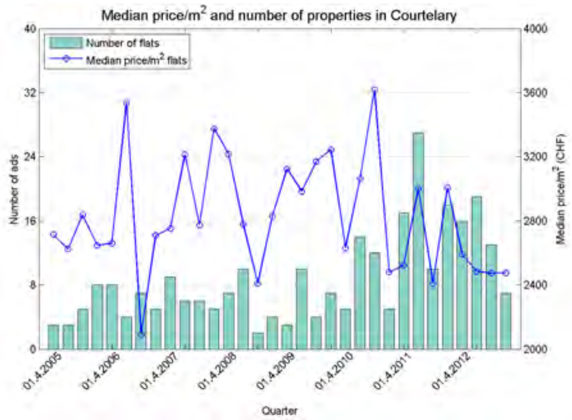


(b) Medium size apartments.

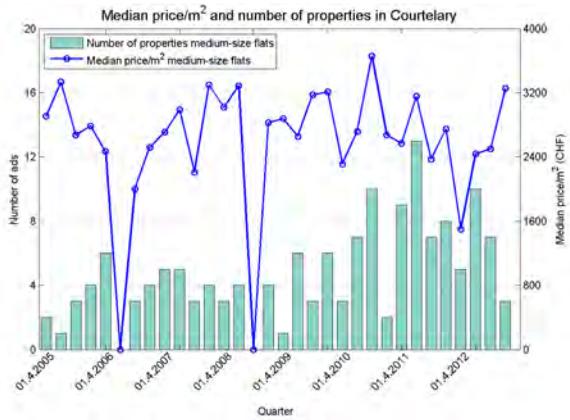


(c) Medium size houses.

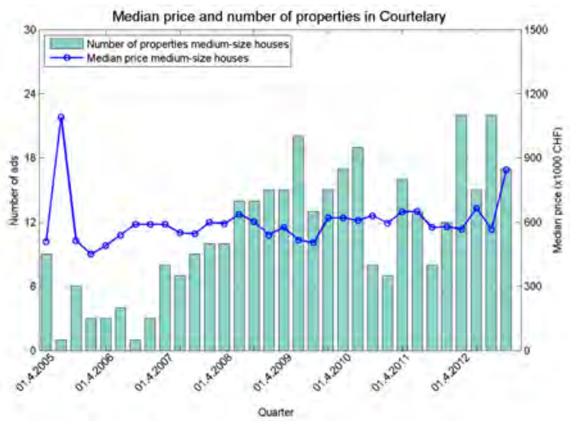
Figure D.18: Development of prices in Burgdorf.



(a) All apartments.

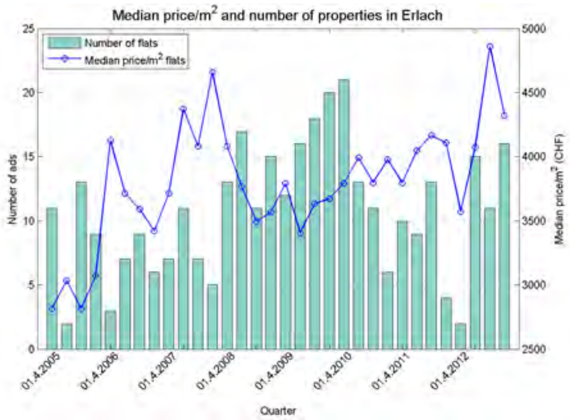


(b) Medium size apartments.

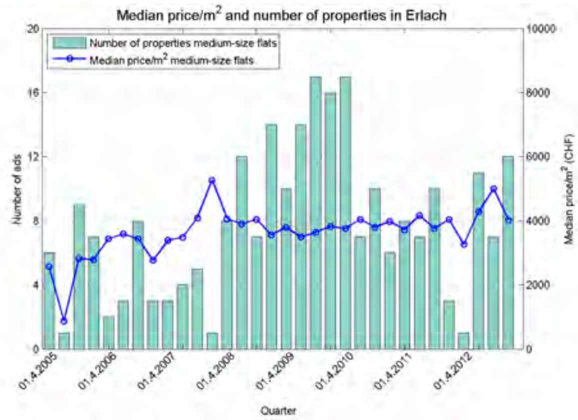


(c) Medium size houses.

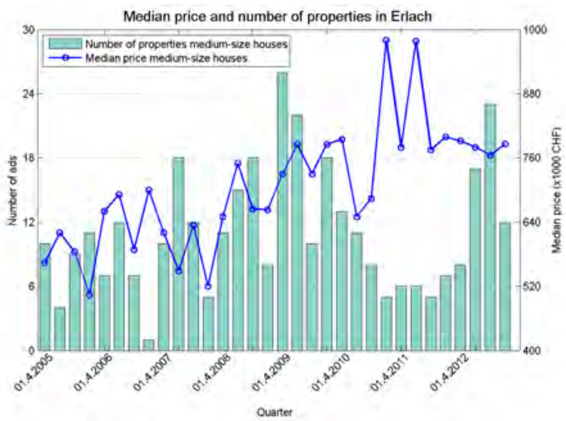
Figure D.19: Development of prices in Courtelary.



(a) All apartments.

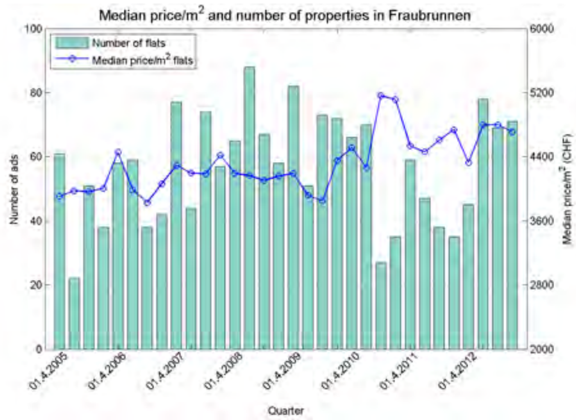


(b) Medium size apartments.

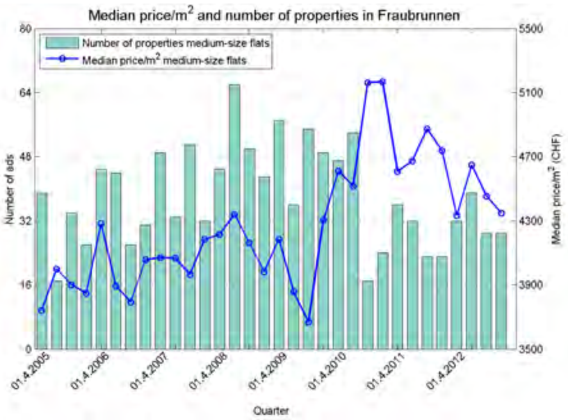


(c) Medium size houses.

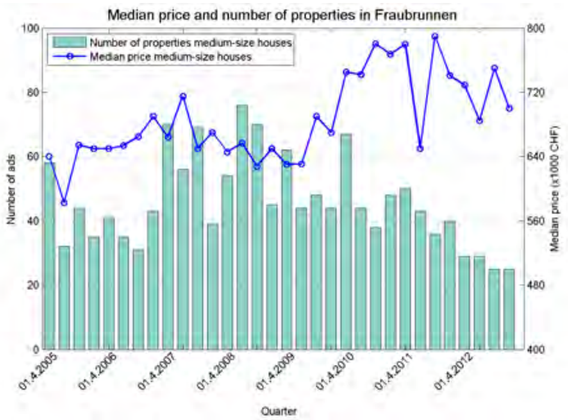
Figure D.20: Development of prices in Erlach.



(a) All apartments.

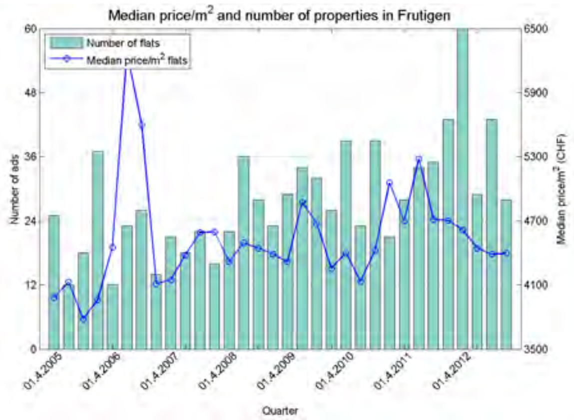


(b) Medium size apartments.

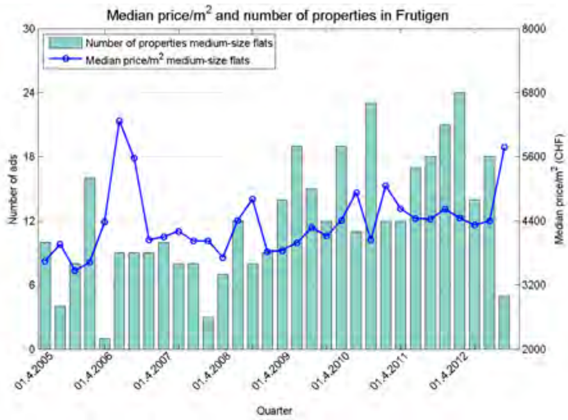


(c) Medium size houses.

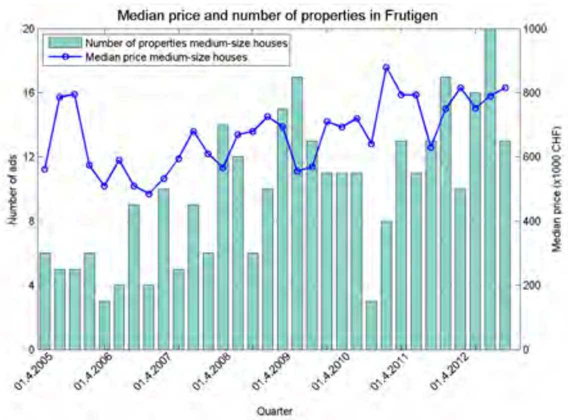
Figure D.21: Development of prices in Fraubrunnen.



(a) All apartments.

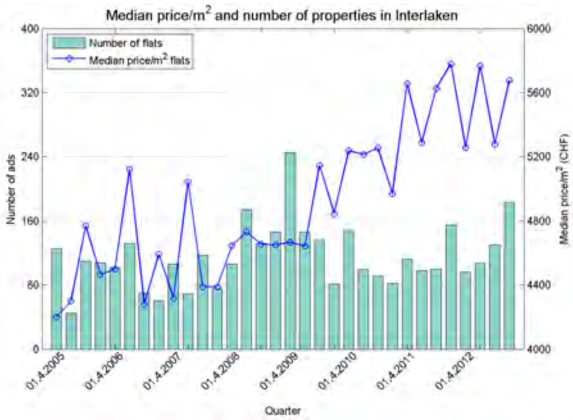


(b) Medium size apartments.

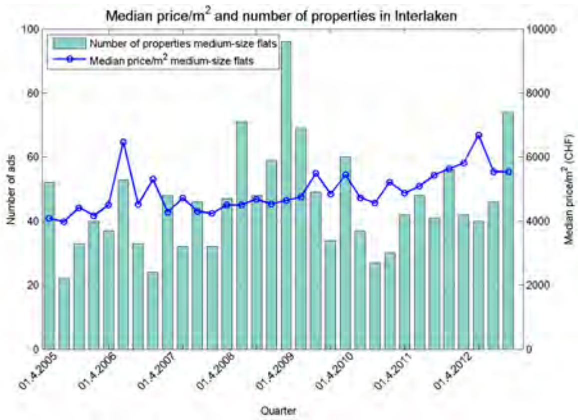


(c) Medium size houses.

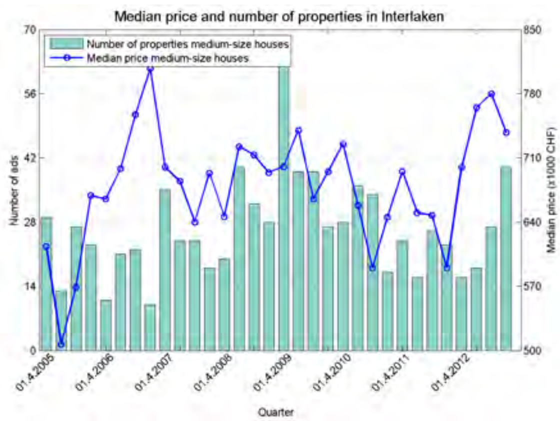
Figure D.22: Development of prices in Frutigen.



(a) All apartments.

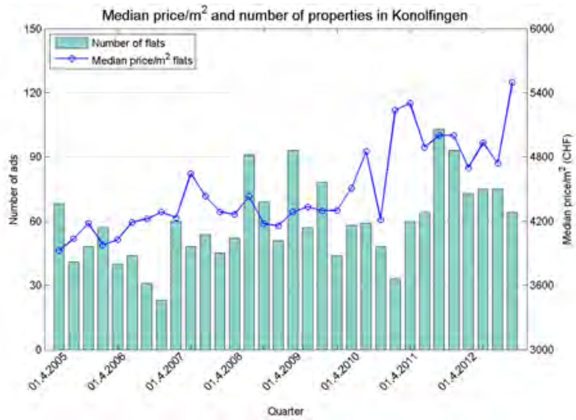


(b) Medium size apartments.

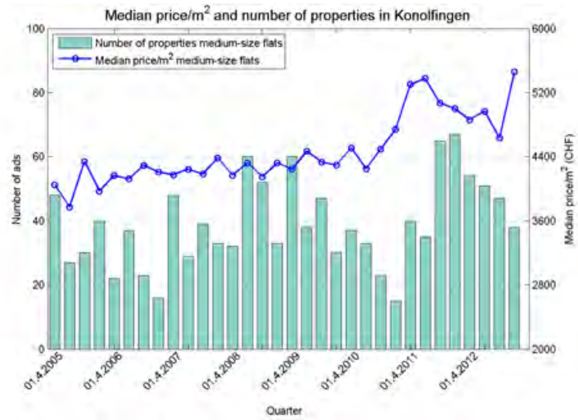


(c) Medium size houses.

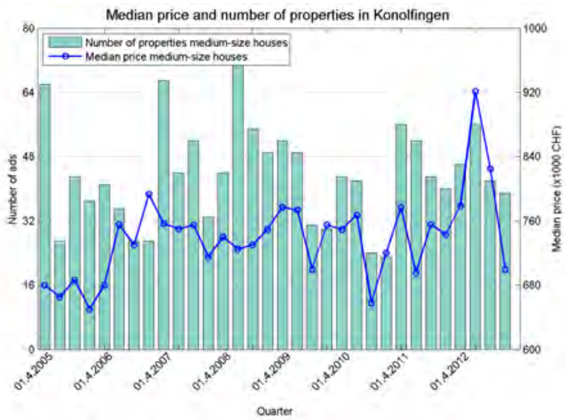
Figure D.23: Development of prices in Interlaken.



(a) All apartments.

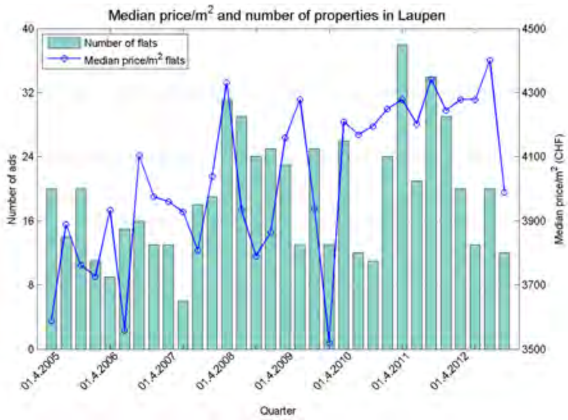


(b) Medium size apartments.

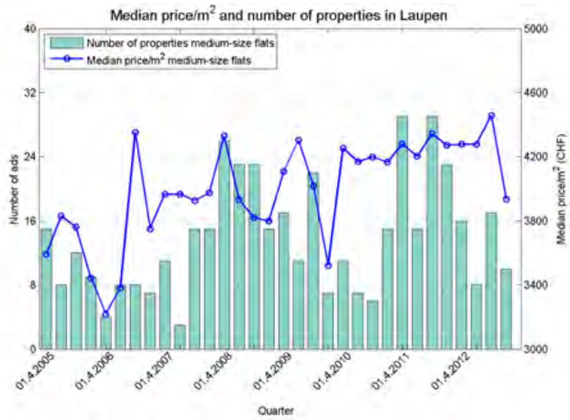


(c) Medium size houses.

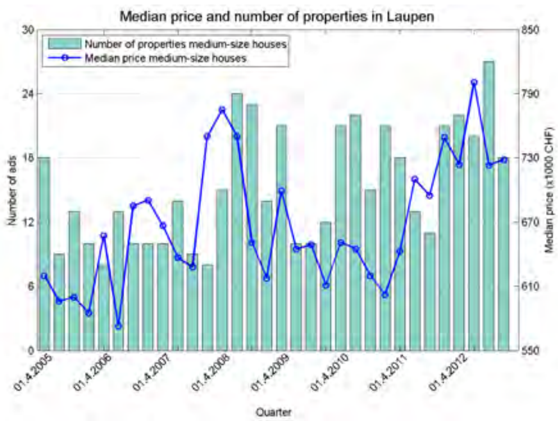
Figure D.24: Development of prices in Konolfingen.



(a) All apartments.

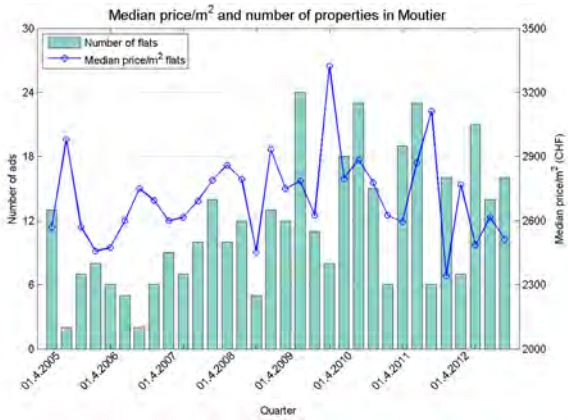


(b) Medium size apartments.

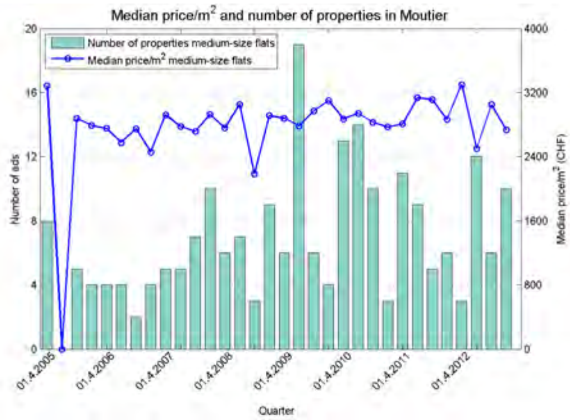


(c) Medium size houses.

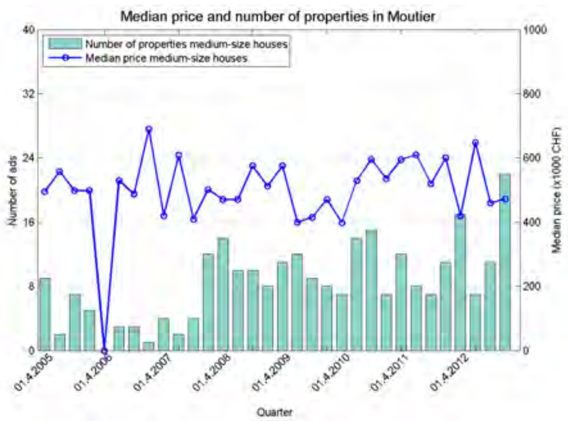
Figure D.25: Development of prices in Laupen.



(a) All apartments.

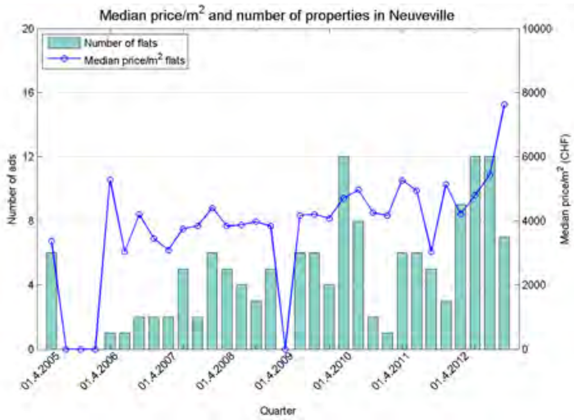


(b) Medium size apartments.

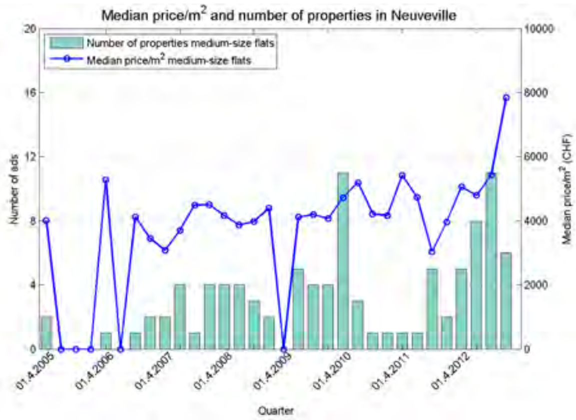


(c) Medium size houses.

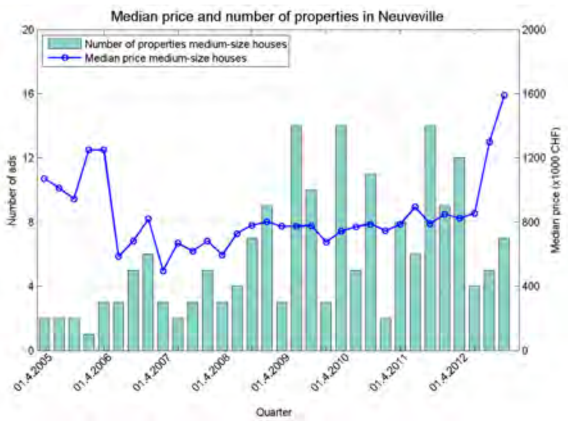
Figure D.26: Development of prices in Moutier.



(a) All apartments.

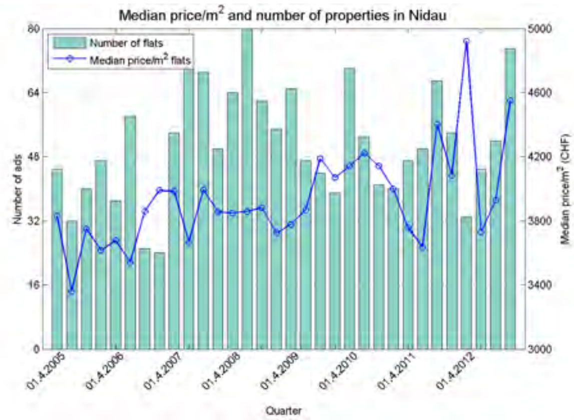


(b) Medium size apartments.

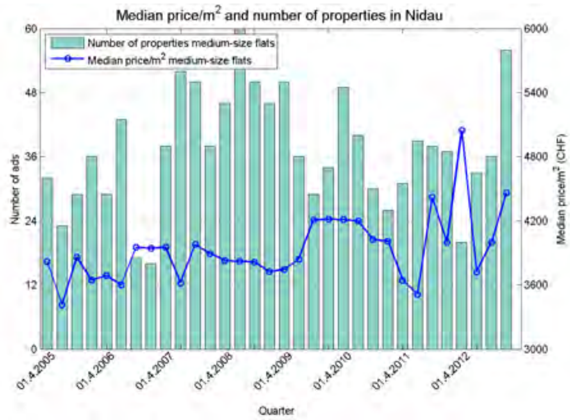


(c) Medium size houses.

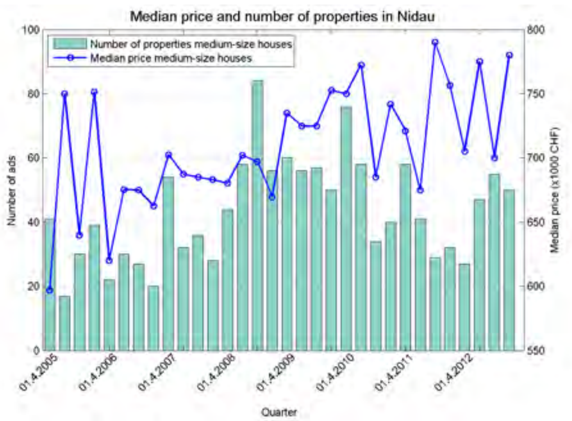
Figure D.27: Development of prices in Neuveville.



(a) All apartments.

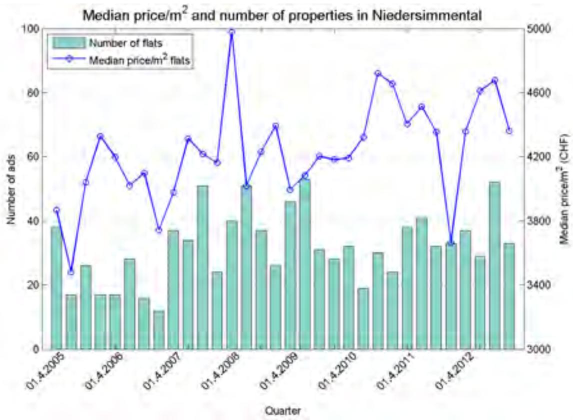


(b) Medium size apartments.

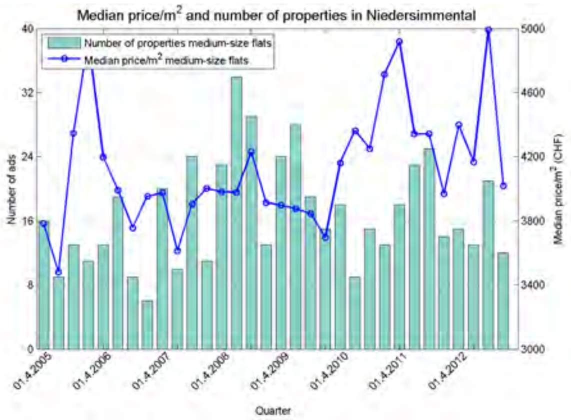


(c) Medium size houses.

Figure D.28: Development of prices in Nidau.



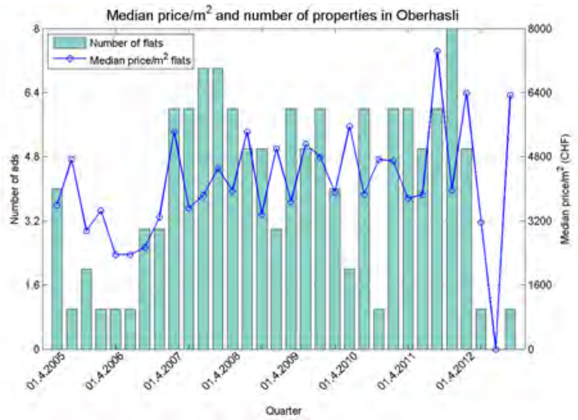
(a) All apartments.



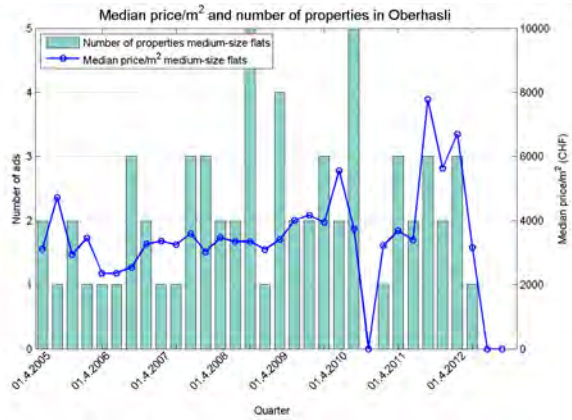
(b) Medium size apartments.

(c) Medium size houses.

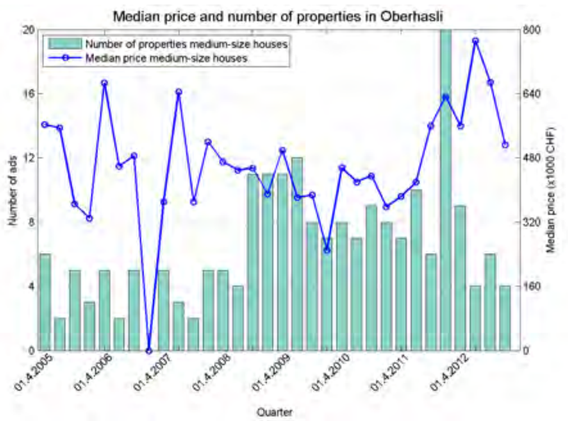
Figure D.29: Development of prices in Niedersimmental.



(a) All apartments.



(b) Medium size apartments.



(c) Medium size houses.

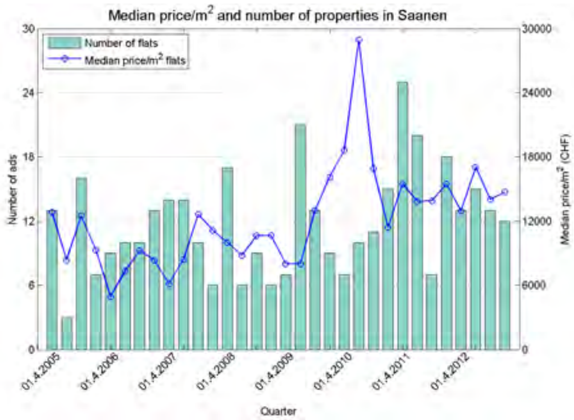
Figure D.30: Development of prices in Oberhasli.

(a) All apartments.

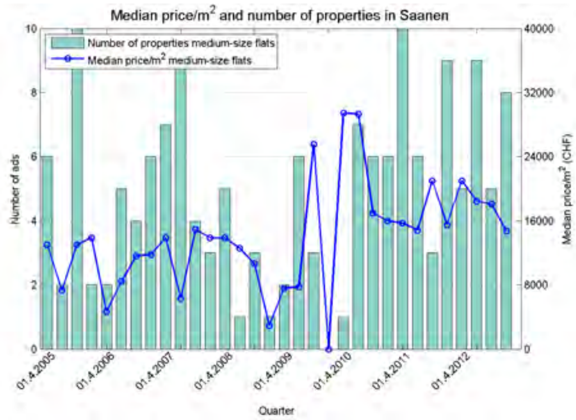
(b) Medium size apartments.

(c) Medium size houses.

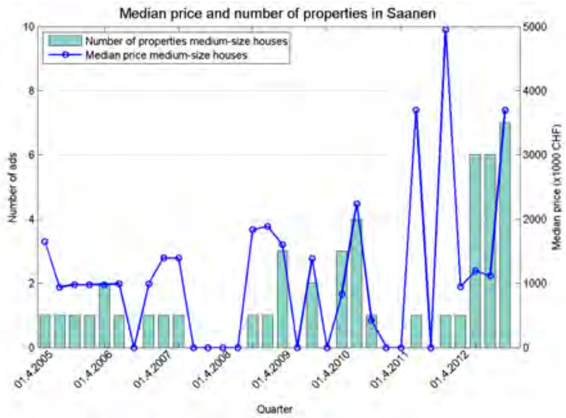
Figure D.31: Development of prices in Obersimmental.



(a) All apartments.

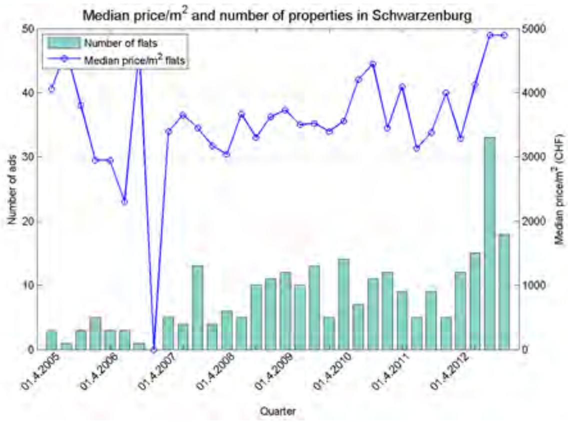


(b) Medium size apartments.

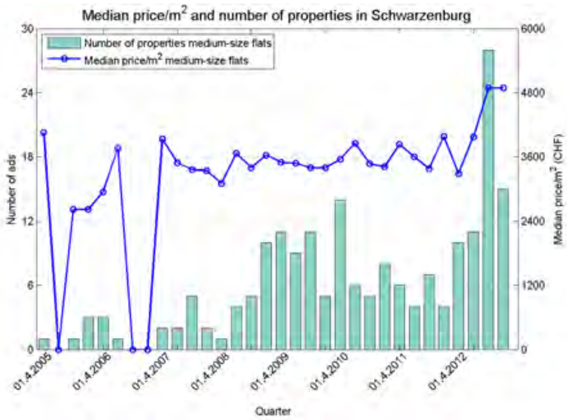


(c) Medium size houses.

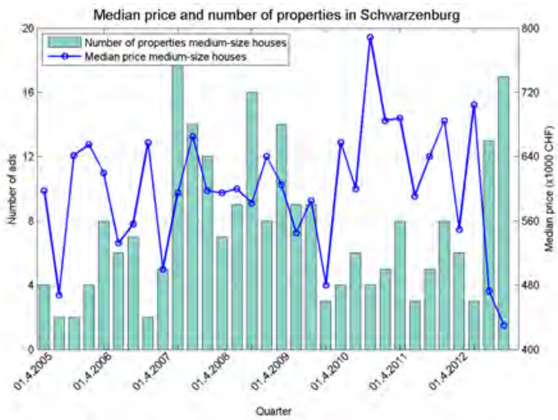
Figure D.32: Development of prices in Saanen.



(a) All apartments.

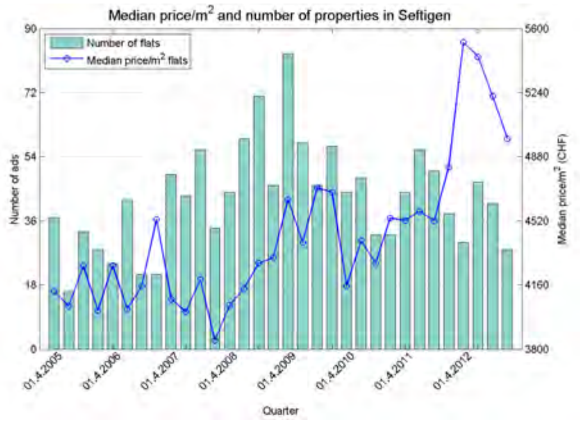


(b) Medium size apartments.

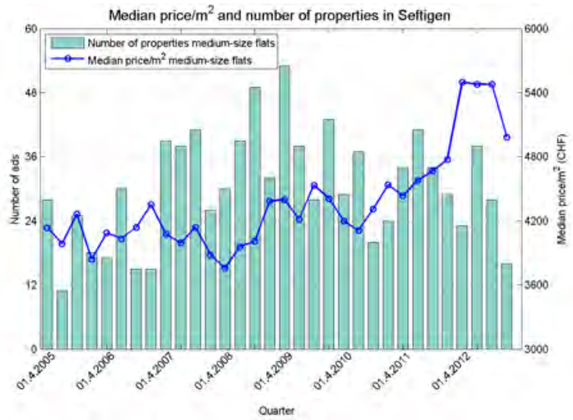


(c) Medium size houses.

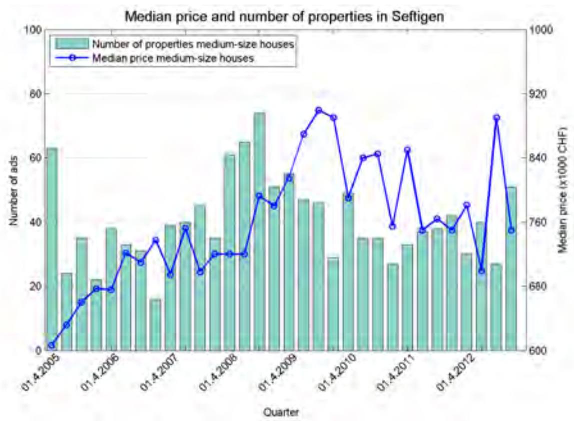
Figure D.33: Development of prices in Schwarzenburg.



(a) All apartments.

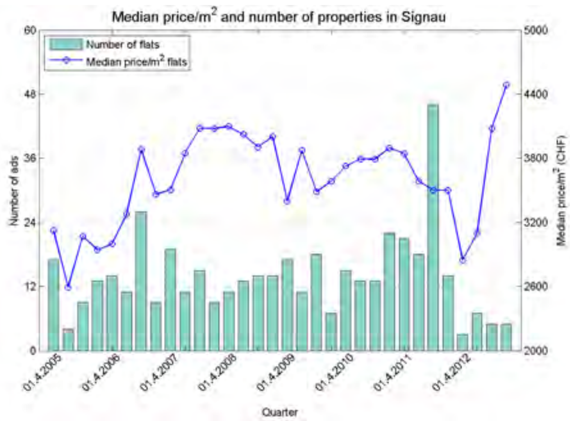


(b) Medium size apartments.

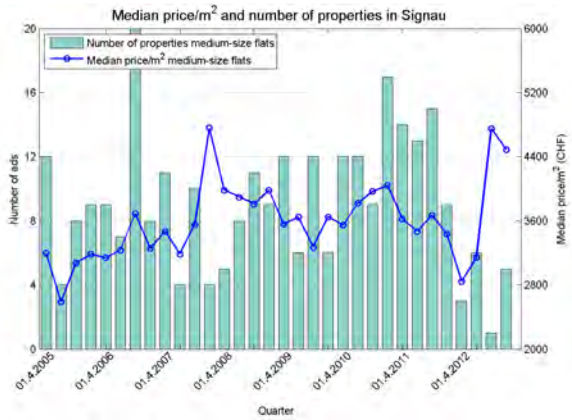


(c) Medium size houses.

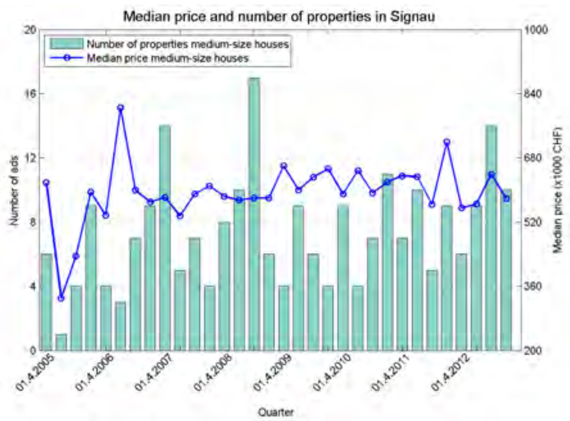
Figure D.34: Development of prices in Seftigen.



(a) All apartments.

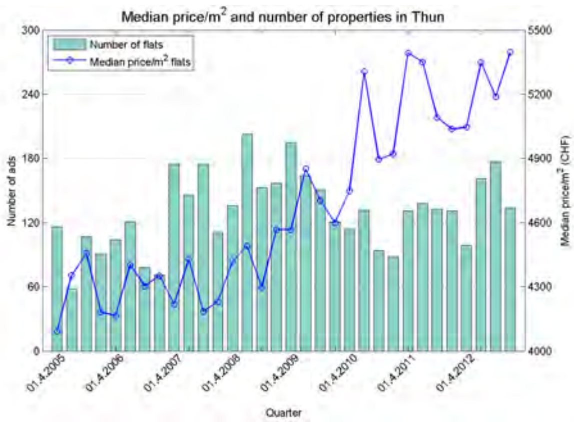


(b) Medium size apartments.

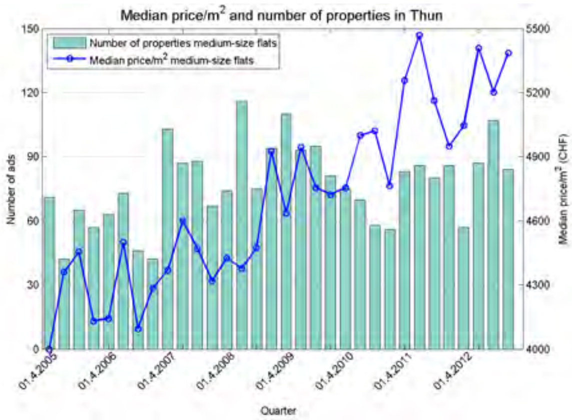


(c) Medium size houses.

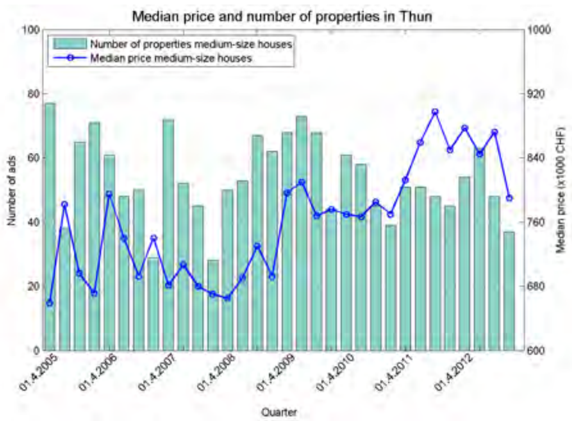
Figure D.35: Development of prices in Signau.



(a) All apartments.

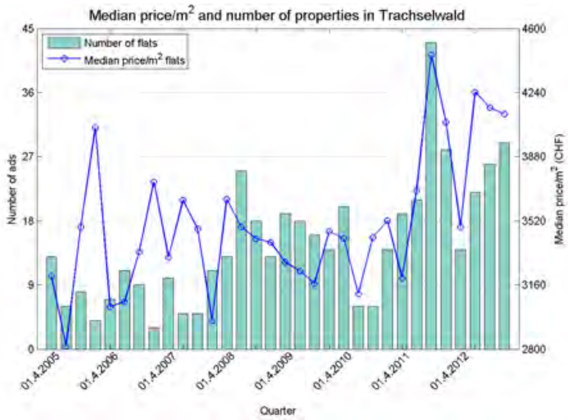


(b) Medium size apartments.

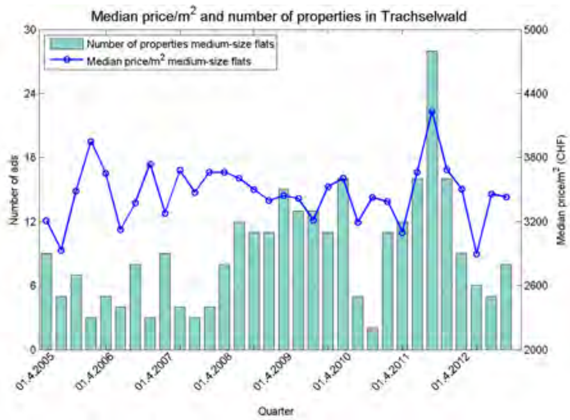


(c) Medium size houses.

Figure D.36: Development of prices in Thun.



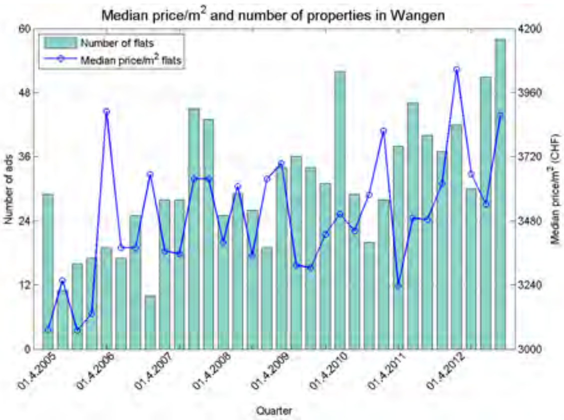
(a) All apartments.



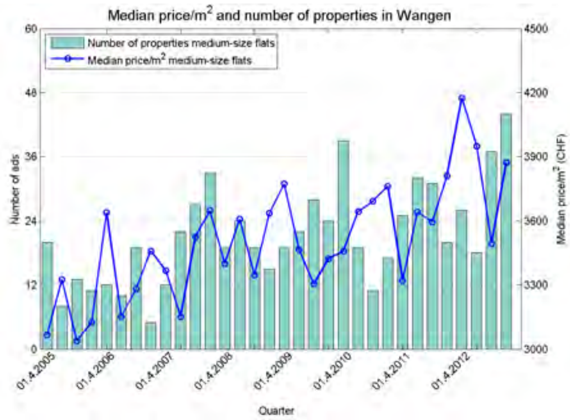
(b) Medium size apartments.

(c) Medium size houses.

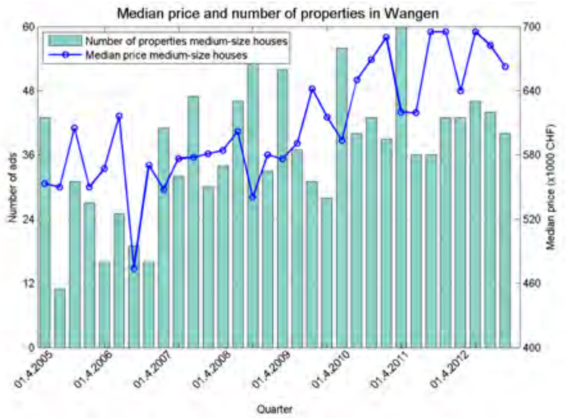
Figure D.37: Development of prices in Trachselwald.



(a) All apartments.

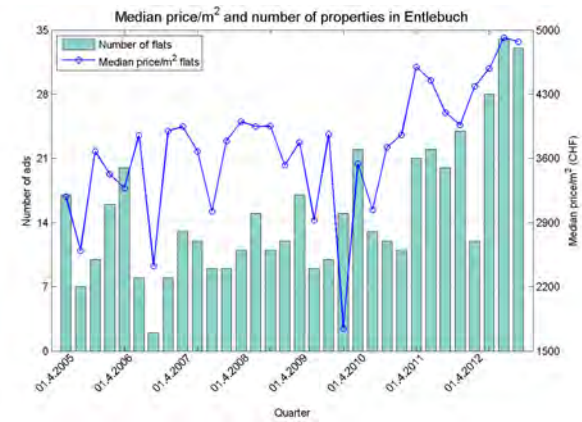


(b) Medium size apartments.

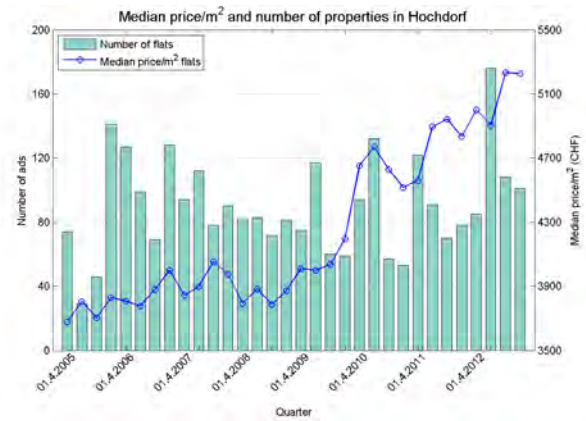


(c) Medium size houses.

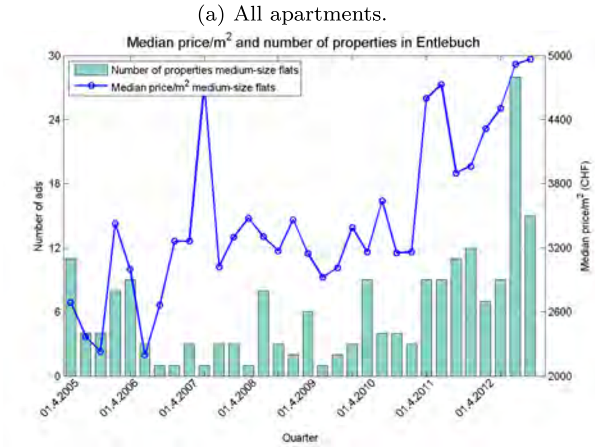
Figure D.38: Development of prices in Wangen.



(a) All apartments.

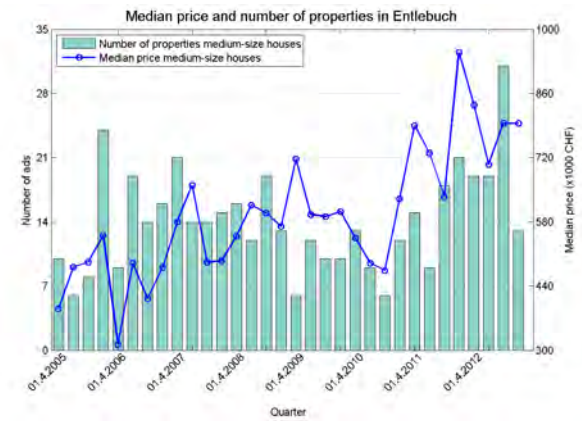


(a) All apartments.

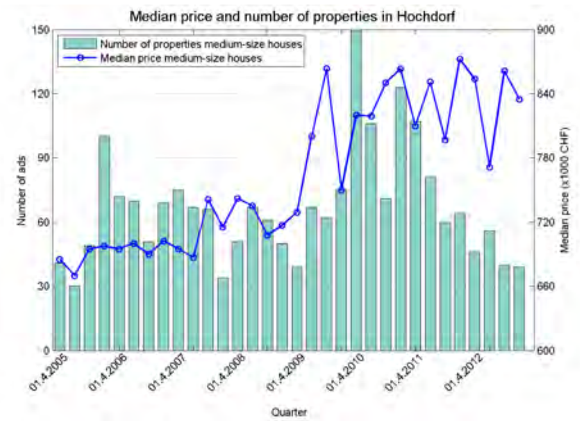


(b) Medium size apartments.

(b) Medium size apartments.



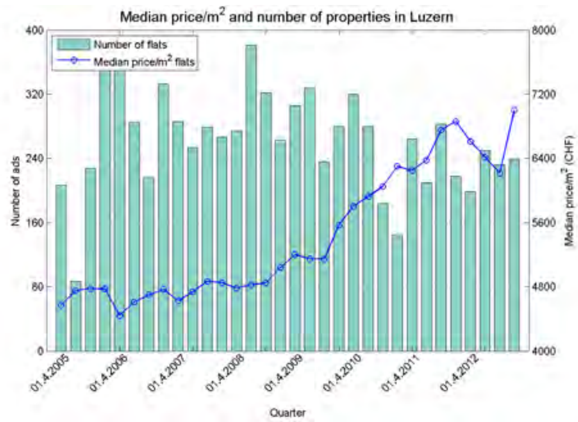
(c) Medium size houses.



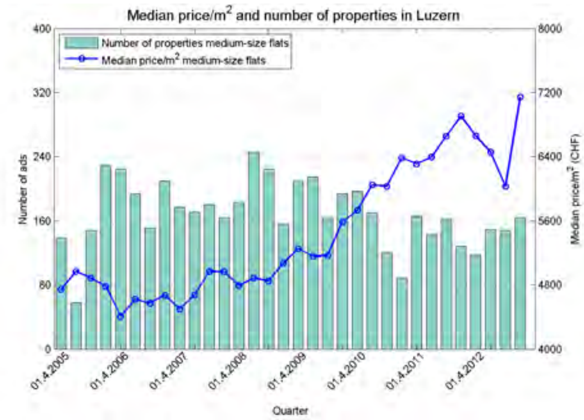
(c) Medium size houses.

Figure D.39: Development of prices in Entlebuch.

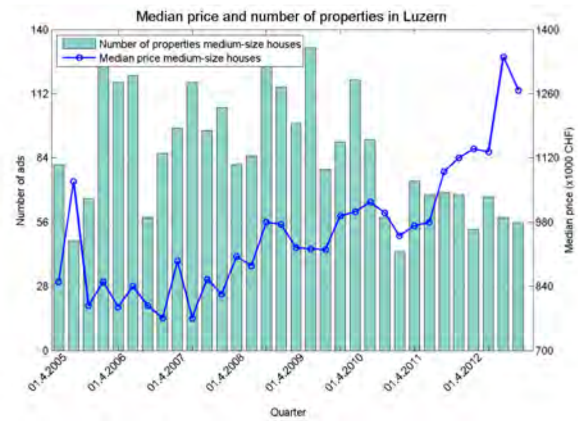
Figure D.40: Development of prices in Hochdorf.



(a) All apartments.

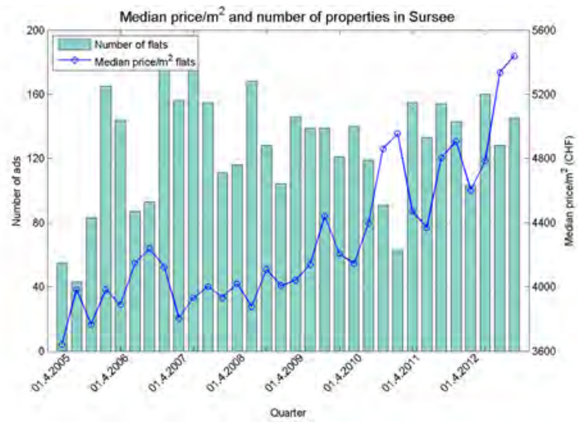


(b) Medium size apartments.

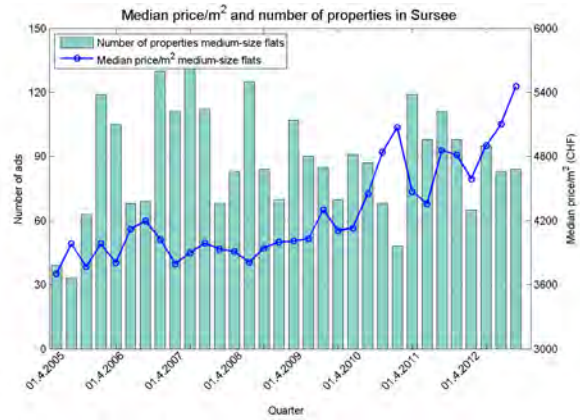


(c) Medium size houses.

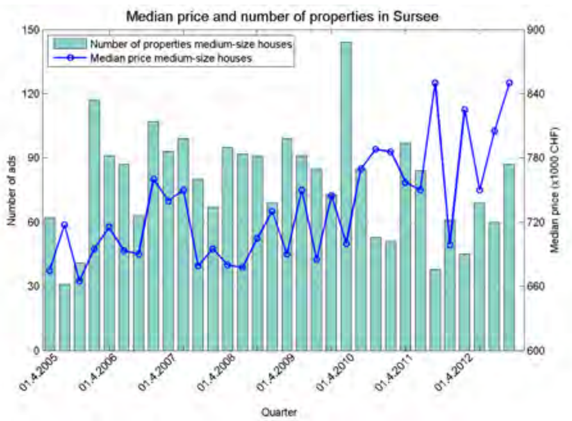
Figure D.41: Development of prices in Luzern.



(a) All apartments.

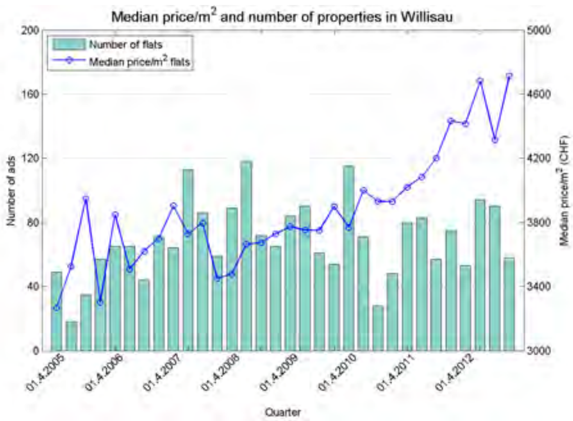


(b) Medium size apartments.

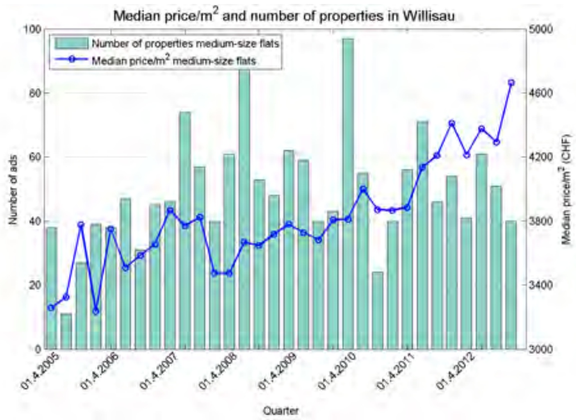


(c) Medium size houses.

Figure D.42: Development of prices in Sursee.



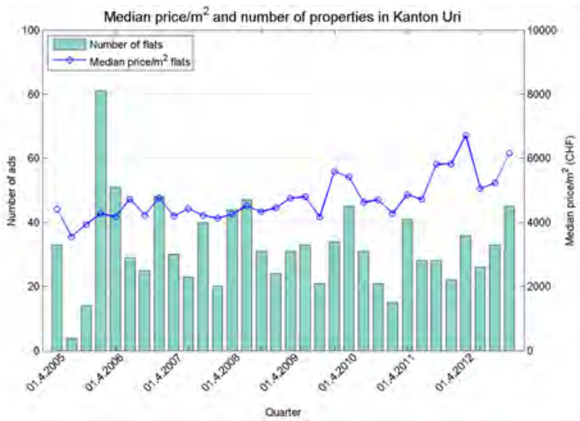
(a) All apartments.



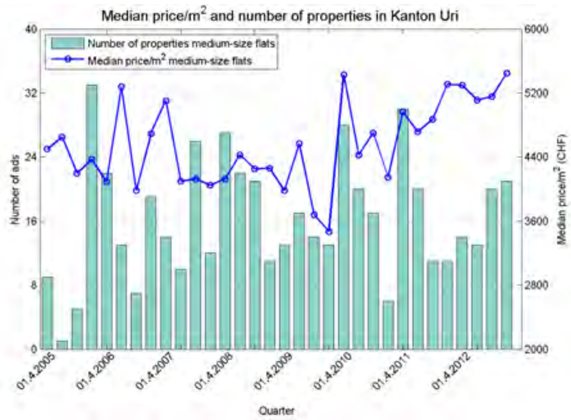
(b) Medium size apartments.

(c) Medium size houses.

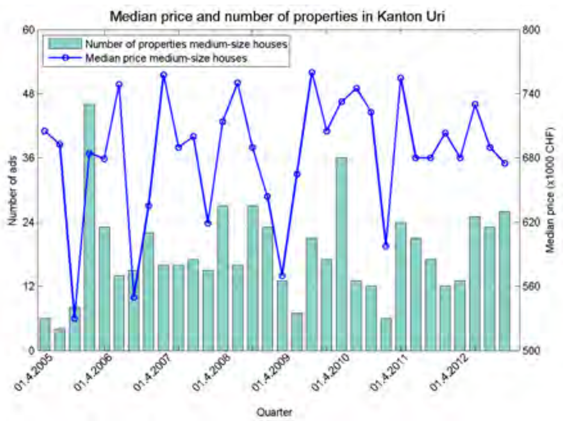
Figure D.43: Development of prices in Willisau.



(a) All apartments.

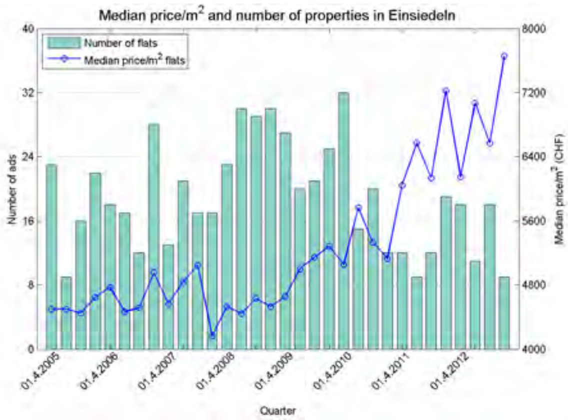


(b) Medium size apartments.

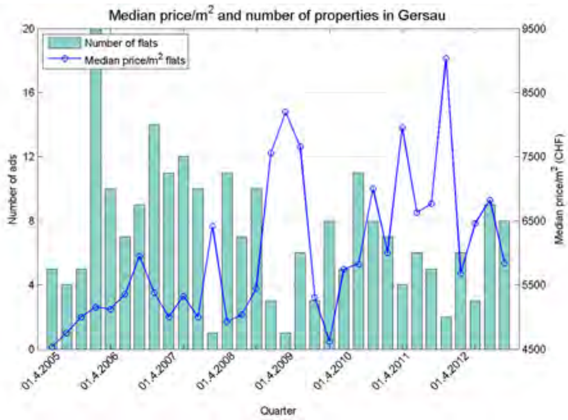


(c) Medium size houses.

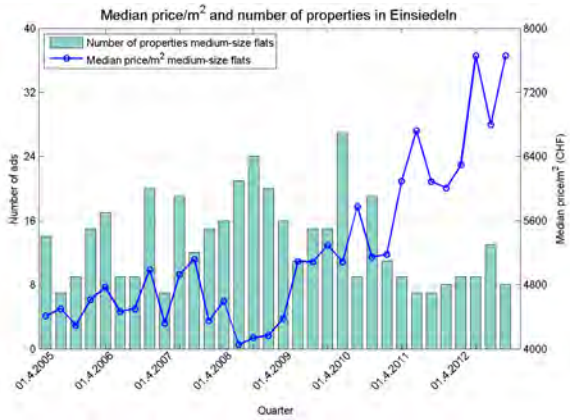
Figure D.44: Development of prices in Kanton Uri.



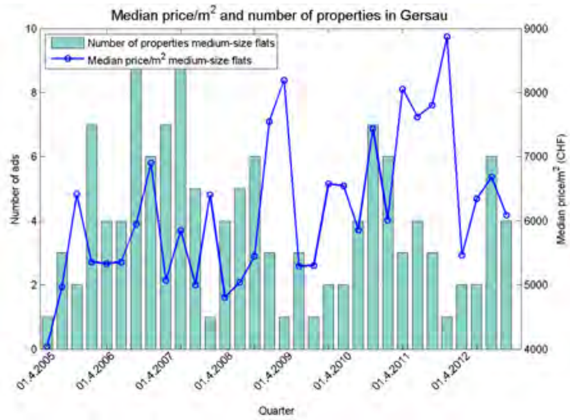
(a) All apartments.



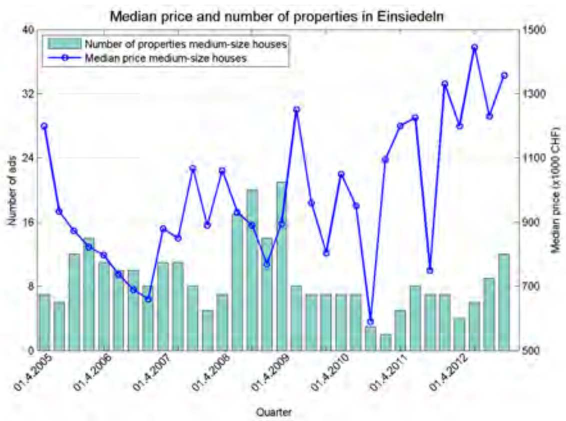
(a) All apartments.



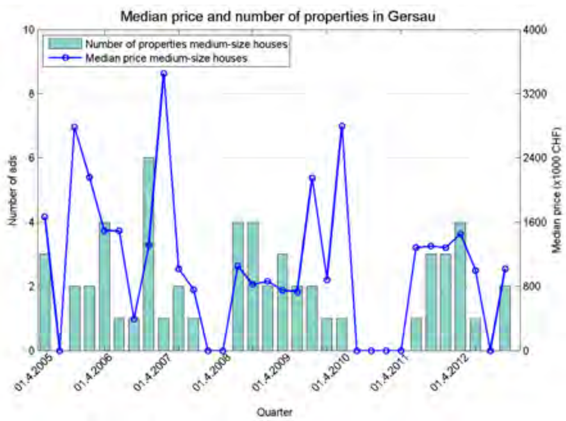
(b) Medium size apartments.



(b) Medium size apartments.



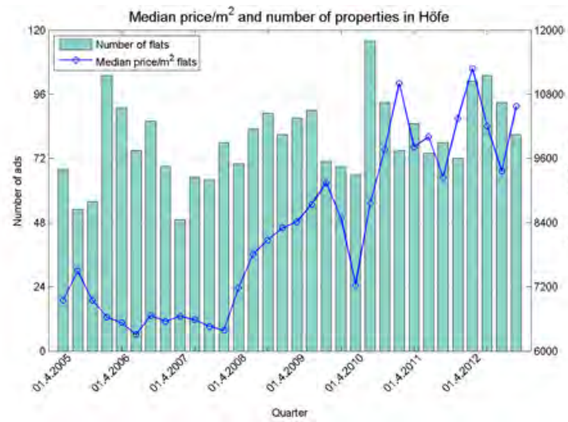
(c) Medium size houses.



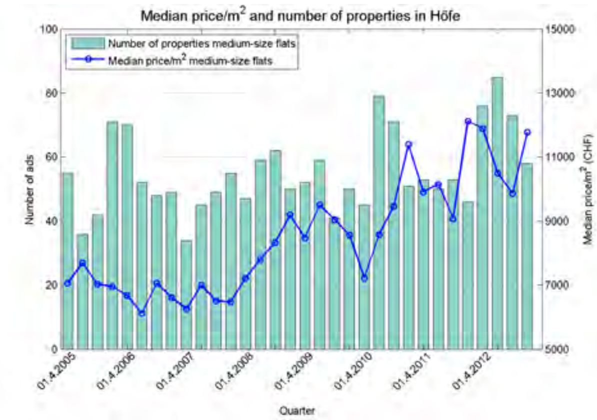
(c) Medium size houses.

Figure D.45: Development of prices in Einsiedeln.

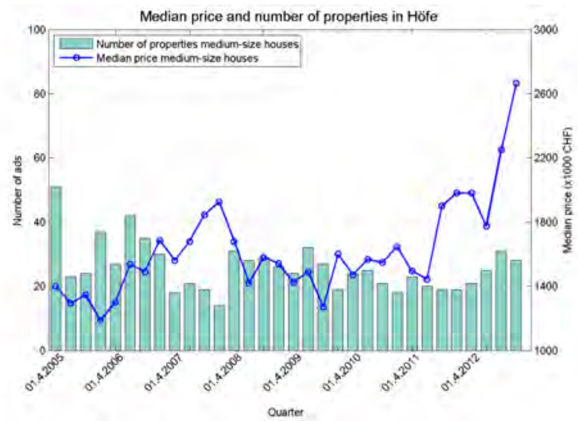
Figure D.46: Development of prices in Gersau.



(a) All apartments.

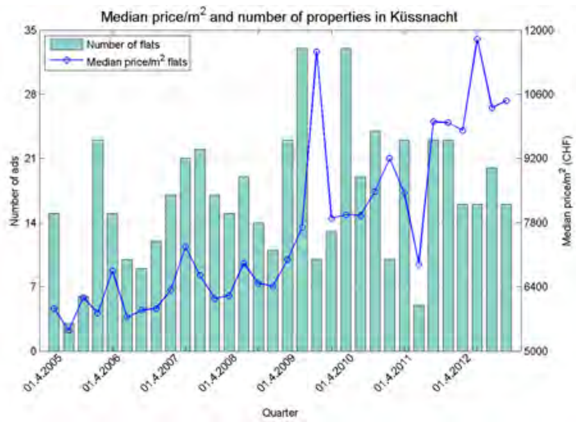


(b) Medium size apartments.

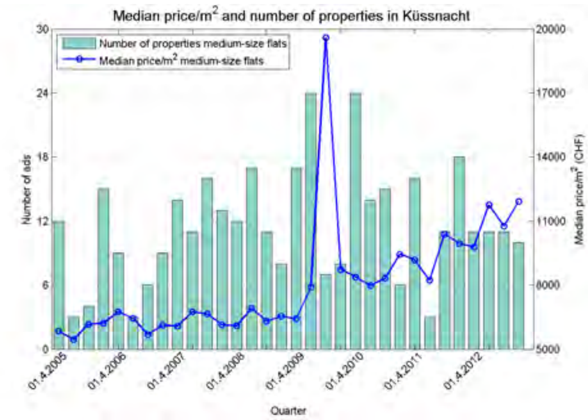


(c) Medium size houses.

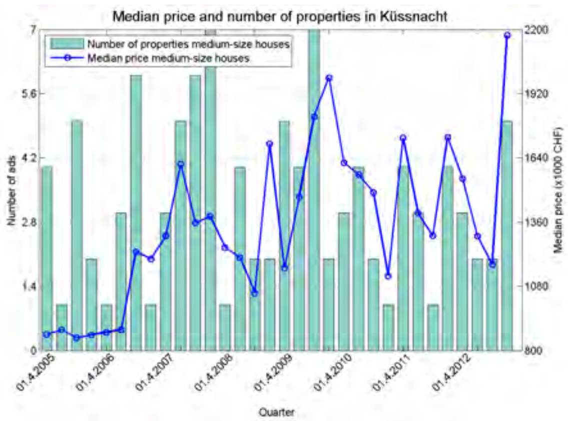
Figure D.47: Development of prices in Höfe.



(a) All apartments.

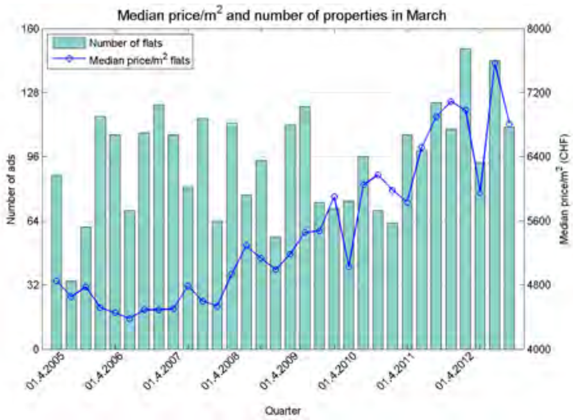


(b) Medium size apartments.

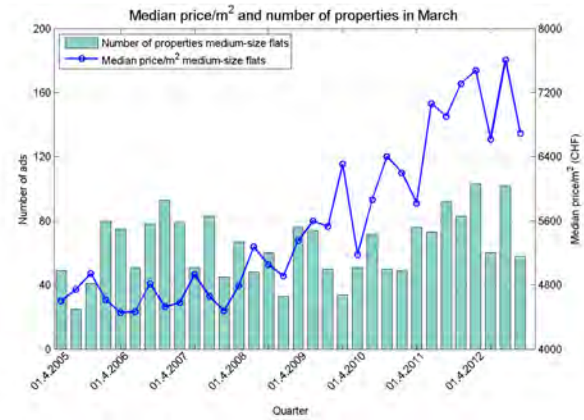


(c) Medium size houses.

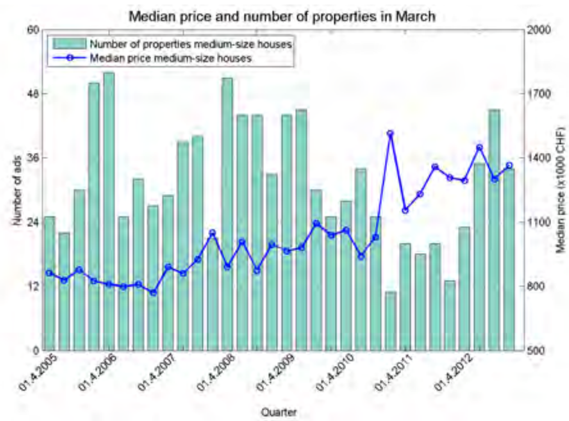
Figure D.48: Development of prices in Küssnacht.



(a) All apartments.

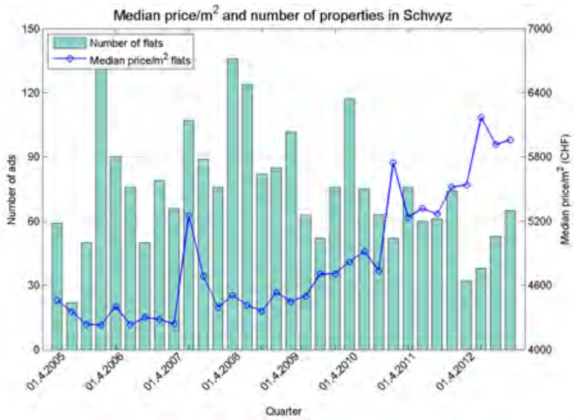


(b) Medium size apartments.

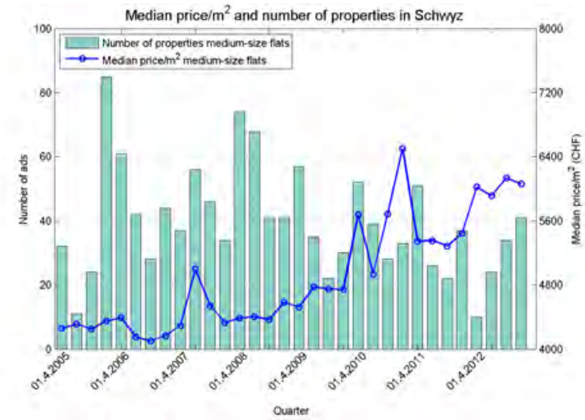


(c) Medium size houses.

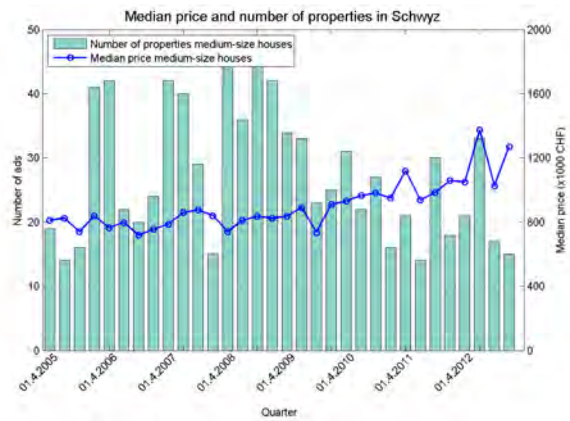
Figure D.49: Development of prices in March.



(a) All apartments.

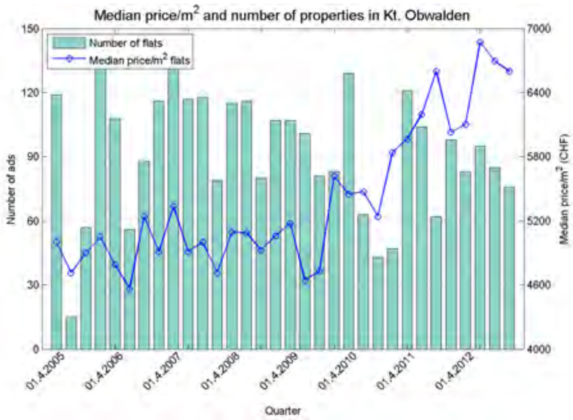


(b) Medium size apartments.

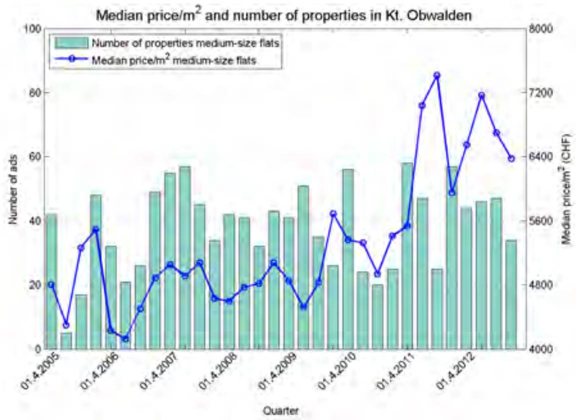


(c) Medium size houses.

Figure D.50: Development of prices in Schwyz.



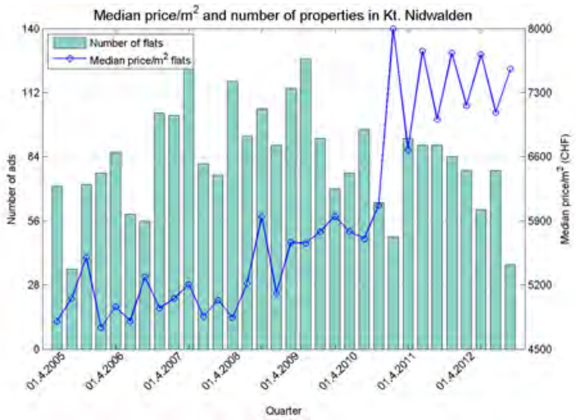
(a) All apartments.



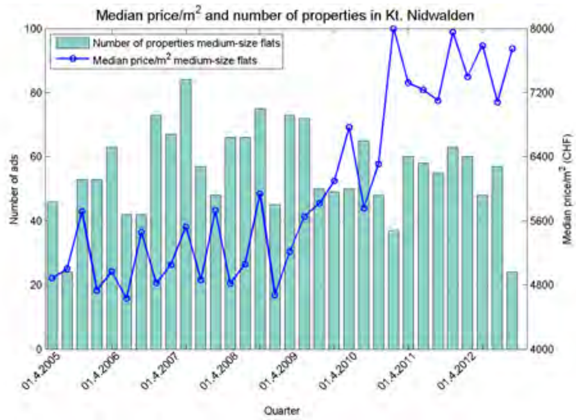
(b) Medium size apartments.

(c) Medium size houses.

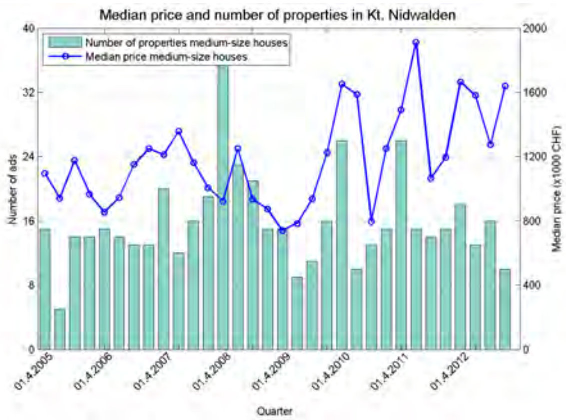
Figure D.51: Development of prices in Kt. Obwalden.



(a) All apartments.

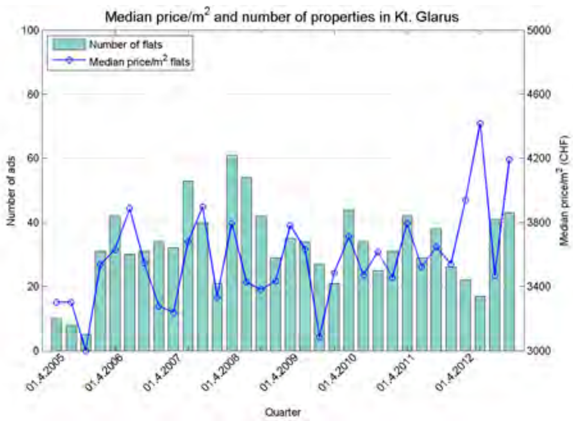


(b) Medium size apartments.

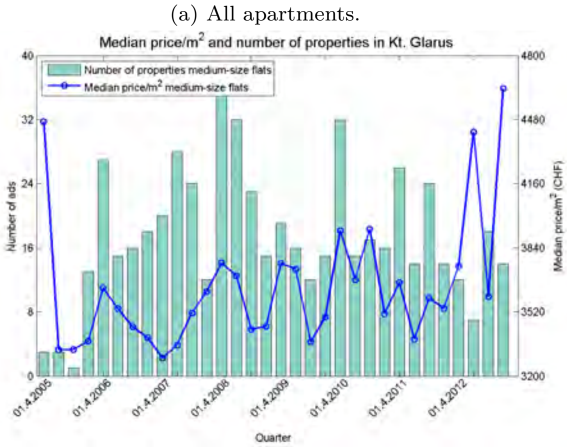


(c) Medium size houses.

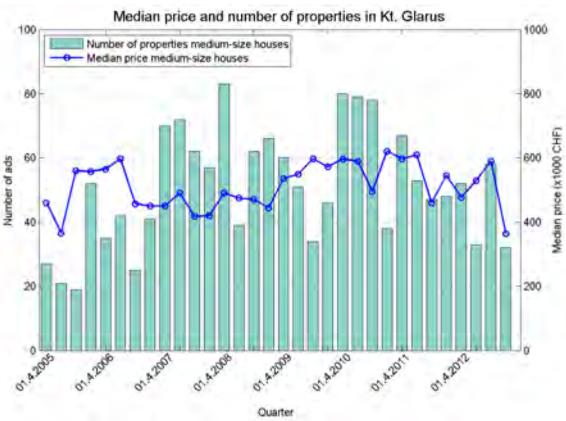
Figure D.52: Development of prices in Kt. Nidwalden.



(a) All apartments.

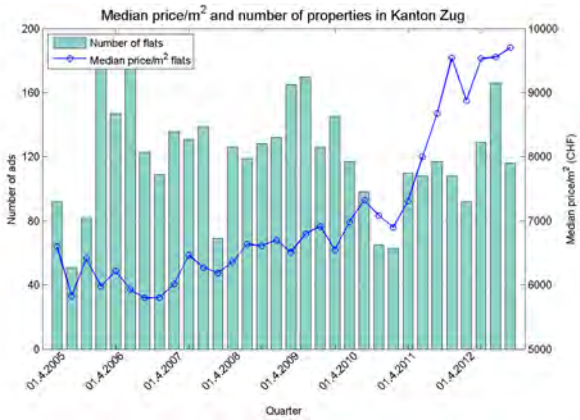


(b) Medium size apartments.

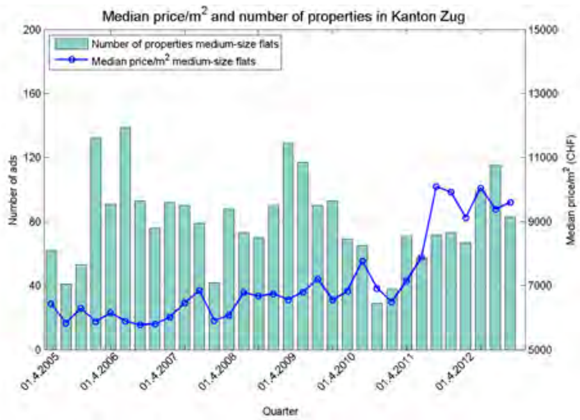


(c) Medium size houses.

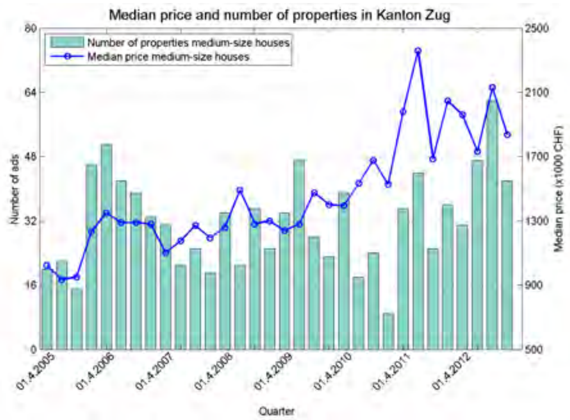
Figure D.53: Development of prices in Kt. Glarus.



(a) All apartments.

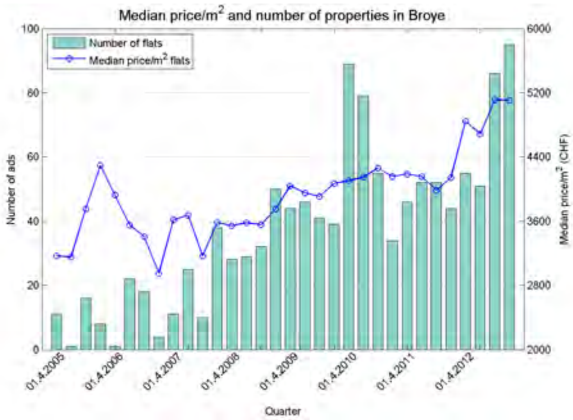


(b) Medium size apartments.

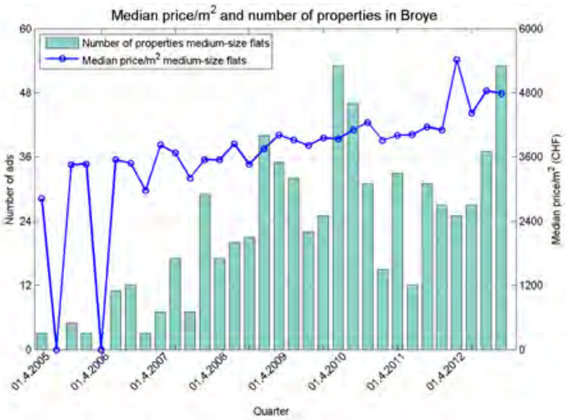


(c) Medium size houses.

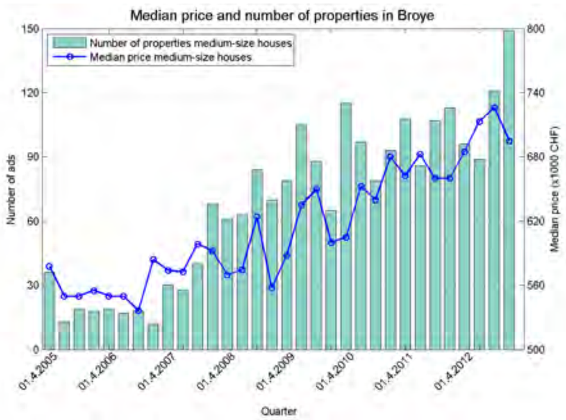
Figure D.54: Development of prices in Kanton Zug.



(a) All apartments.

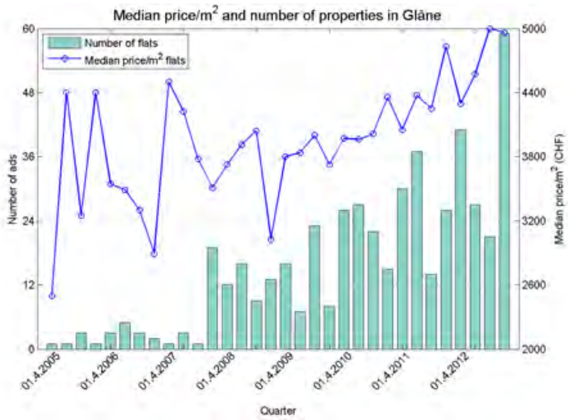


(b) Medium size apartments.

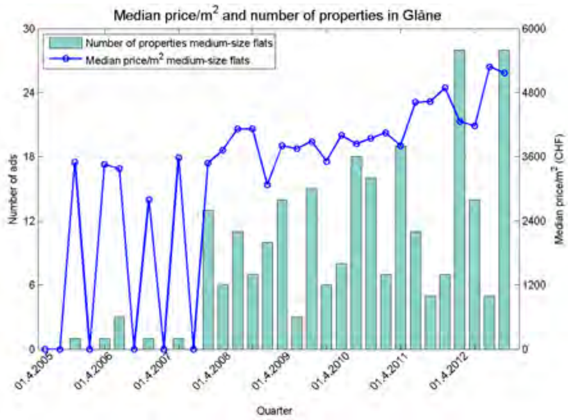


(c) Medium size houses.

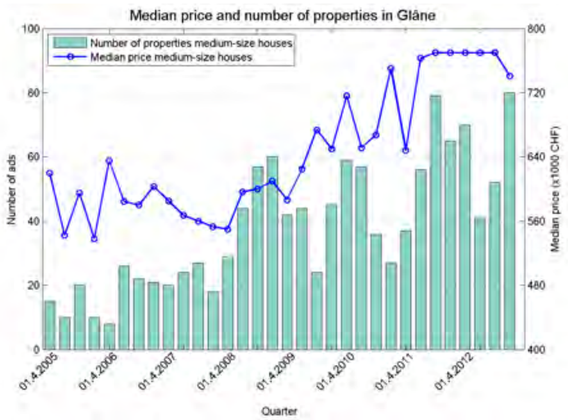
Figure D.55: Development of prices in Broye.



(a) All apartments.

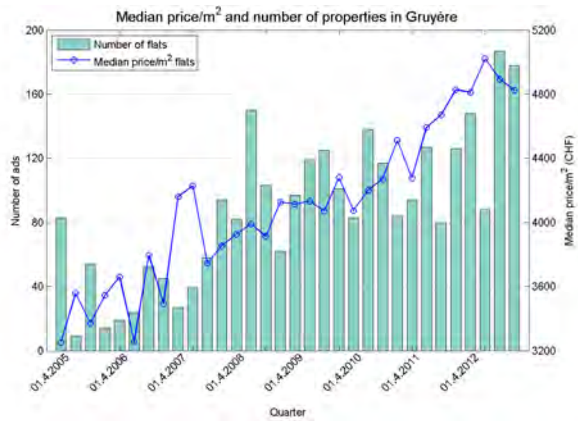


(b) Medium size apartments.

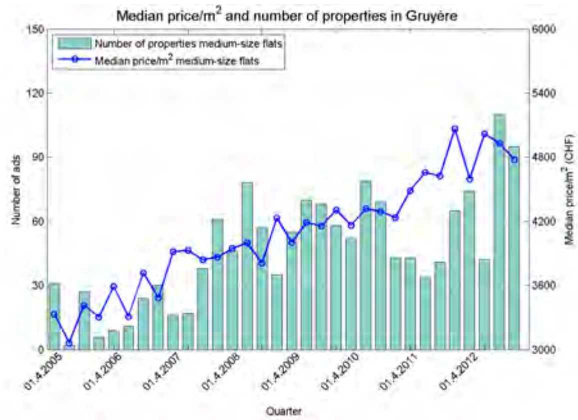


(c) Medium size houses.

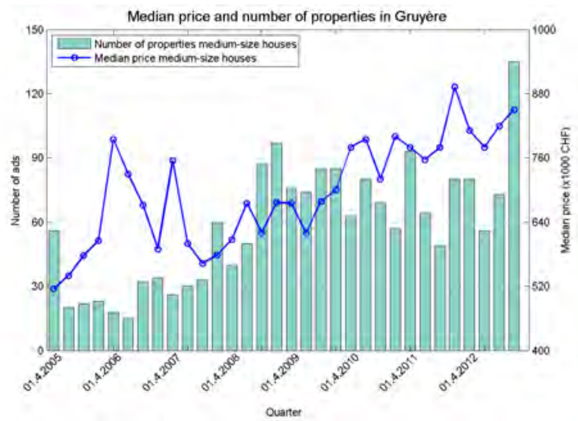
Figure D.56: Development of prices in Glâne.



(a) All apartments.

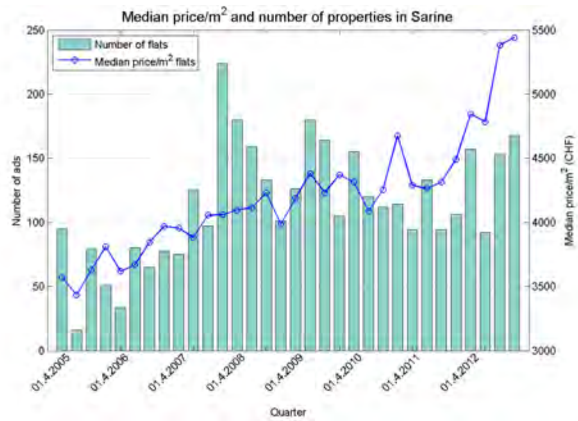


(b) Medium size apartments.

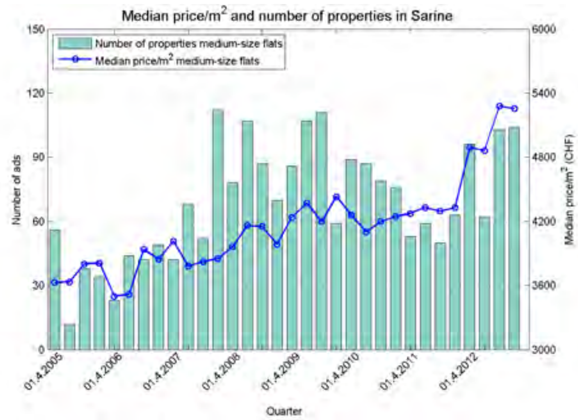


(c) Medium size houses.

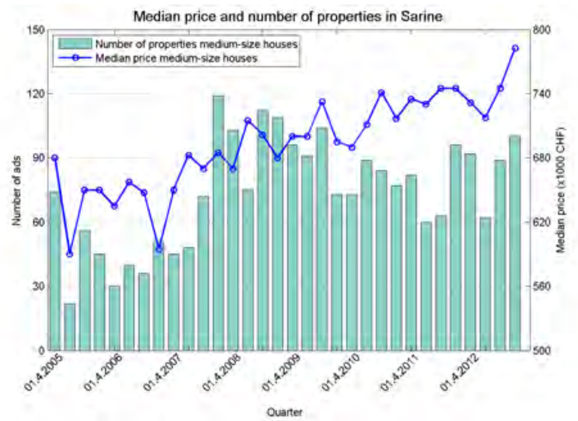
Figure D.57: Development of prices in Gruyère.



(a) All apartments.

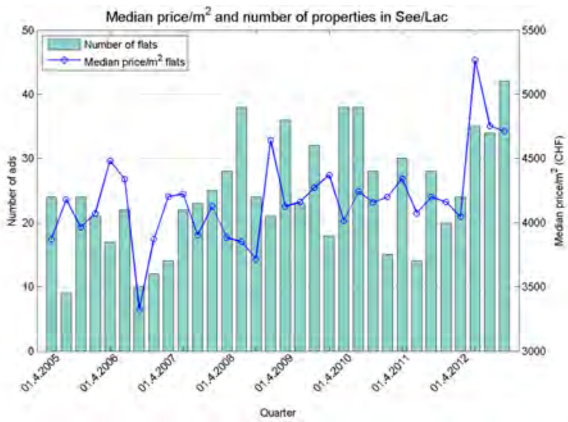


(b) Medium size apartments.

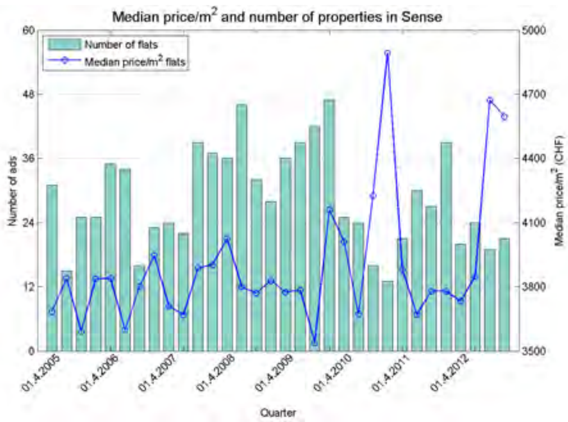


(c) Medium size houses.

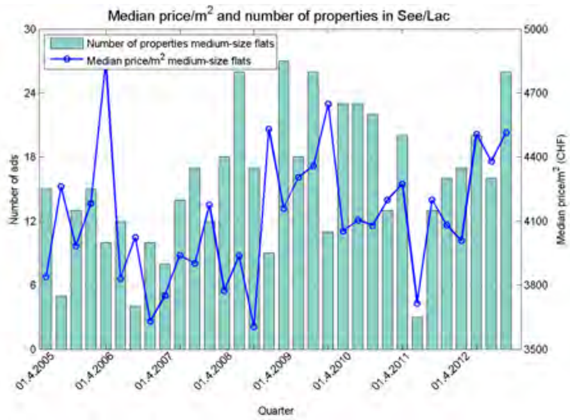
Figure D.58: Development of prices in Sarine.



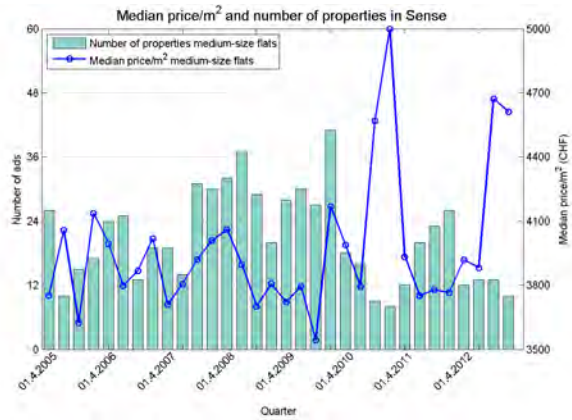
(a) All apartments.



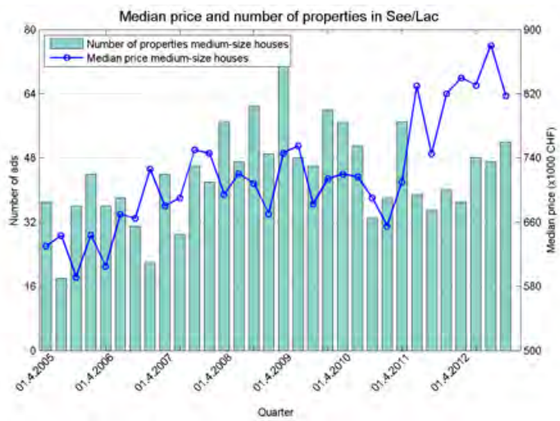
(a) All apartments.



(b) Medium size apartments.

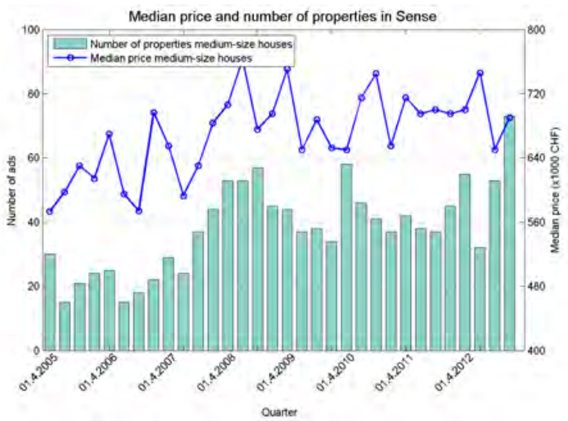


(b) Medium size apartments.



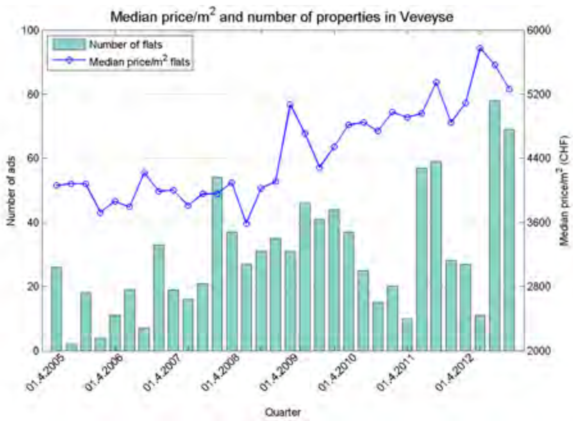
(c) Medium size houses.

Figure D.59: Development of prices in See/Lac.

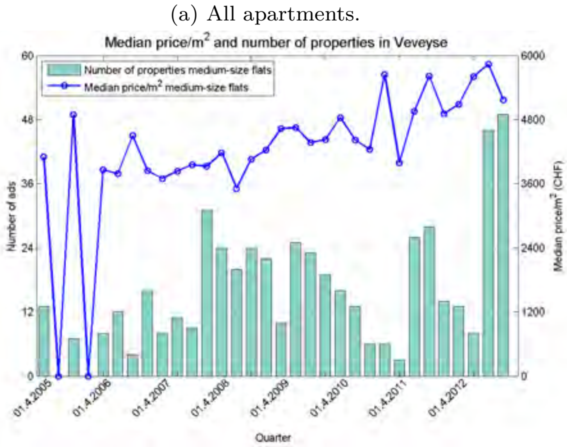


(c) Medium size houses.

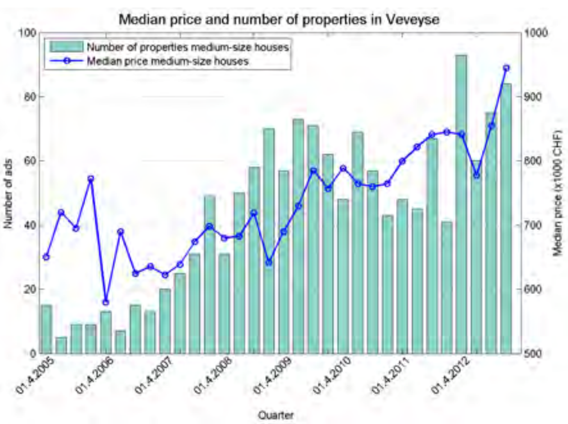
Figure D.60: Development of prices in Sense.



(a) All apartments.

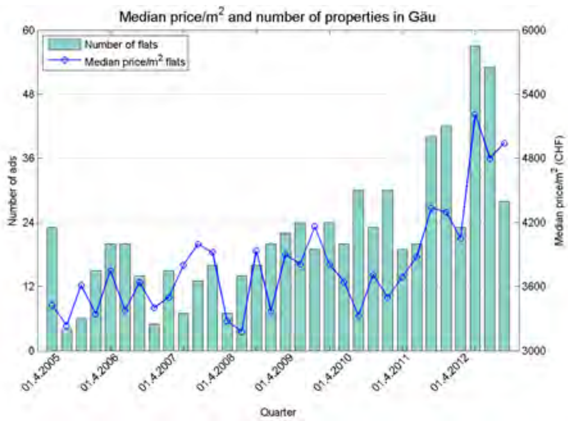


(b) Medium size apartments.

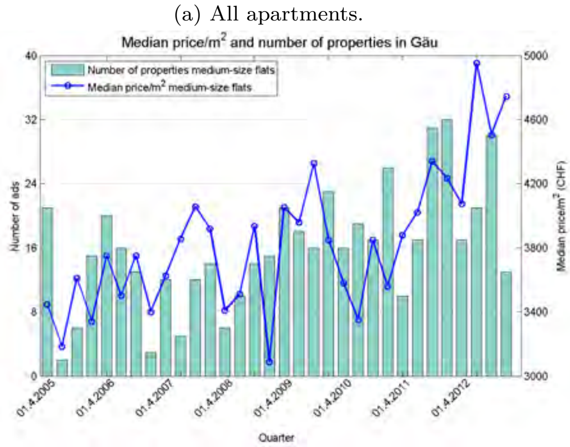


(c) Medium size houses.

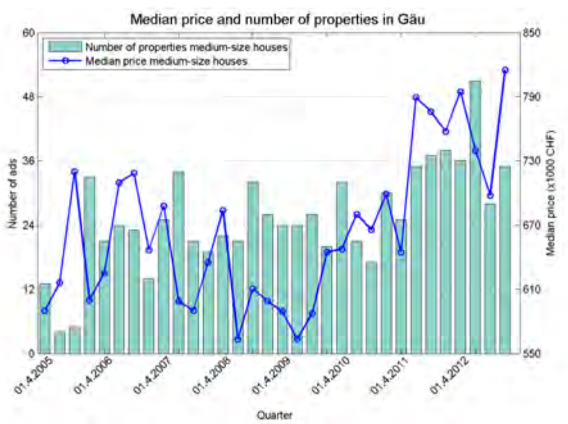
Figure D.61: Development of prices in Veveyse.



(a) All apartments.

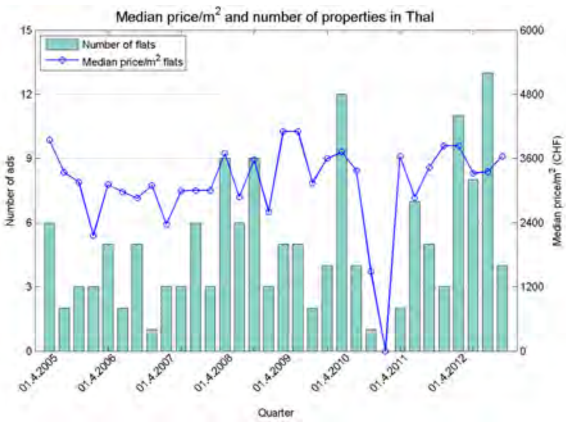


(b) Medium size apartments.

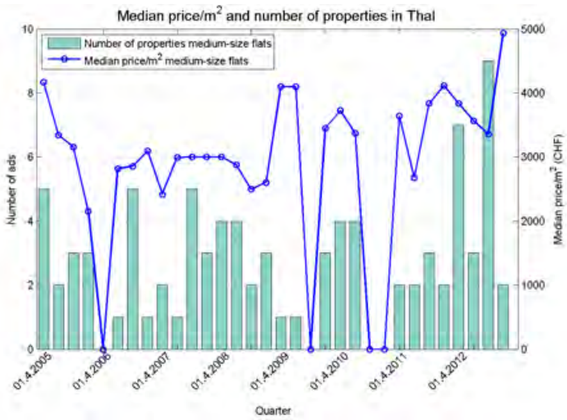


(c) Medium size houses.

Figure D.62: Development of prices in Gäu.



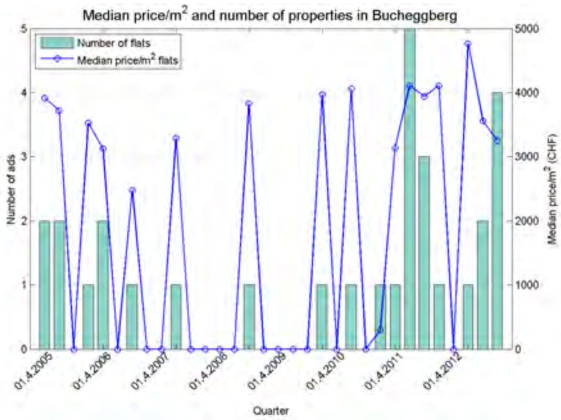
(a) All apartments.



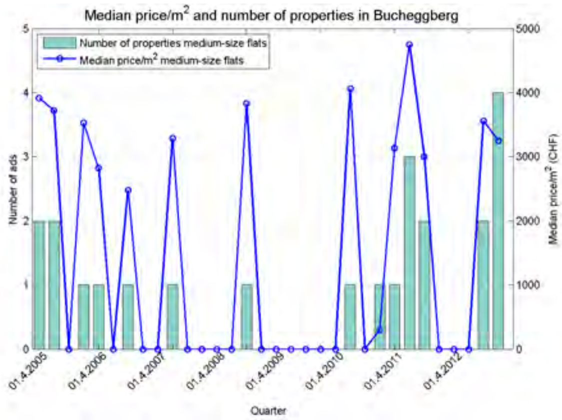
(b) Medium size apartments.

(c) Medium size houses.

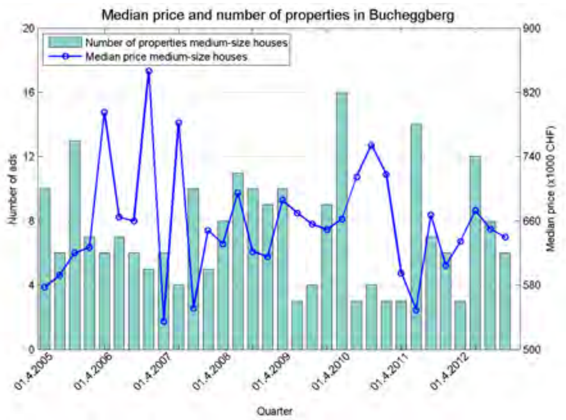
Figure D.63: Development of prices in Thal.



(a) All apartments.

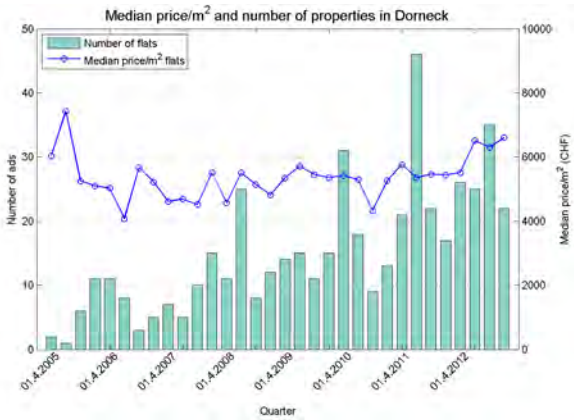


(b) Medium size apartments.

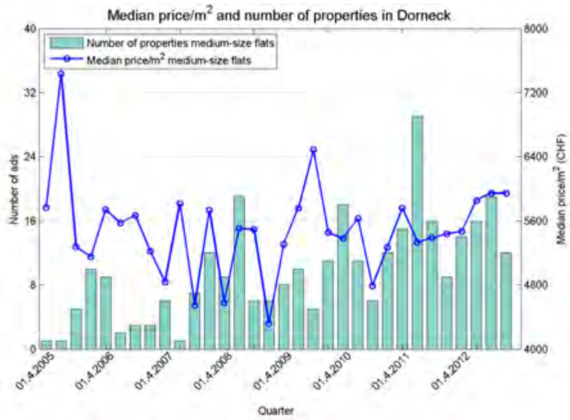


(c) Medium size houses.

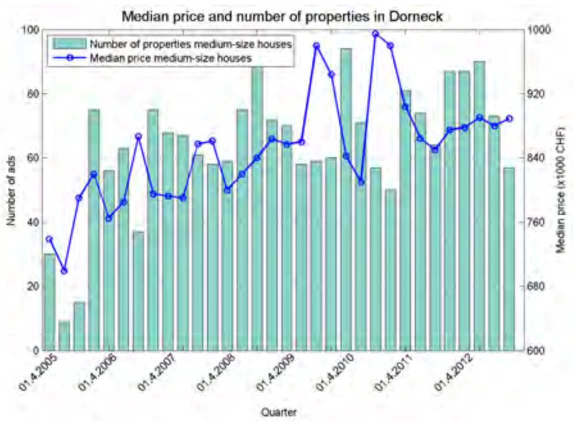
Figure D.64: Development of prices in Bucheggberg.



(a) All apartments.

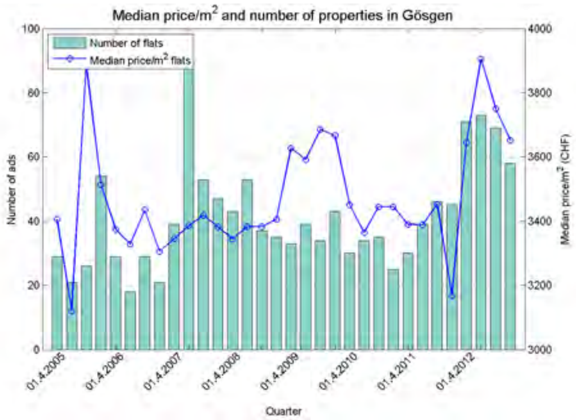


(b) Medium size apartments.

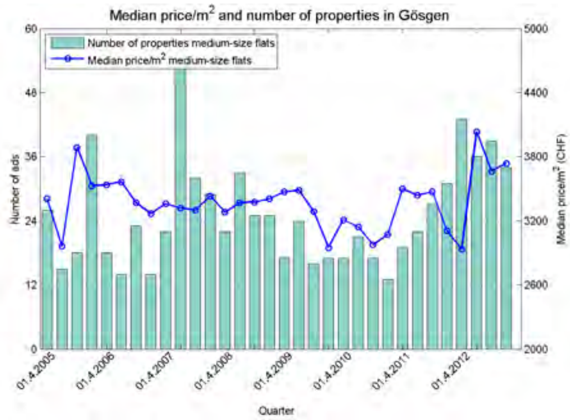


(c) Medium size houses.

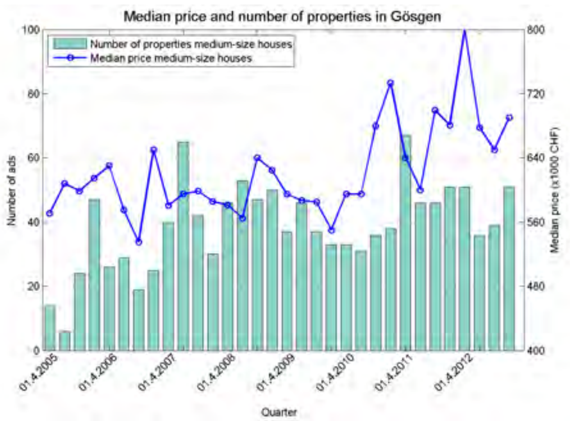
Figure D.65: Development of prices in Dorneck.



(a) All apartments.

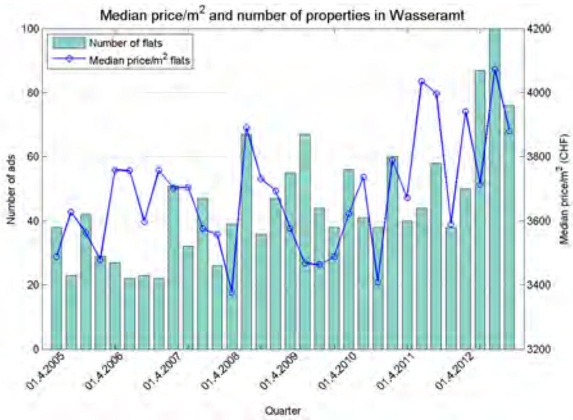


(b) Medium size apartments.

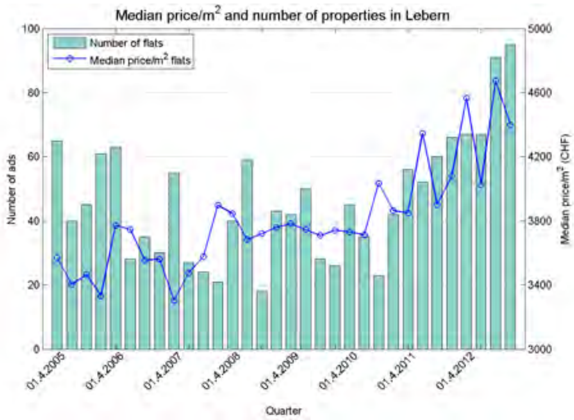


(c) Medium size houses.

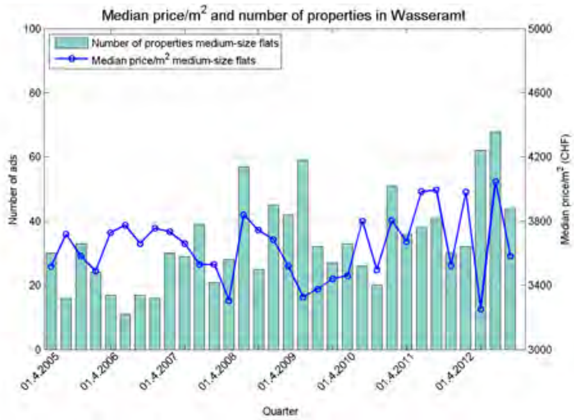
Figure D.66: Development of prices in Gösgen.



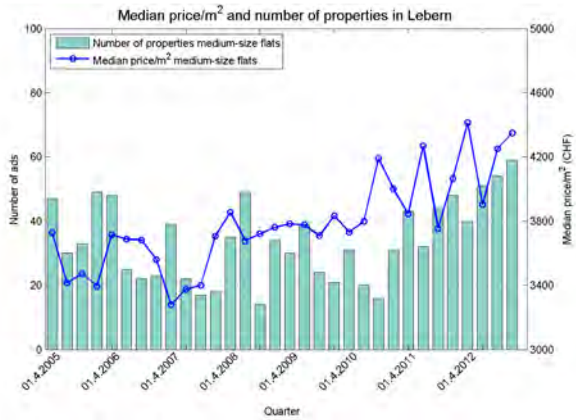
(a) All apartments.



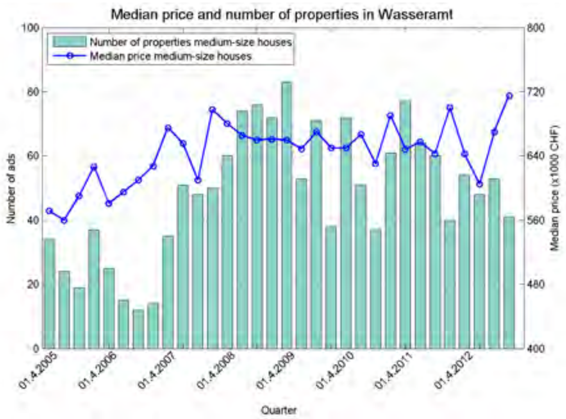
(a) All apartments.



(b) Medium size apartments.

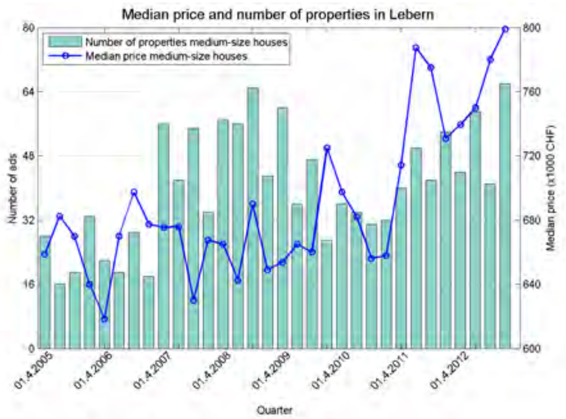


(b) Medium size apartments.



(c) Medium size houses.

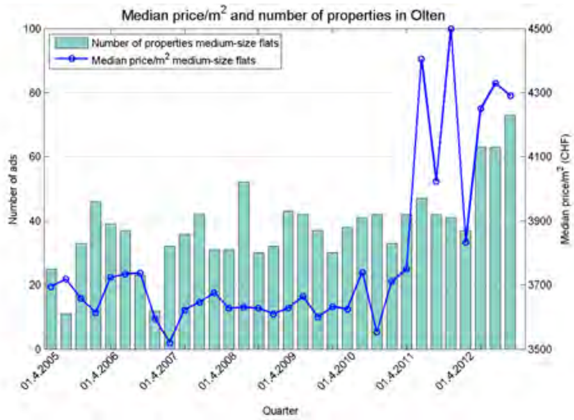
Figure D.67: Development of prices in Wasseramt.



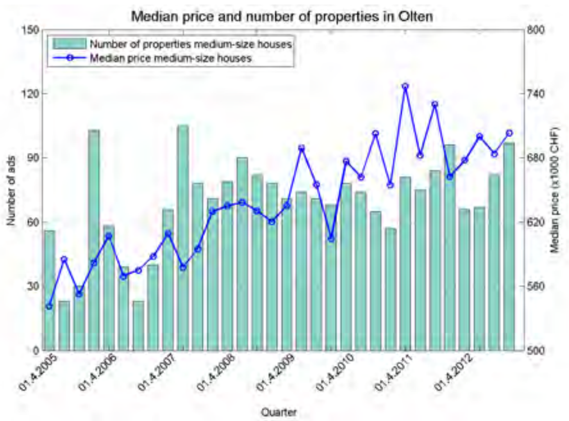
(c) Medium size houses.

Figure D.68: Development of prices in Lebern.

(a) All apartments.

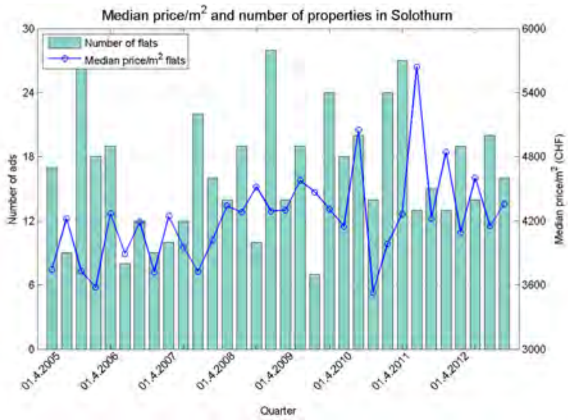


(b) Medium size apartments.

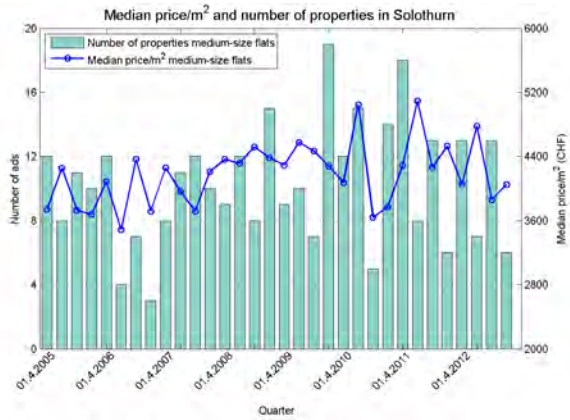


(c) Medium size houses.

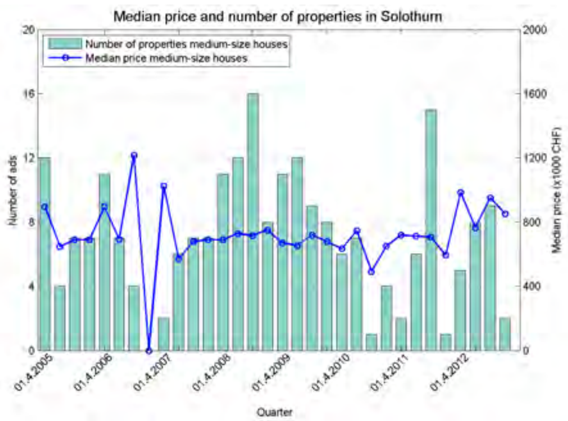
Figure D.69: Development of prices in Olten.



(a) All apartments.

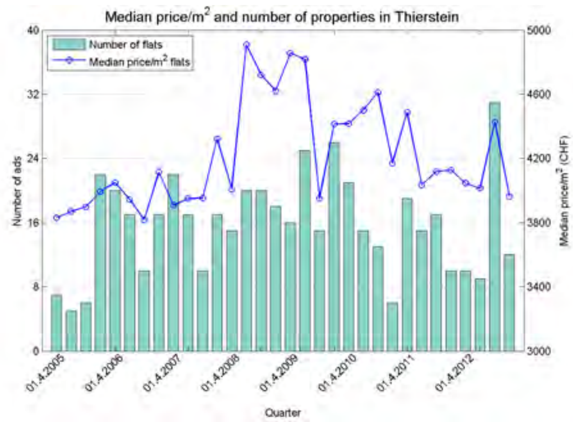


(b) Medium size apartments.

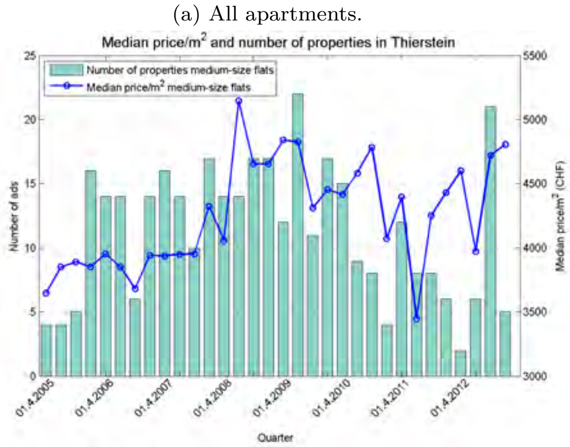


(c) Medium size houses.

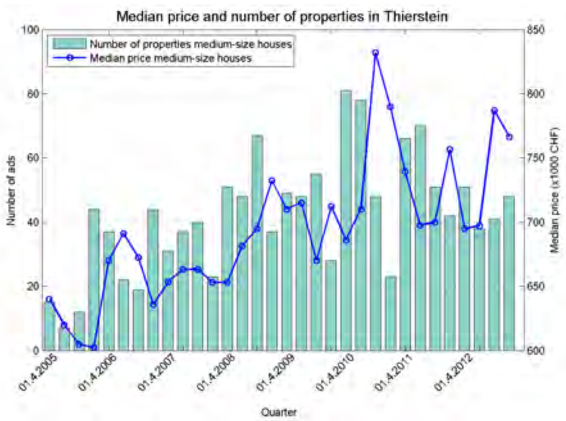
Figure D.70: Development of prices in Solothurn.



(a) All apartments.

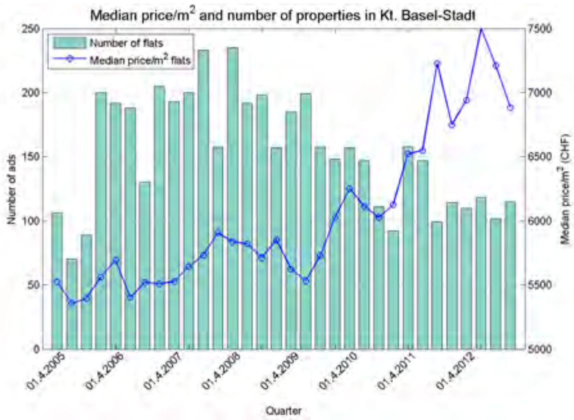


(b) Medium size apartments.

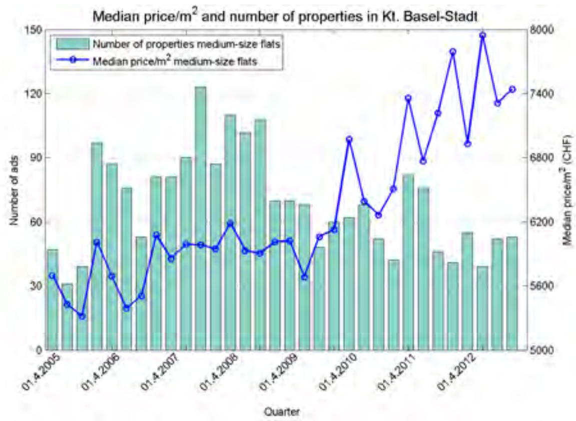


(c) Medium size houses.

Figure D.71: Development of prices in Thierstein.



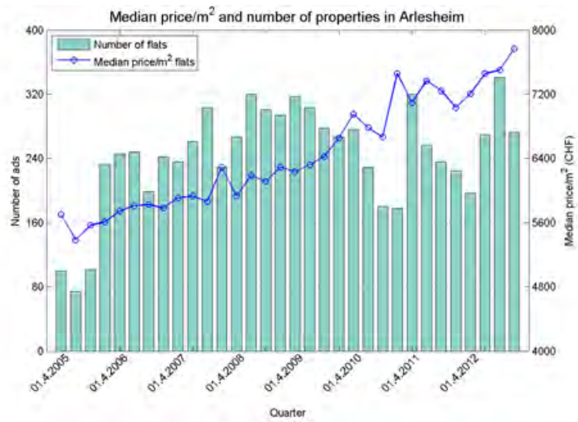
(a) All apartments.



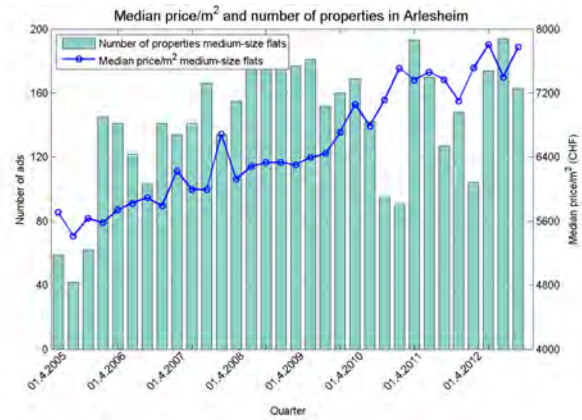
(b) Medium size apartments.

(c) Medium size houses.

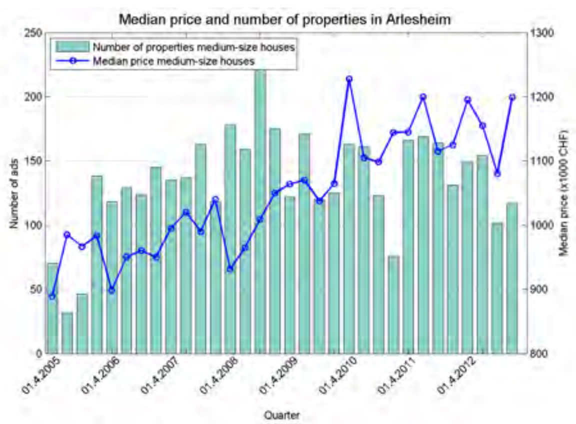
Figure D.72: Development of prices in Kt. Basel-Stadt.



(a) All apartments.

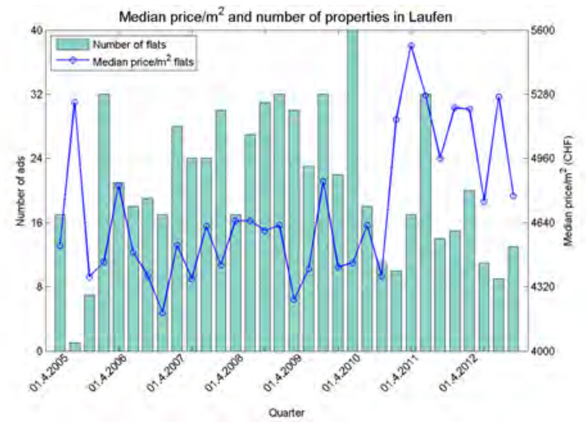


(b) Medium size apartments.

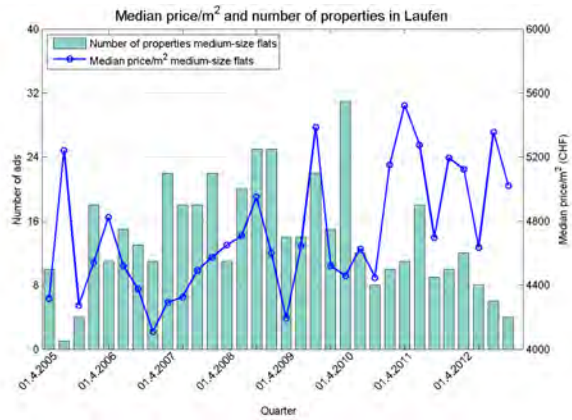


(c) Medium size houses.

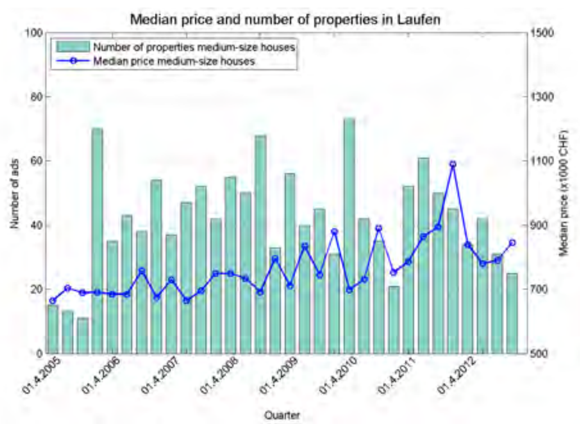
Figure D.73: Development of prices in Arlesheim.



(a) All apartments.

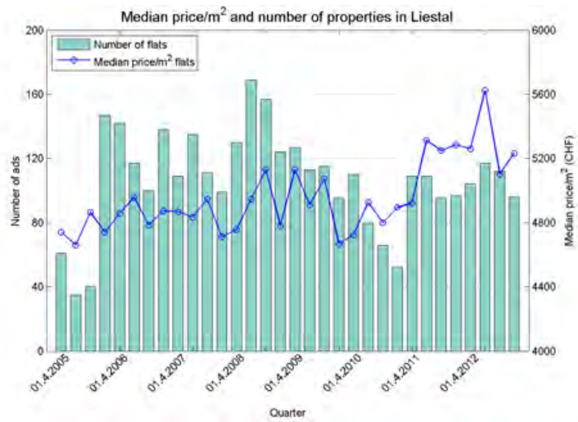


(b) Medium size apartments.

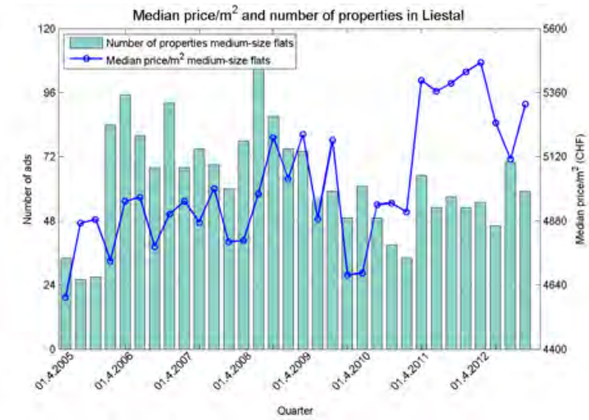


(c) Medium size houses.

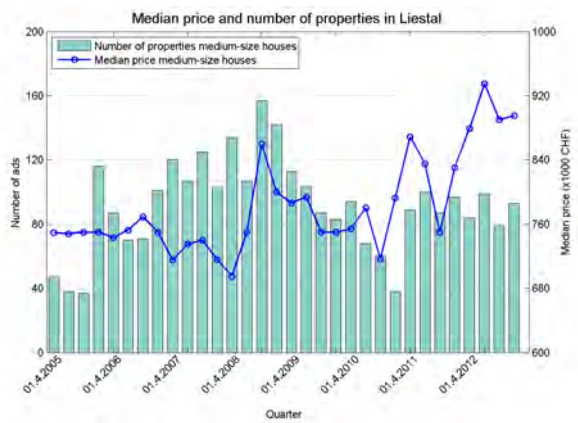
Figure D.74: Development of prices in Laufen.



(a) All apartments.

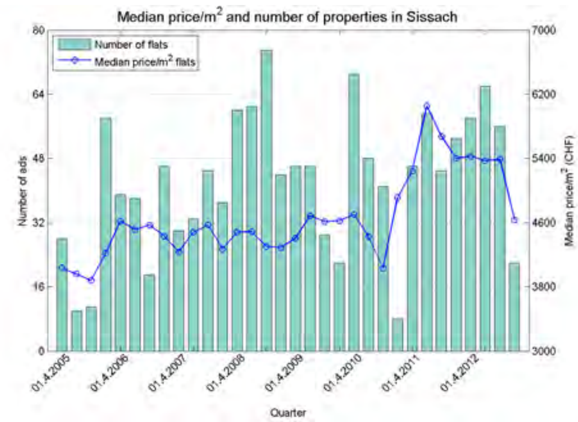


(b) Medium size apartments.

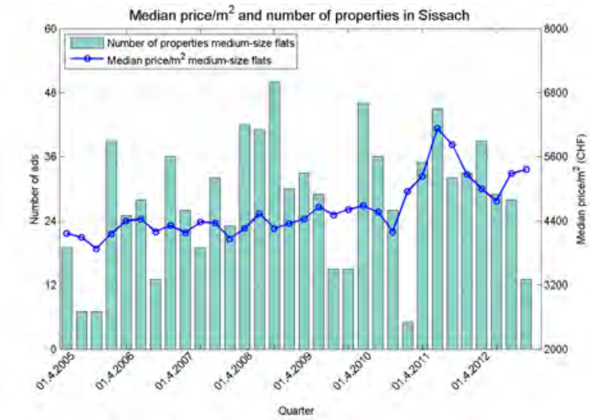


(c) Medium size houses.

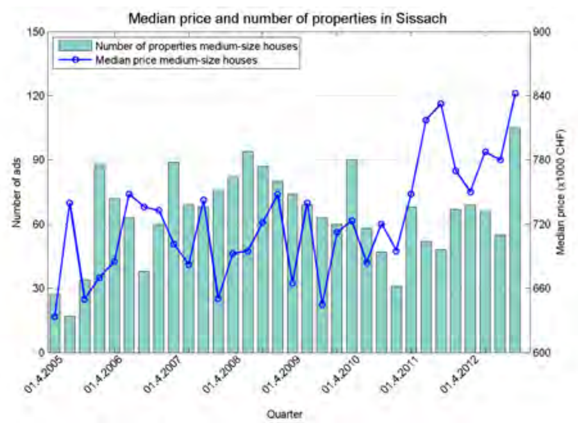
Figure D.75: Development of prices in Liestal.



(a) All apartments.

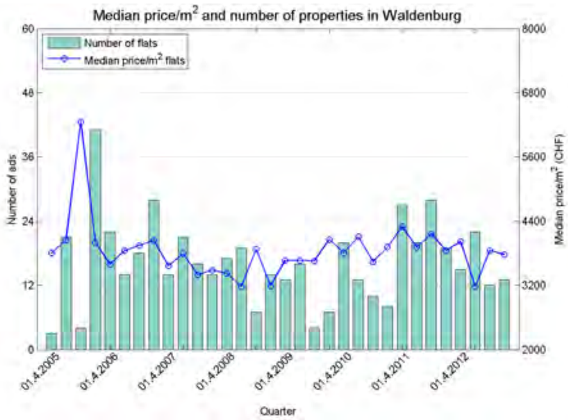


(b) Medium size apartments.

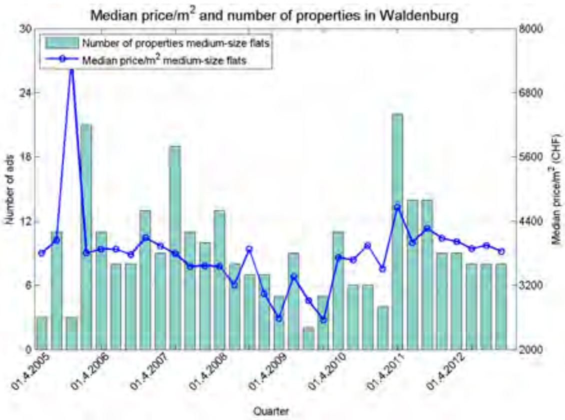


(c) Medium size houses.

Figure D.76: Development of prices in Sissach.



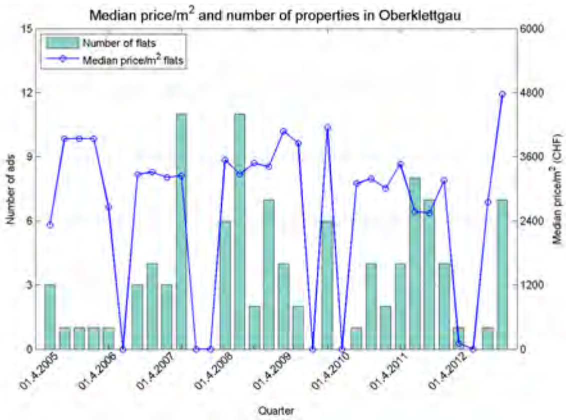
(a) All apartments.



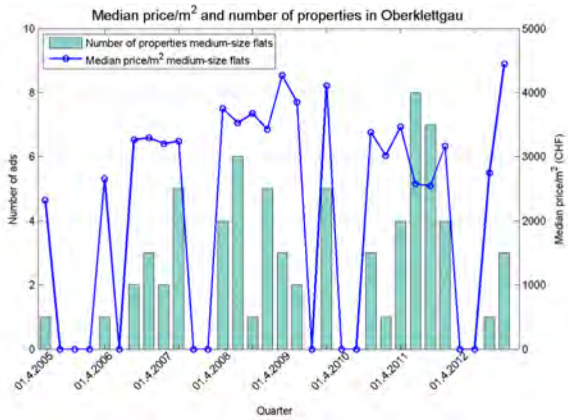
(b) Medium size apartments.

(c) Medium size houses.

Figure D.77: Development of prices in Waldenburg.



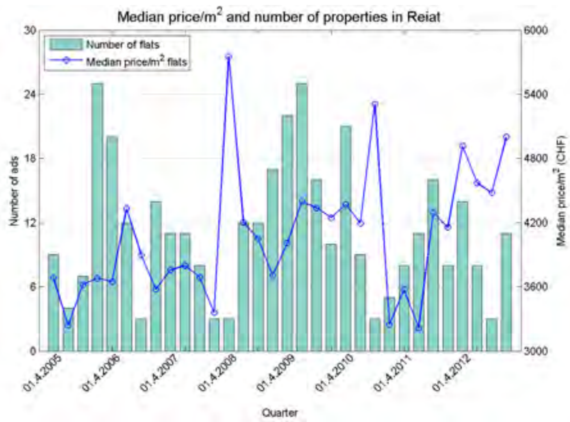
(a) All apartments.



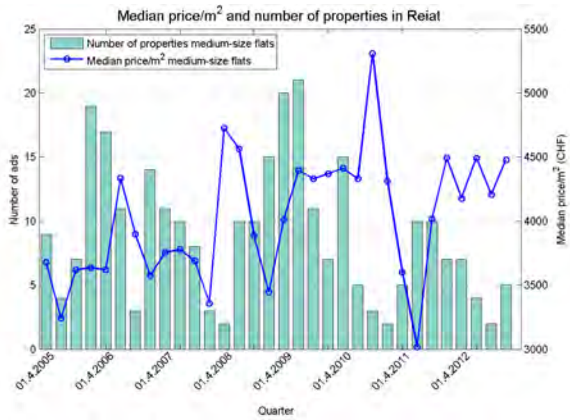
(b) Medium size apartments.

(c) Medium size houses.

Figure D.78: Development of prices in Oberklettgau.



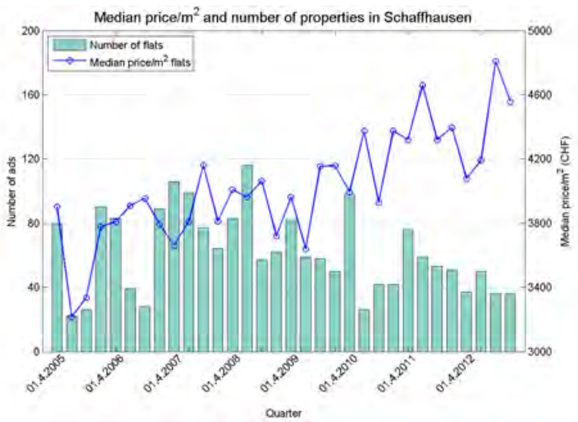
(a) All apartments.



(b) Medium size apartments.

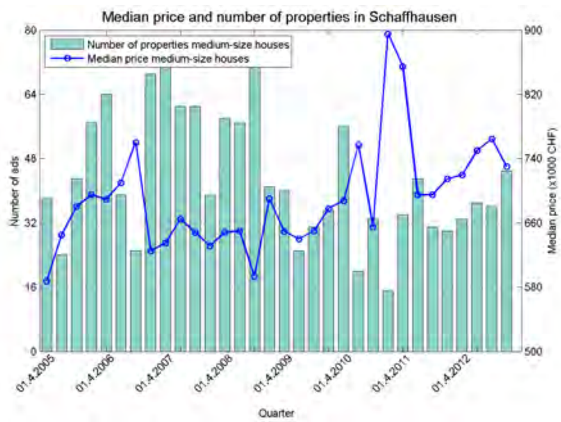
(c) Medium size houses.

Figure D.79: Development of prices in Reiat.



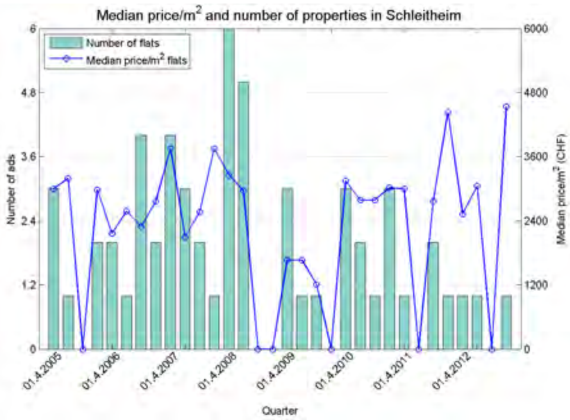
(a) All apartments.

(b) Medium size apartments.

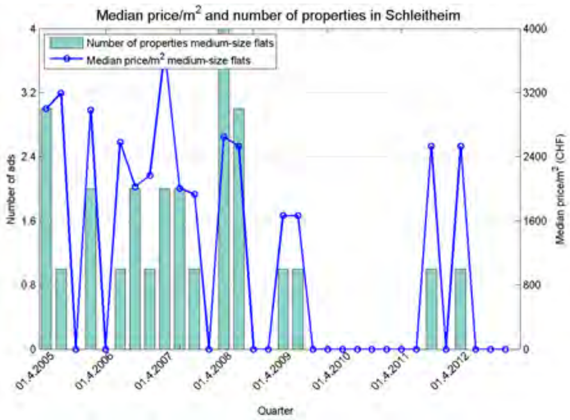


(c) Medium size houses.

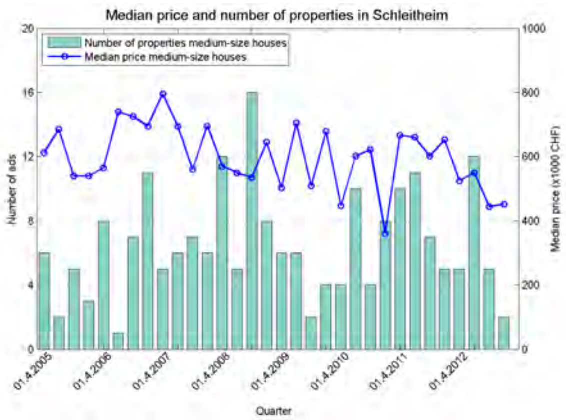
Figure D.80: Development of prices in Schaffhausen.



(a) All apartments.



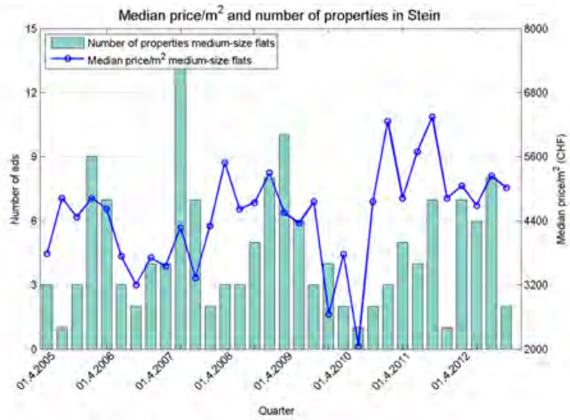
(b) Medium size apartments.



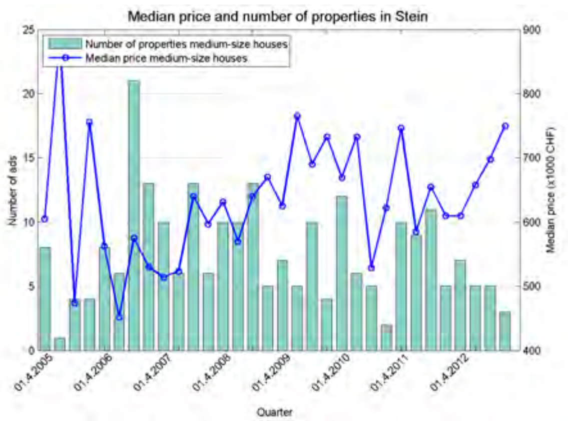
(c) Medium size houses.

Figure D.81: Development of prices in Schleitheim.

(a) All apartments.

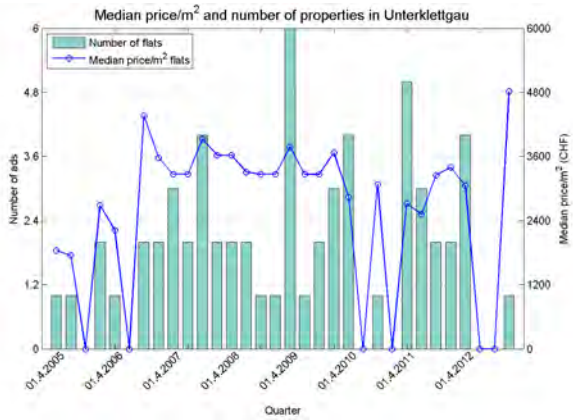


(b) Medium size apartments.

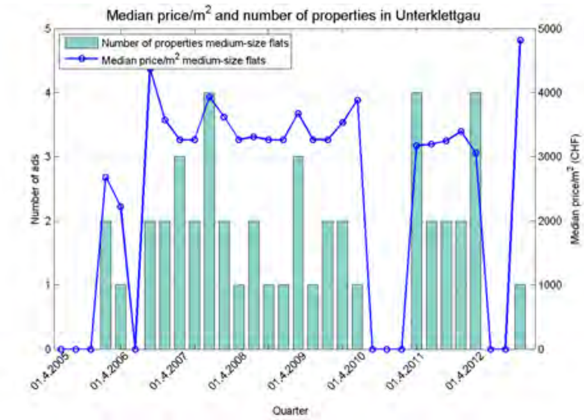


(c) Medium size houses.

Figure D.82: Development of prices in Stein.



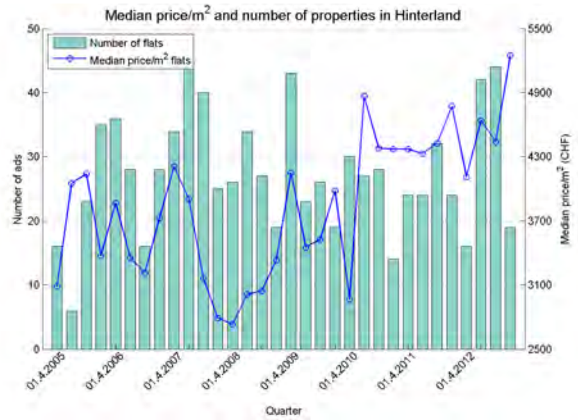
(a) All apartments.



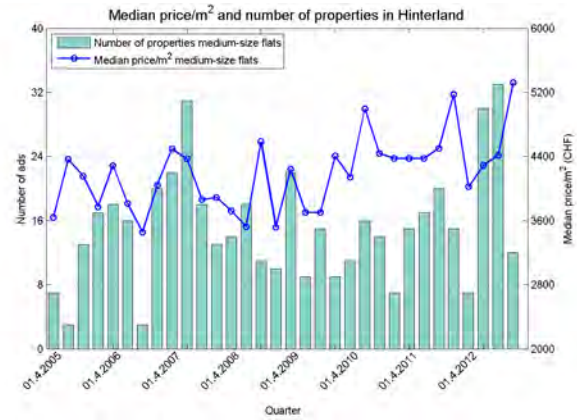
(b) Medium size apartments.

(c) Medium size houses.

Figure D.83: Development of prices in Unterklettgau.



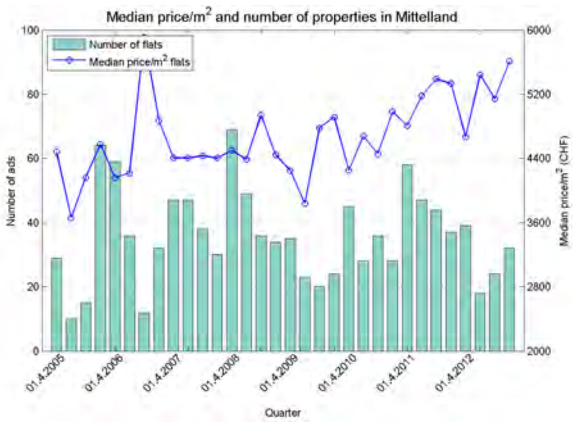
(a) All apartments.



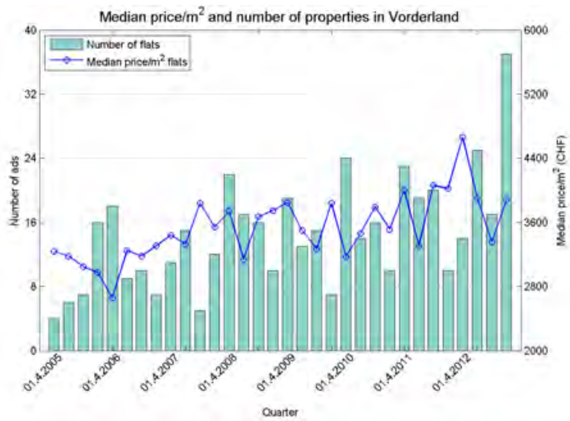
(b) Medium size apartments.

(c) Medium size houses.

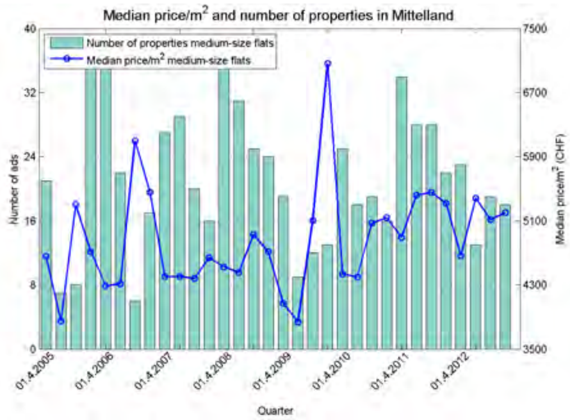
Figure D.84: Development of prices in Hinterland.



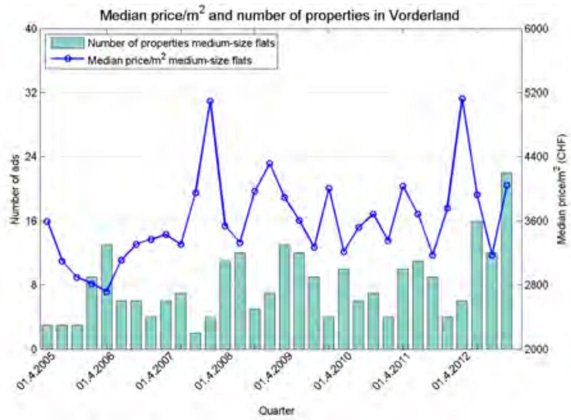
(a) All apartments.



(a) All apartments.

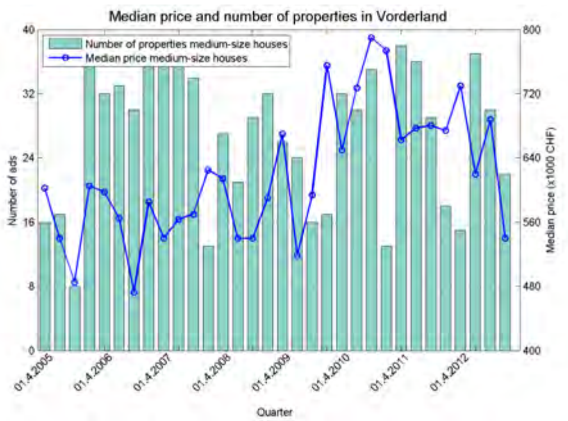


(b) Medium size apartments.



(b) Medium size apartments.

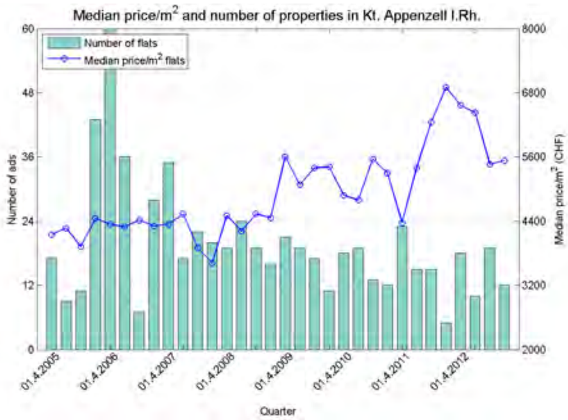
(c) Medium size houses.



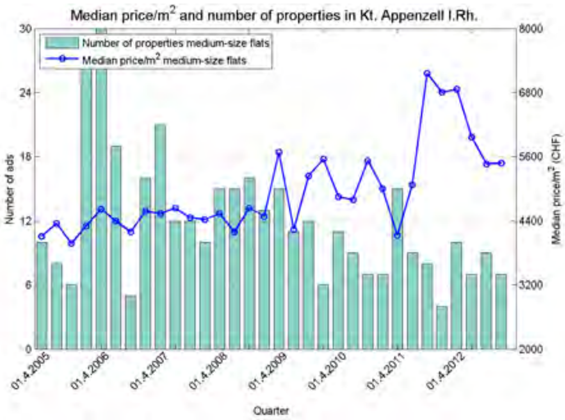
(c) Medium size houses.

Figure D.85: Development of prices in Mittelland.

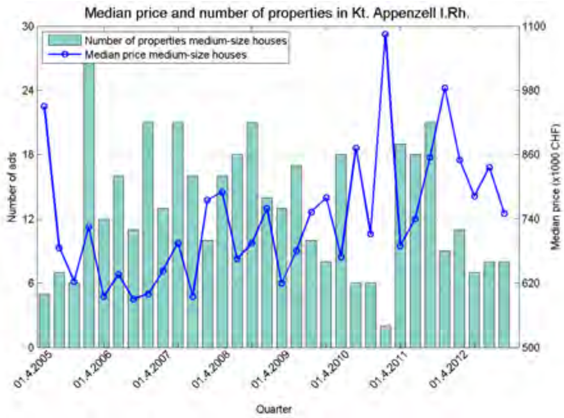
Figure D.86: Development of prices in Vorderland.



(a) All apartments.

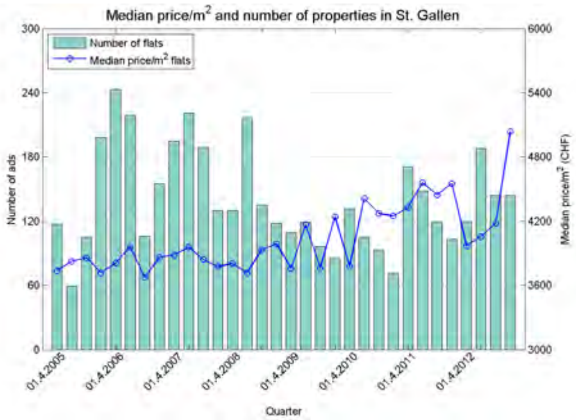


(b) Medium size apartments.

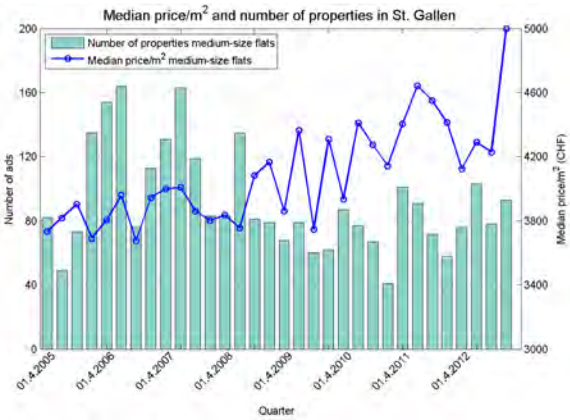


(c) Medium size houses.

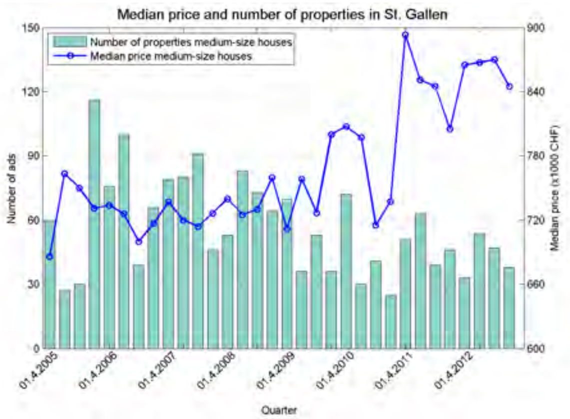
Figure D.87: Development of prices in Kt. Appenzell I.Rh..



(a) All apartments.

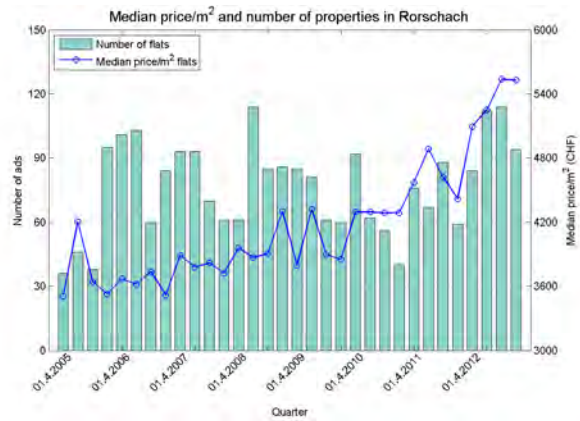


(b) Medium size apartments.

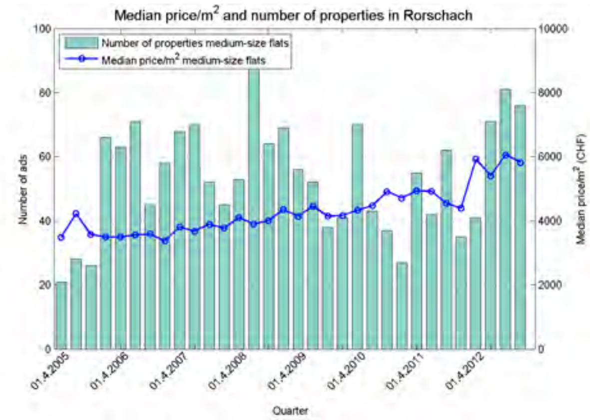


(c) Medium size houses.

Figure D.88: Development of prices in St. Gallen.



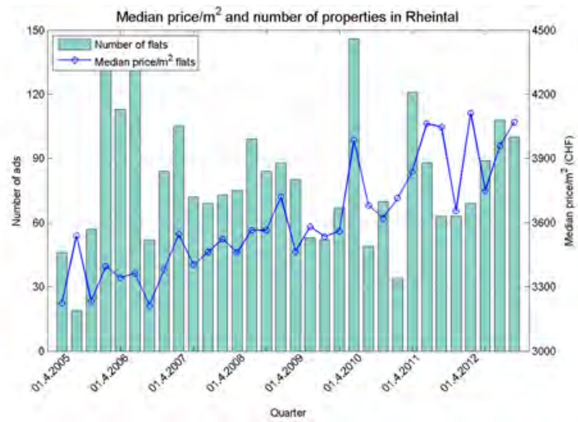
(a) All apartments.



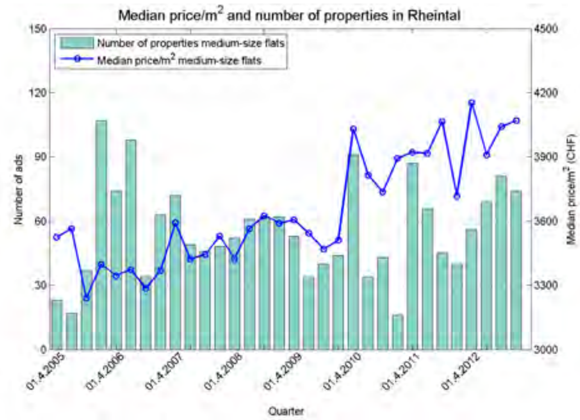
(b) Medium size apartments.

(c) Medium size houses.

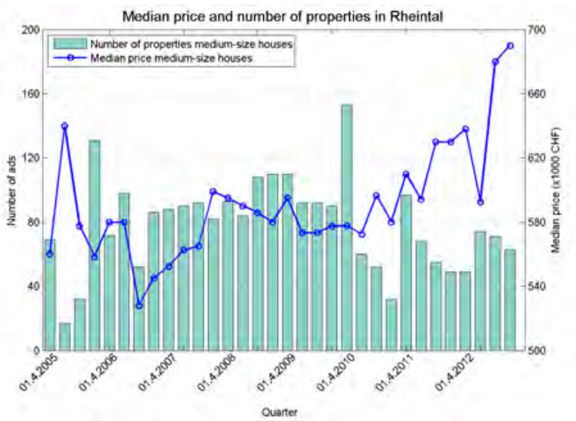
Figure D.89: Development of prices in Rorschach.



(a) All apartments.

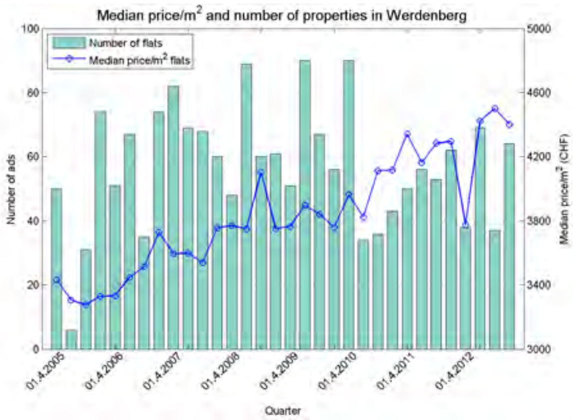


(b) Medium size apartments.

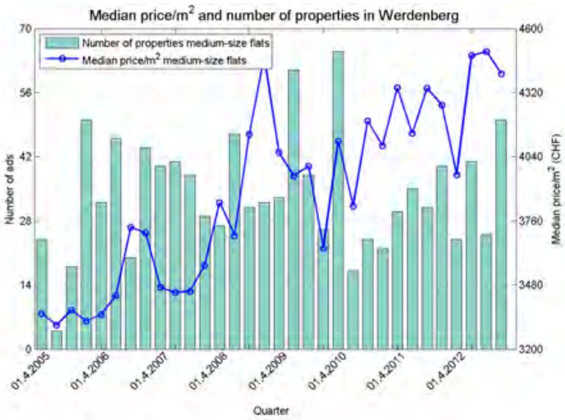


(c) Medium size houses.

Figure D.90: Development of prices in Rheintal.



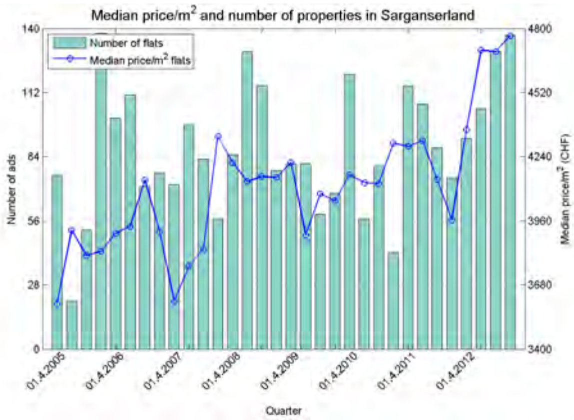
(a) All apartments.



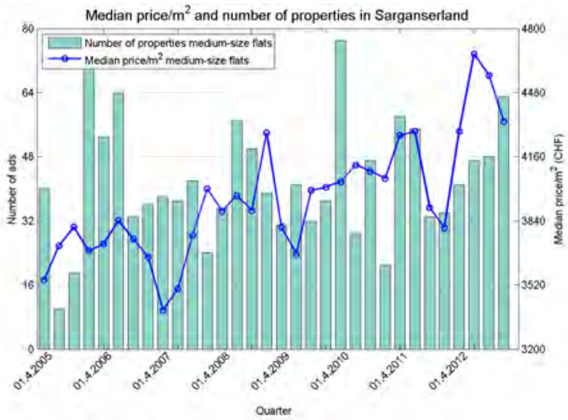
(b) Medium size apartments.

(c) Medium size houses.

Figure D.91: Development of prices in Werdenberg.



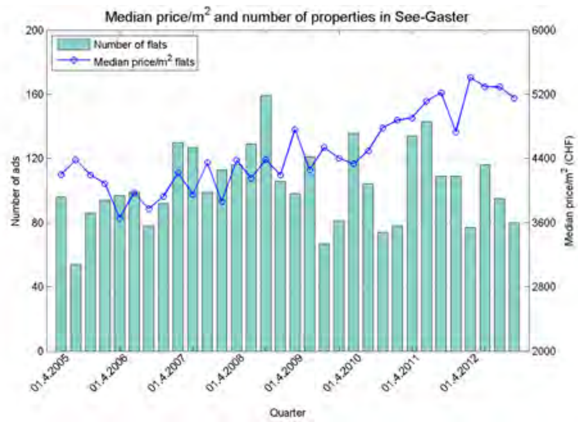
(a) All apartments.



(b) Medium size apartments.

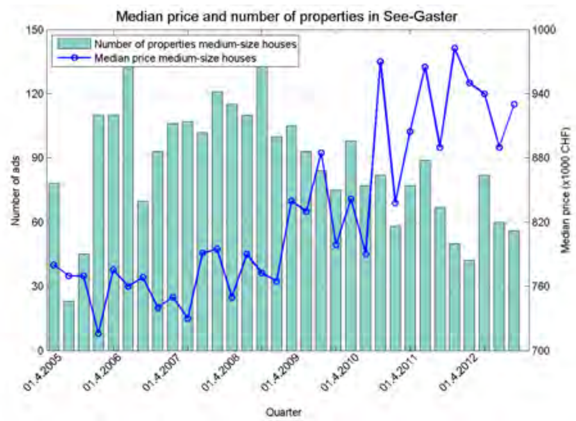
(c) Medium size houses.

Figure D.92: Development of prices in Sarganserland.



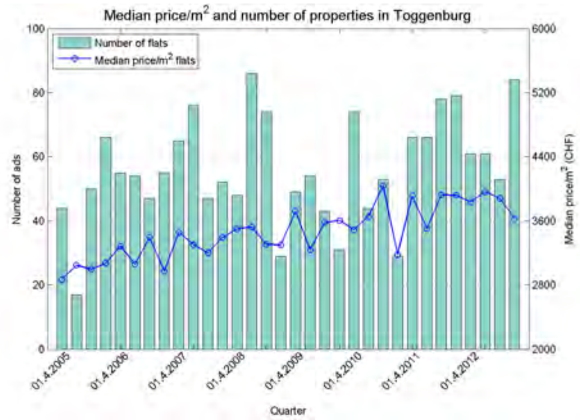
(a) All apartments.

(b) Medium size apartments.

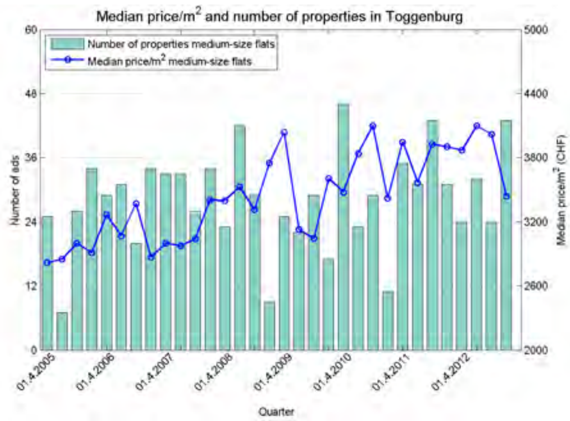


(c) Medium size houses.

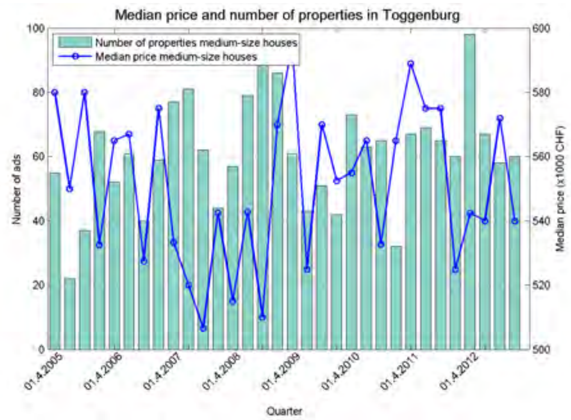
Figure D.93: Development of prices in See-Gaster.



(a) All apartments.

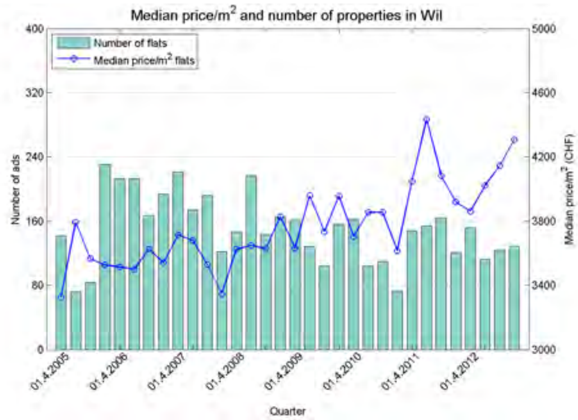


(b) Medium size apartments.

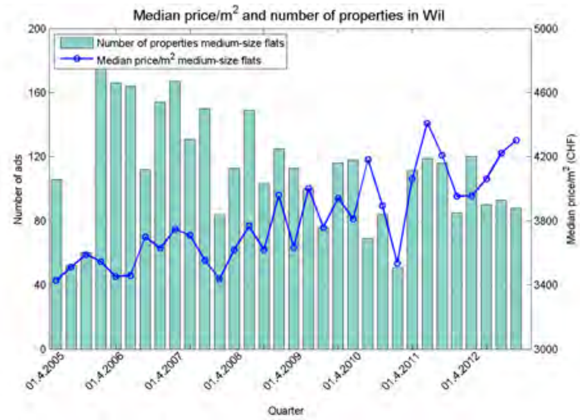


(c) Medium size houses.

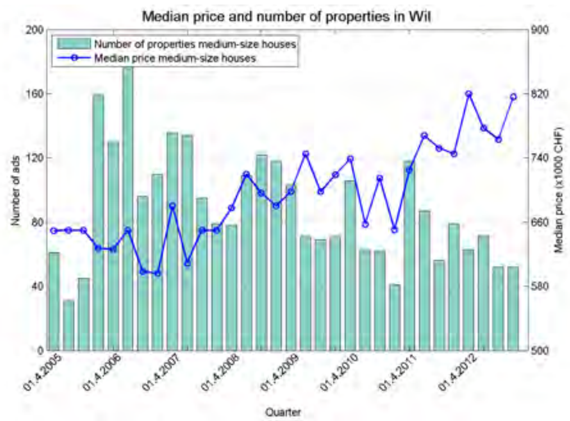
Figure D.94: Development of prices in Toggenburg.



(a) All apartments.

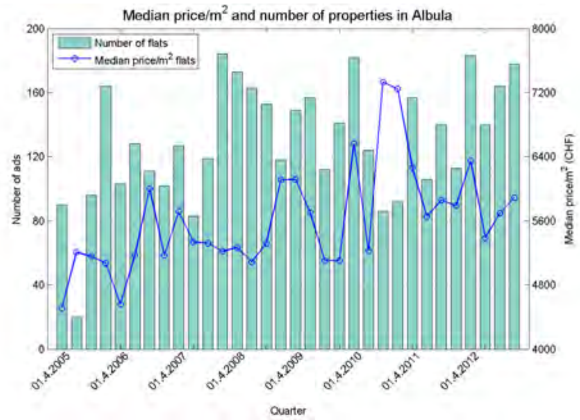


(b) Medium size apartments.

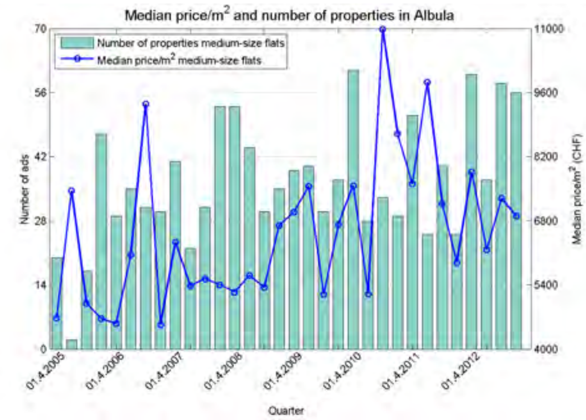


(c) Medium size houses.

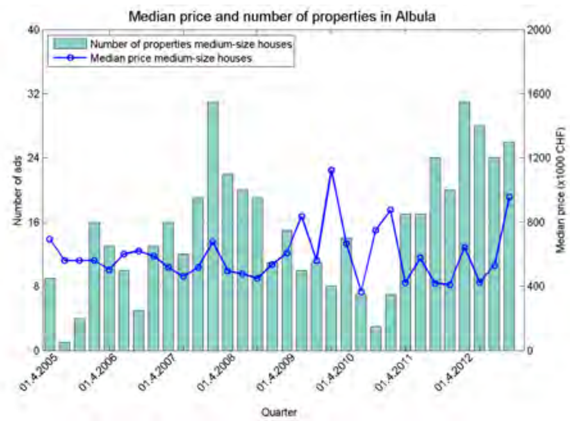
Figure D.95: Development of prices in Wil.



(a) All apartments.

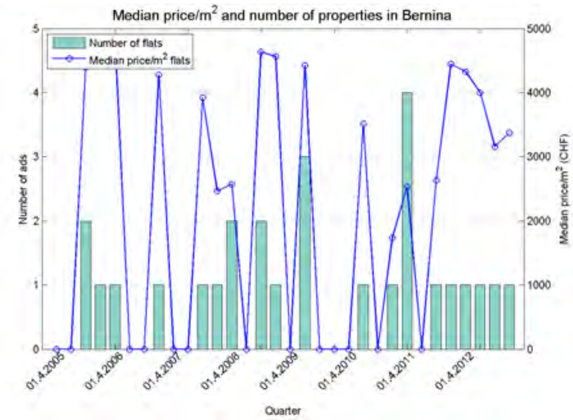


(b) Medium size apartments.

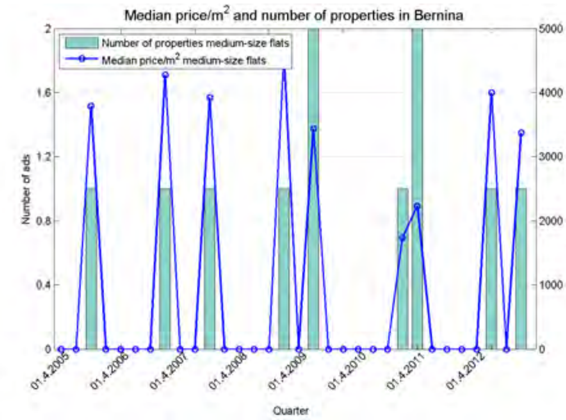


(c) Medium size houses.

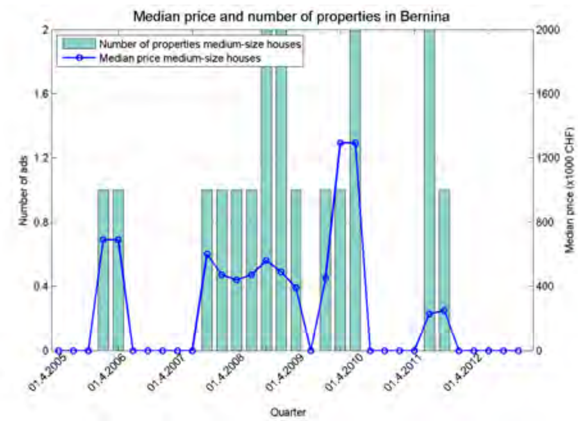
Figure D.96: Development of prices in Albula.



(a) All apartments.

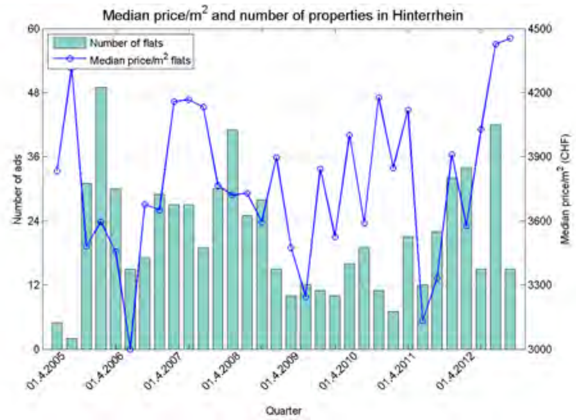


(b) Medium size apartments.

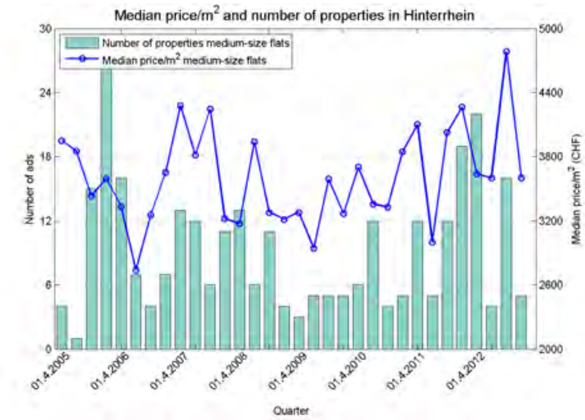


(c) Medium size houses.

Figure D.97: Development of prices in Bernina.



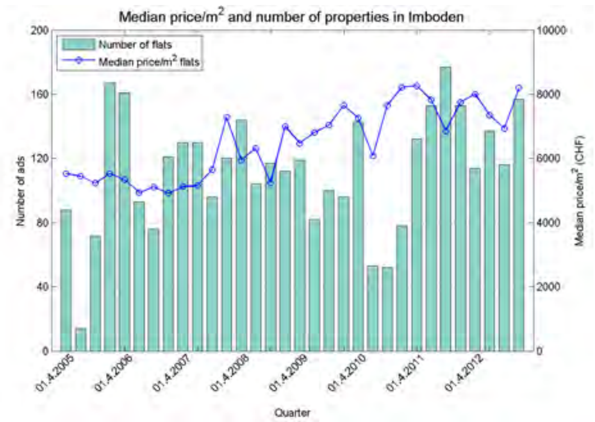
(a) All apartments.



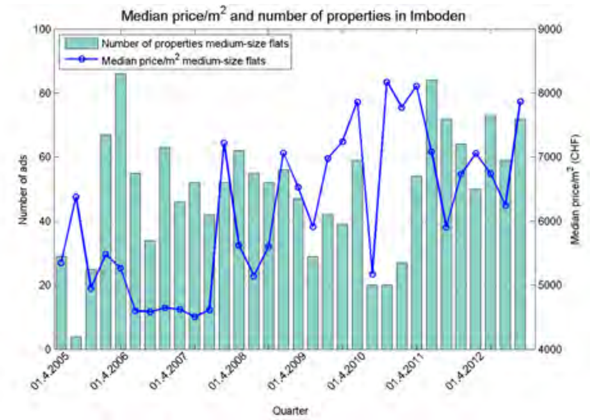
(b) Medium size apartments.

(c) Medium size houses.

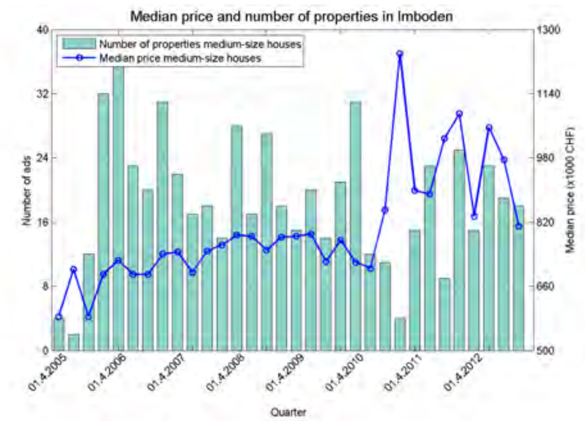
Figure D.98: Development of prices in Hinterrhein.



(a) All apartments.

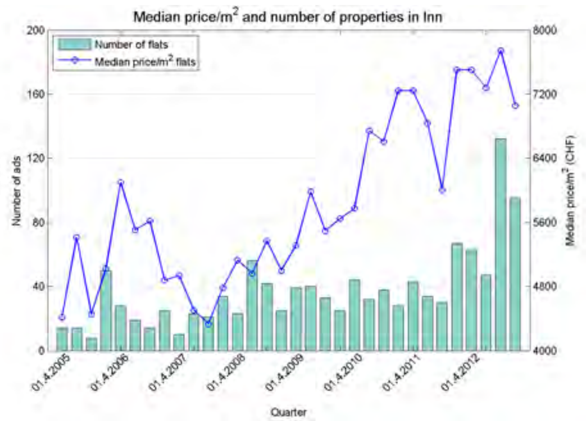


(b) Medium size apartments.

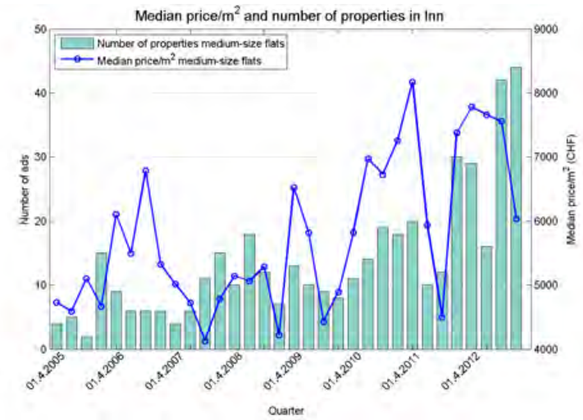


(c) Medium size houses.

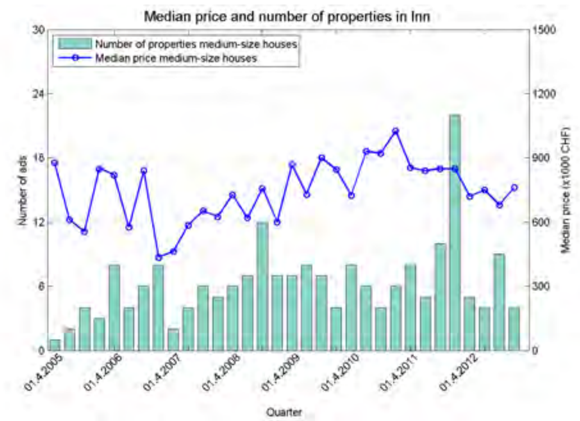
Figure D.99: Development of prices in Imboden.



(a) All apartments.

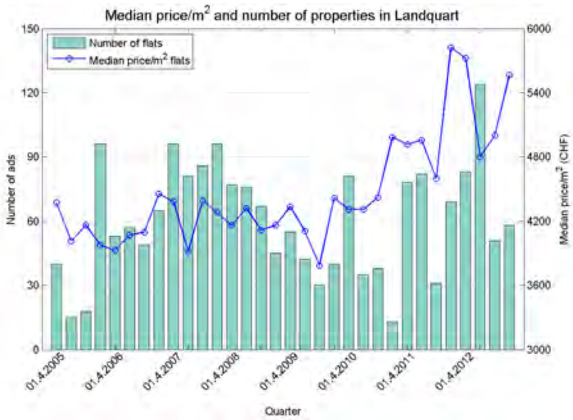


(b) Medium size apartments.

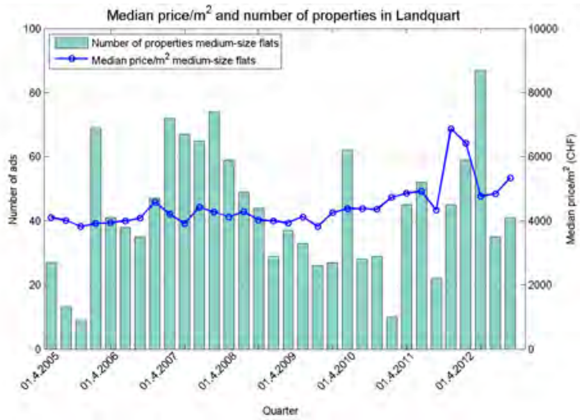


(c) Medium size houses.

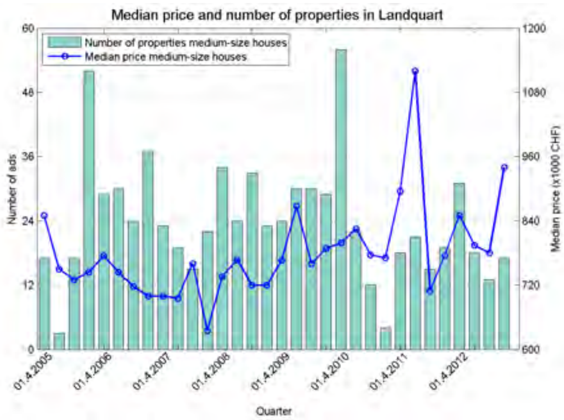
Figure D.100: Development of prices in Inn.



(a) All apartments.

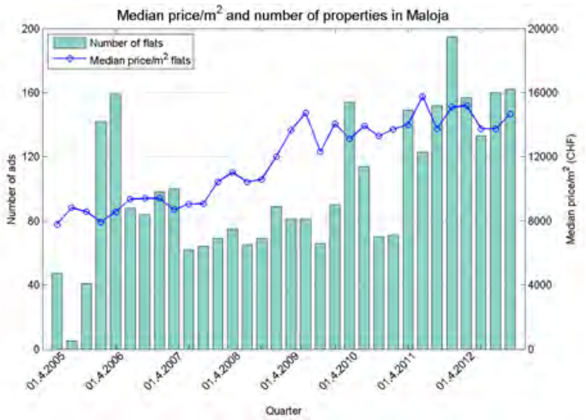


(b) Medium size apartments.

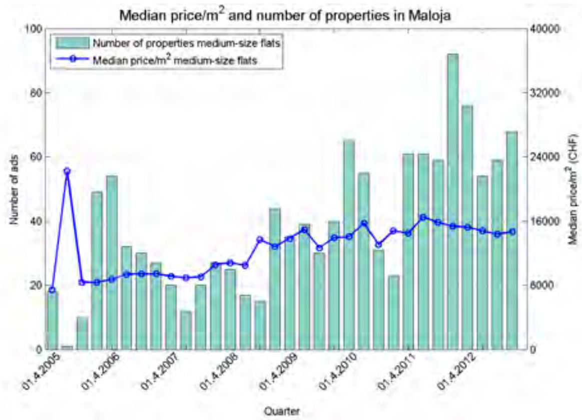


(c) Medium size houses.

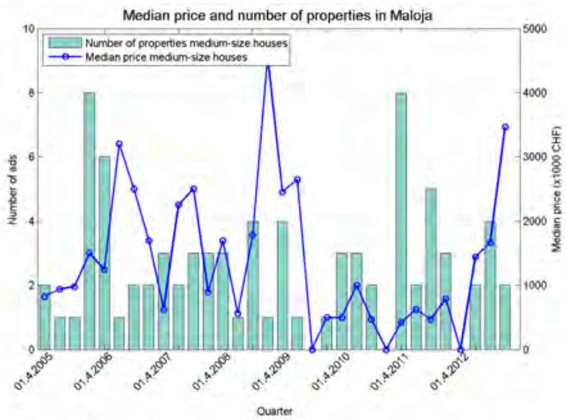
Figure D.101: Development of prices in Landquart.



(a) All apartments.

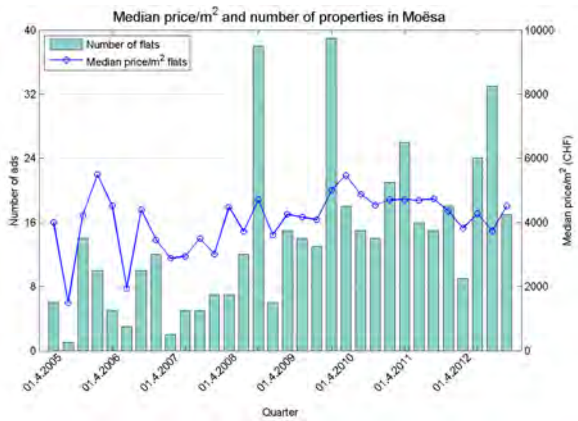


(b) Medium size apartments.

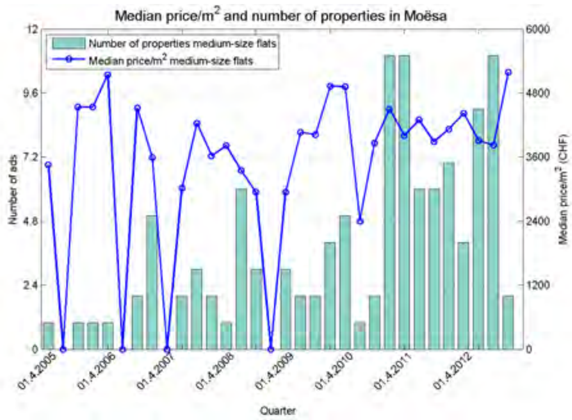


(c) Medium size houses.

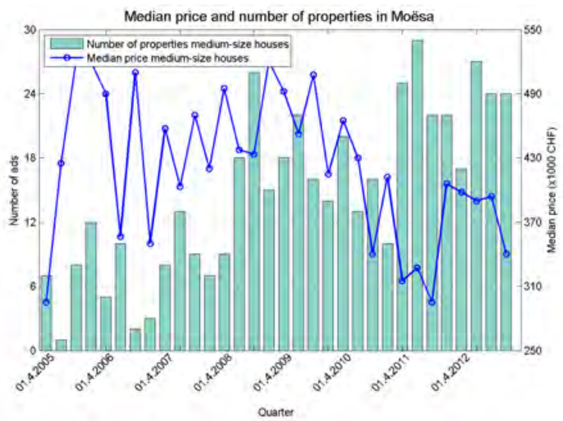
Figure D.102: Development of prices in Maloja.



(a) All apartments.

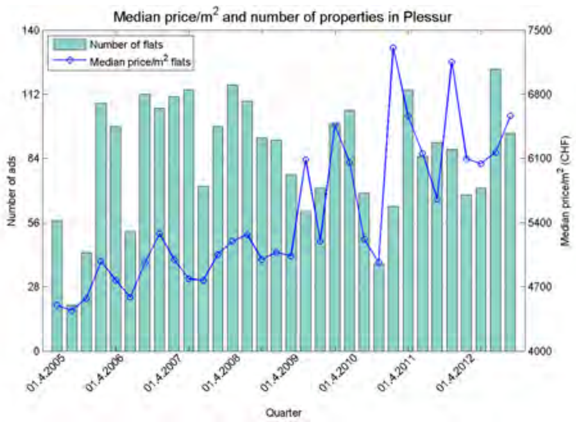


(b) Medium size apartments.

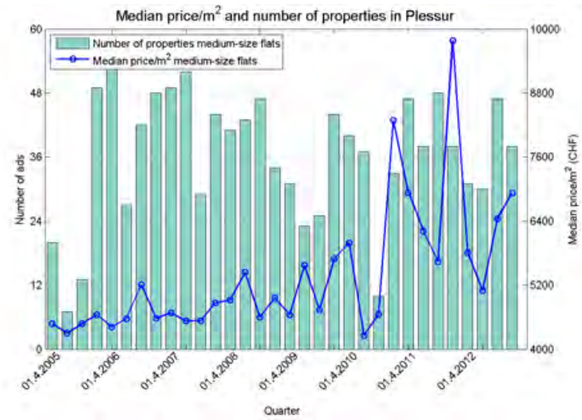


(c) Medium size houses.

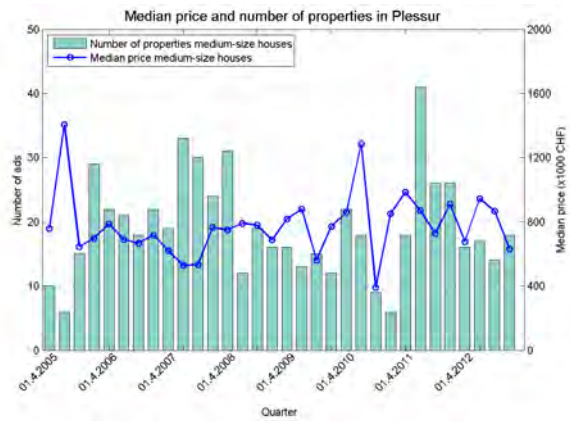
Figure D.103: Development of prices in Moësa.



(a) All apartments.

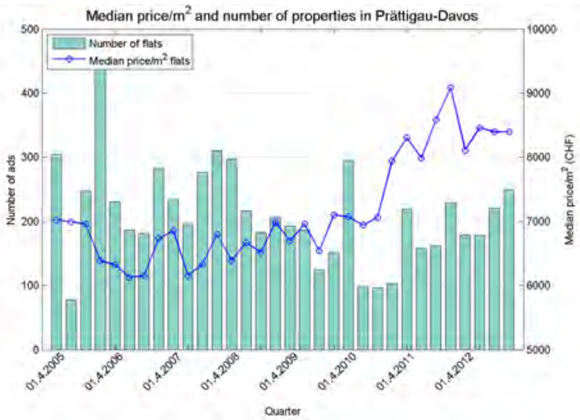


(b) Medium size apartments.

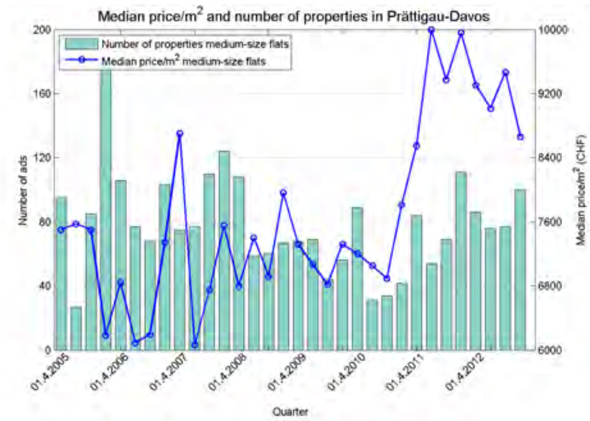


(c) Medium size houses.

Figure D.104: Development of prices in Plessur.



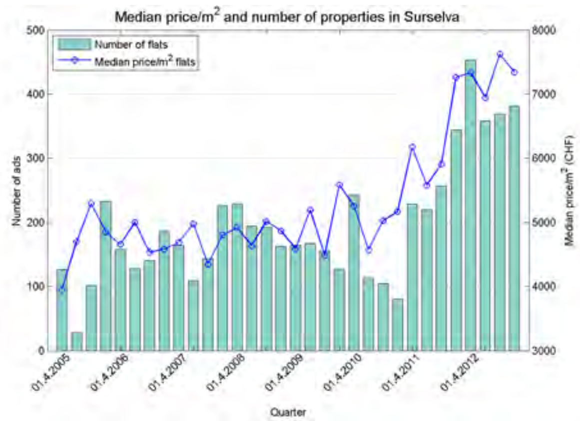
(a) All apartments.



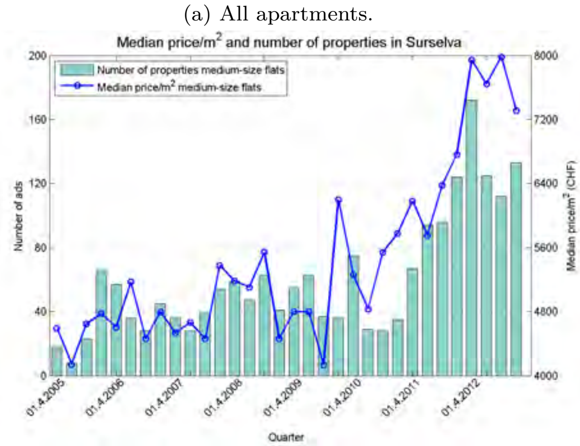
(b) Medium size apartments.

(c) Medium size houses.

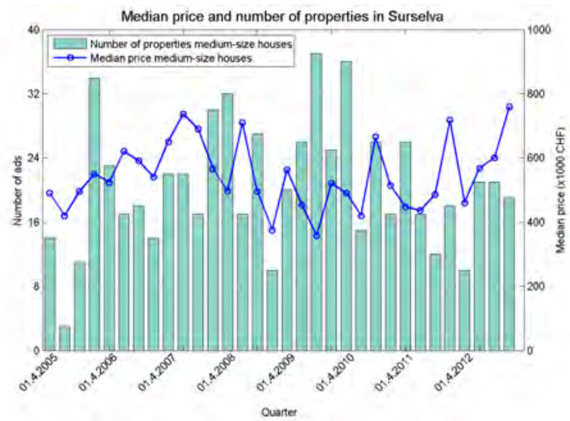
Figure D.105: Development of prices in Prättigau-Davos.



(a) All apartments.

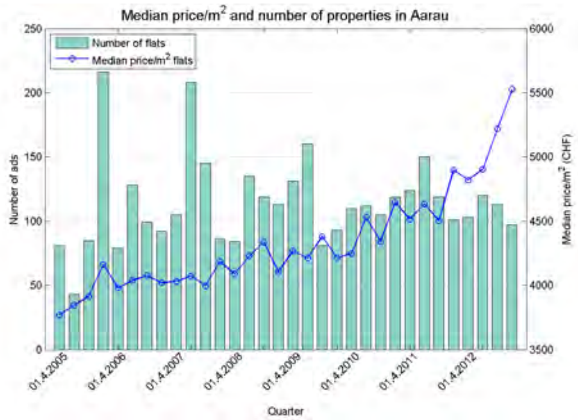


(b) Medium size apartments.

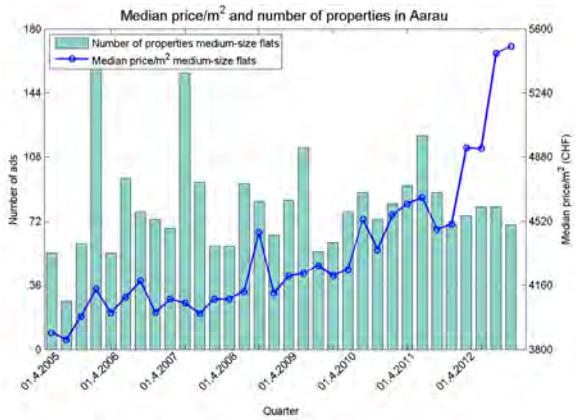


(c) Medium size houses.

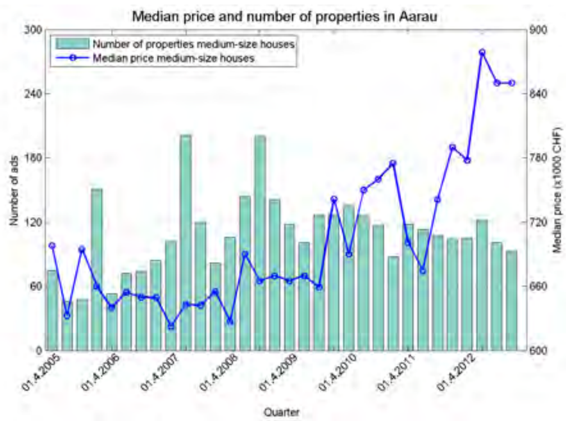
Figure D.106: Development of prices in Surselva.



(a) All apartments.

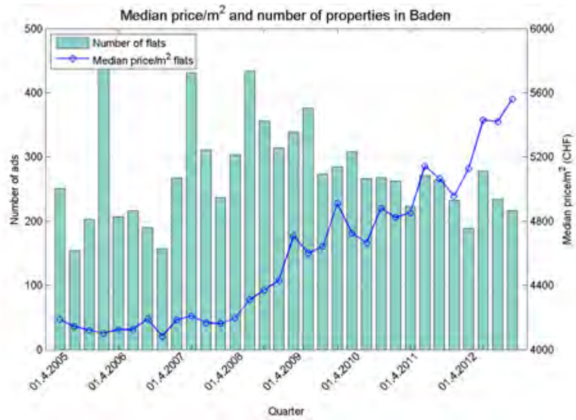


(b) Medium size apartments.

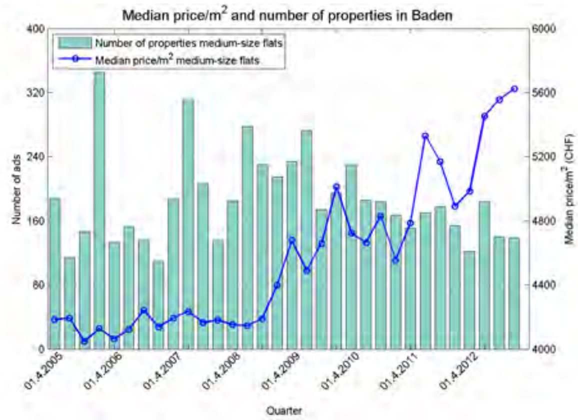


(c) Medium size houses.

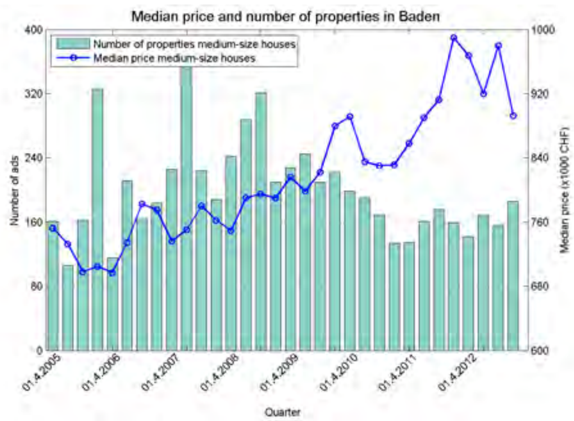
Figure D.107: Development of prices in Aarau.



(a) All apartments.

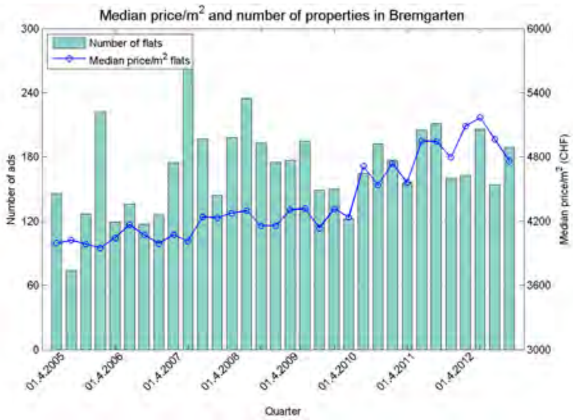


(b) Medium size apartments.

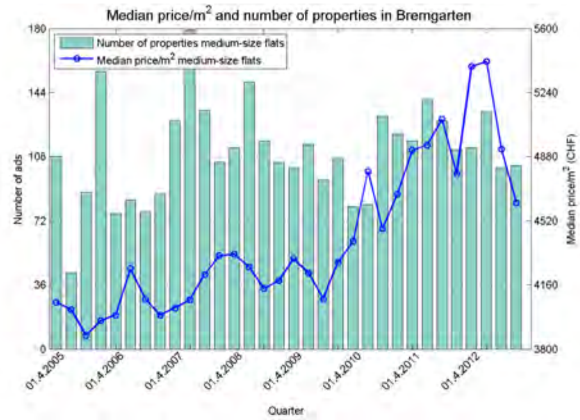


(c) Medium size houses.

Figure D.108: Development of prices in Baden.



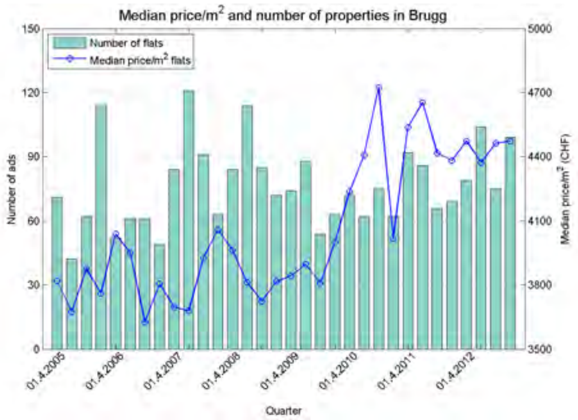
(a) All apartments.



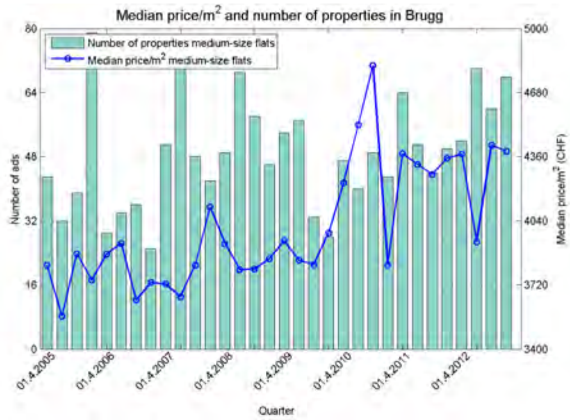
(b) Medium size apartments.

(c) Medium size houses.

Figure D.109: Development of prices in Bremgarten.



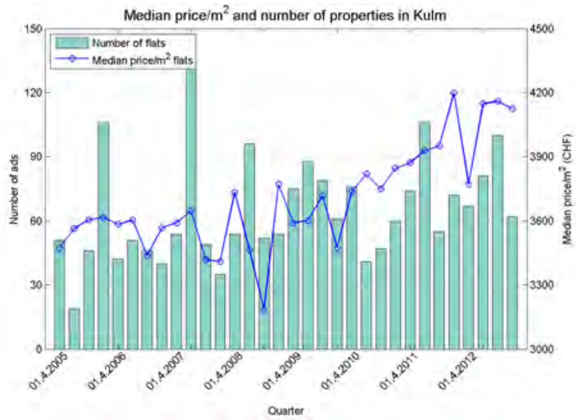
(a) All apartments.



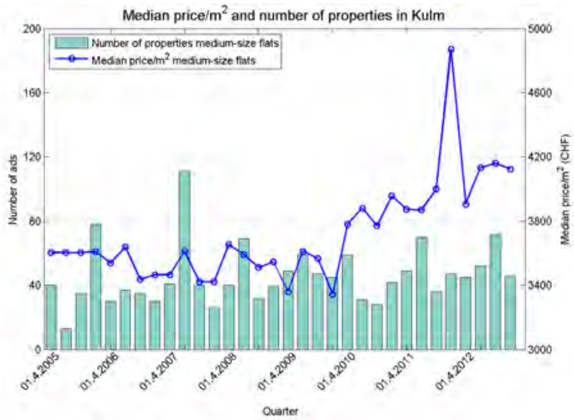
(b) Medium size apartments.

(c) Medium size houses.

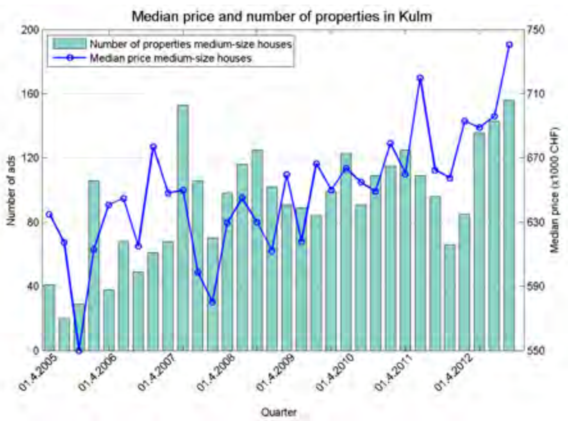
Figure D.110: Development of prices in Brugg.



(a) All apartments.

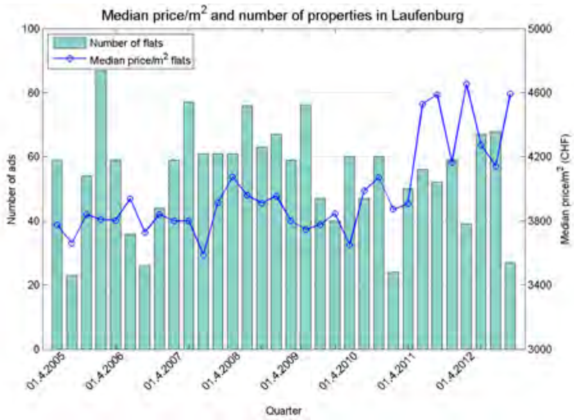


(b) Medium size apartments.

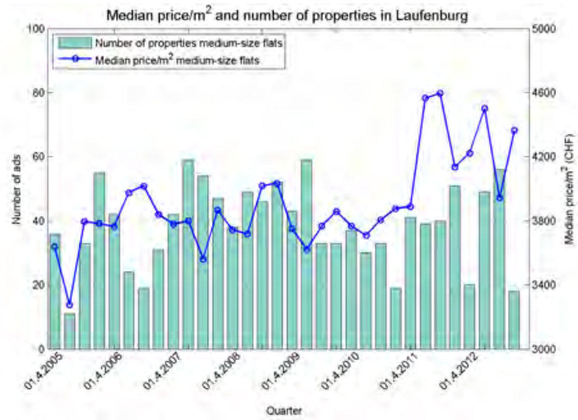


(c) Medium size houses.

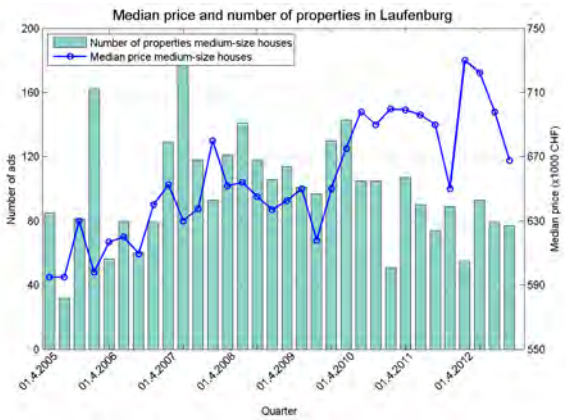
Figure D.111: Development of prices in Kulm.



(a) All apartments.

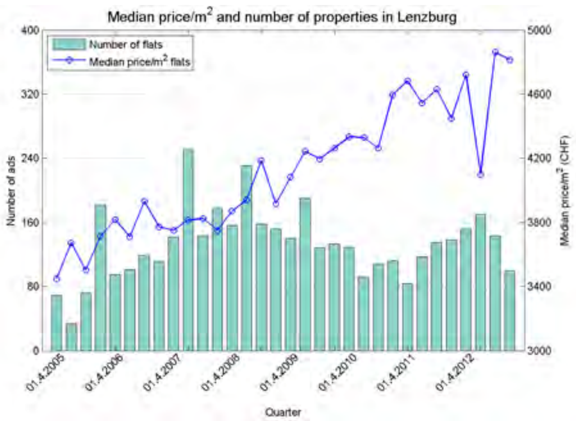


(b) Medium size apartments.

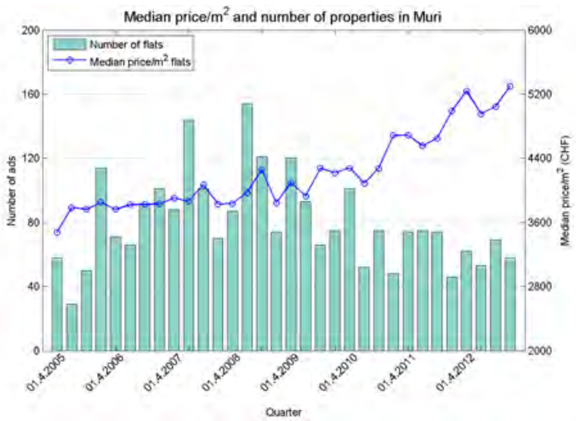


(c) Medium size houses.

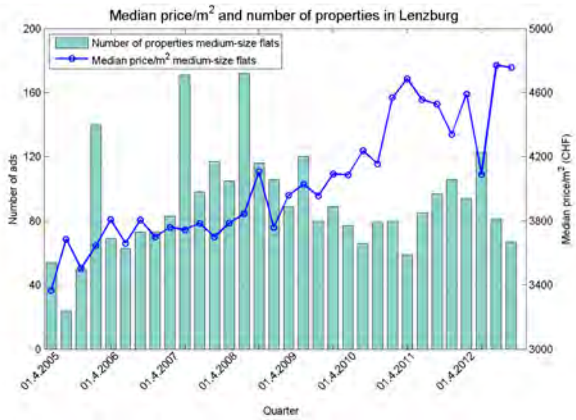
Figure D.112: Development of prices in Laufenburg.



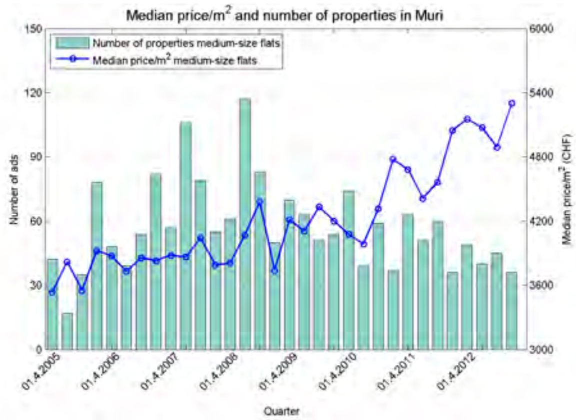
(a) All apartments.



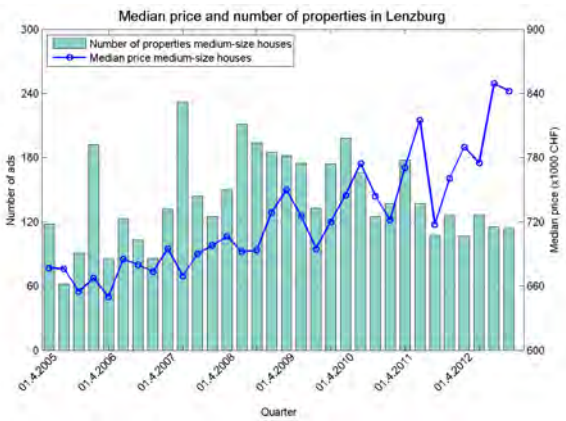
(a) All apartments.



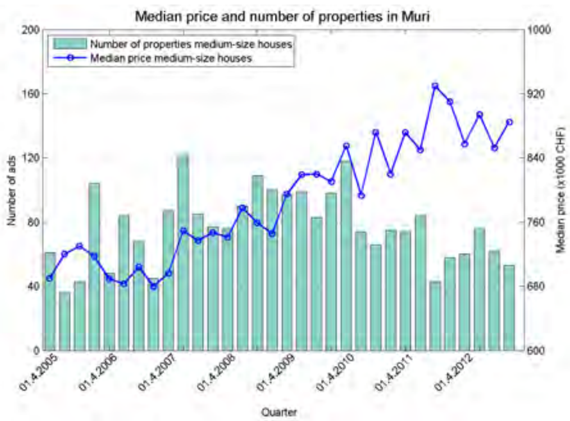
(b) Medium size apartments.



(b) Medium size apartments.



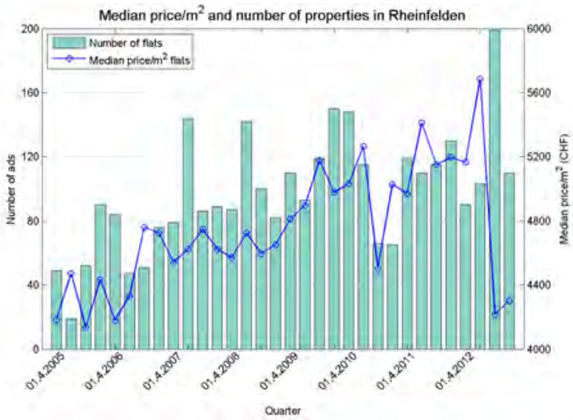
(c) Medium size houses.



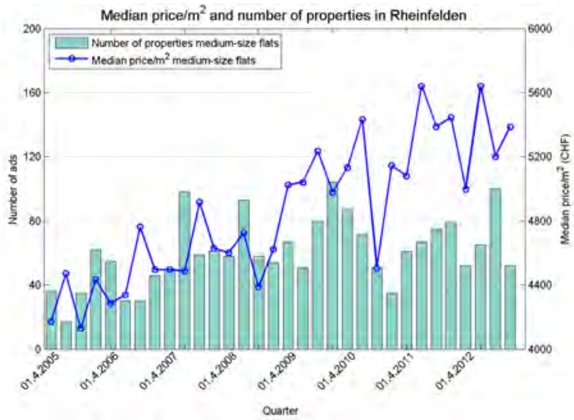
(c) Medium size houses.

Figure D.113: Development of prices in Lenzburg.

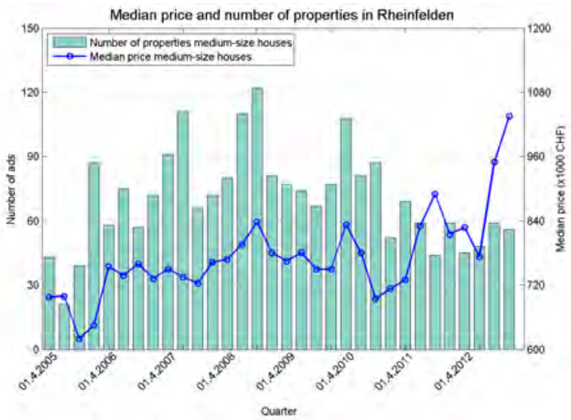
Figure D.114: Development of prices in Muri.



(a) All apartments.

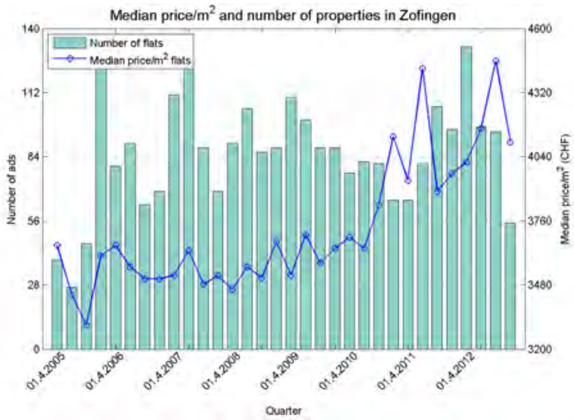


(b) Medium size apartments.

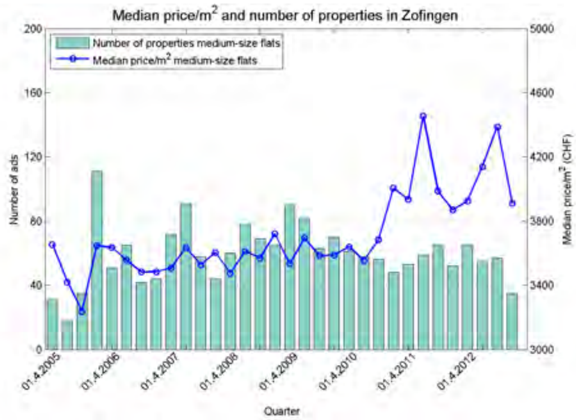


(c) Medium size houses.

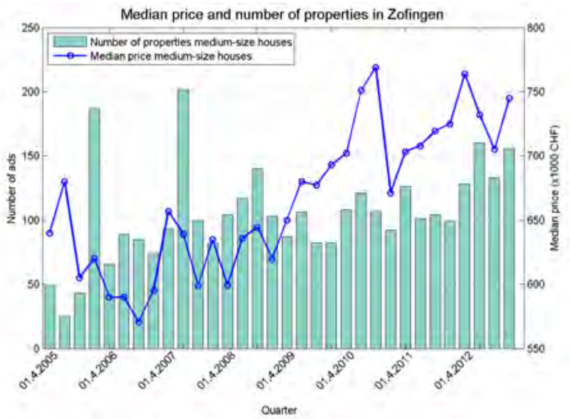
Figure D.115: Development of prices in Rheinfelden.



(a) All apartments.

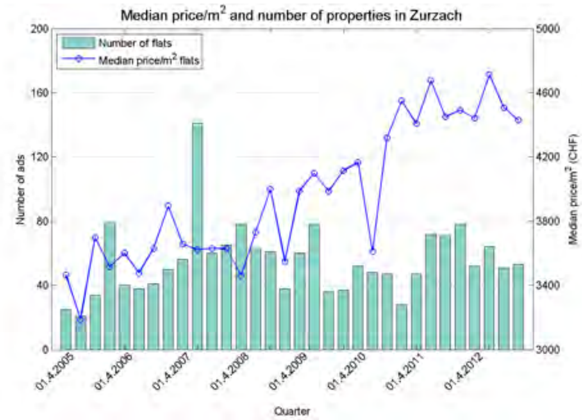


(b) Medium size apartments.

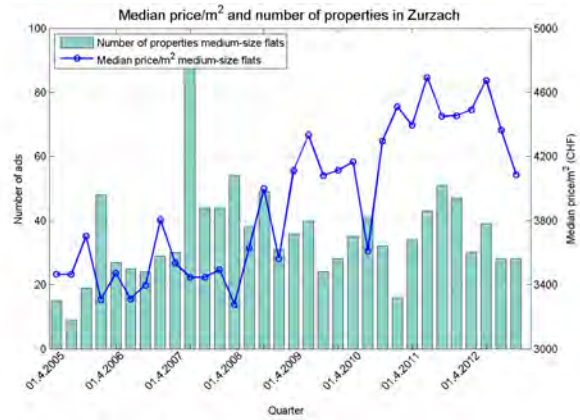


(c) Medium size houses.

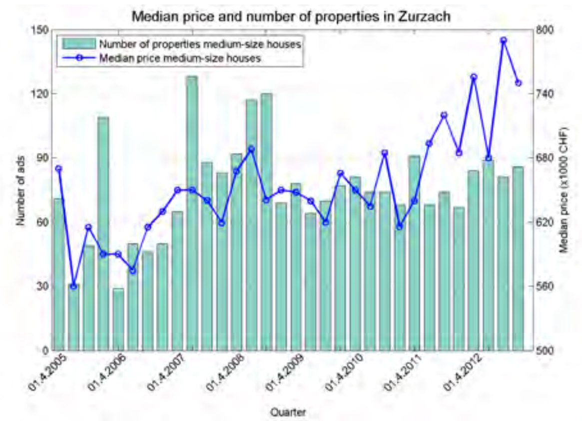
Figure D.116: Development of prices in Zofingen.



(a) All apartments.

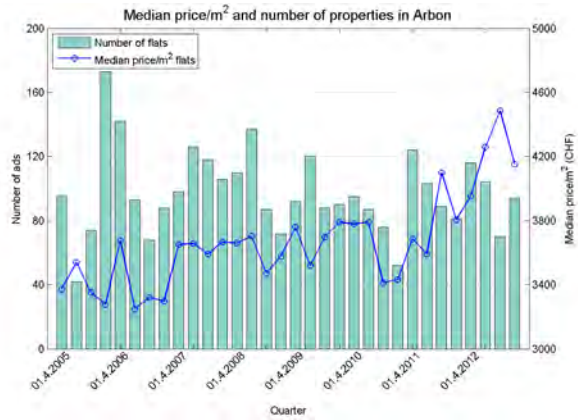


(b) Medium size apartments.

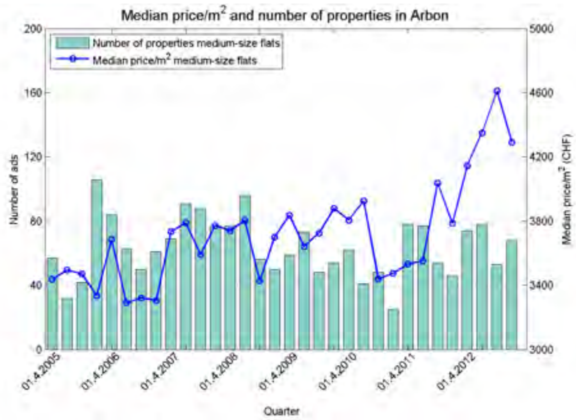


(c) Medium size houses.

Figure D.117: Development of prices in Zurzach.



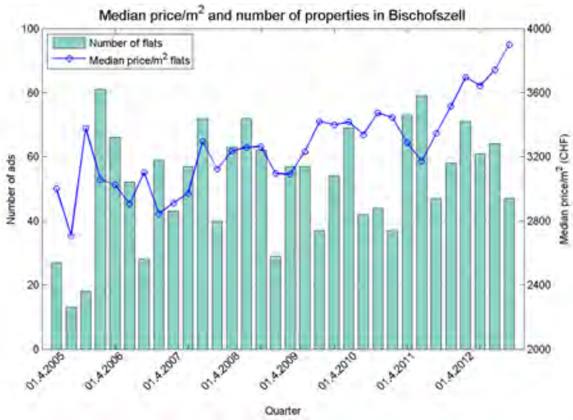
(a) All apartments.



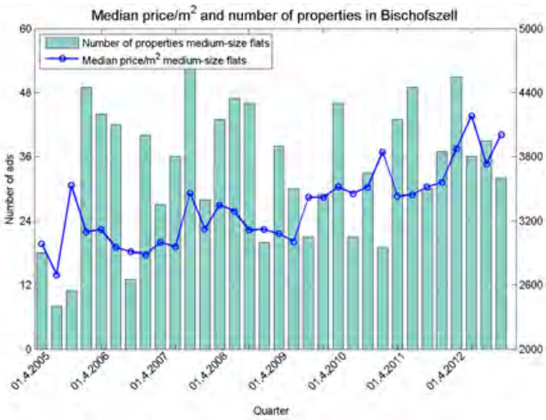
(b) Medium size apartments.

(c) Medium size houses.

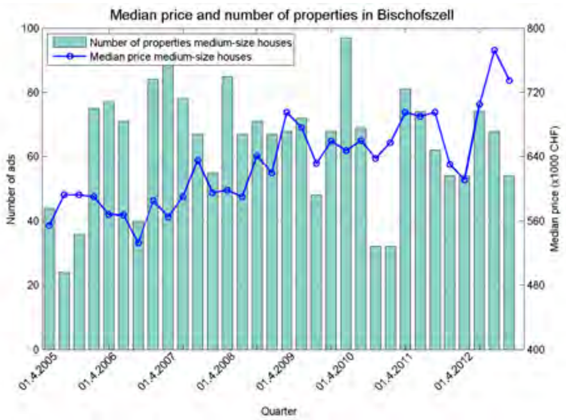
Figure D.118: Development of prices in Arbon.



(a) All apartments.

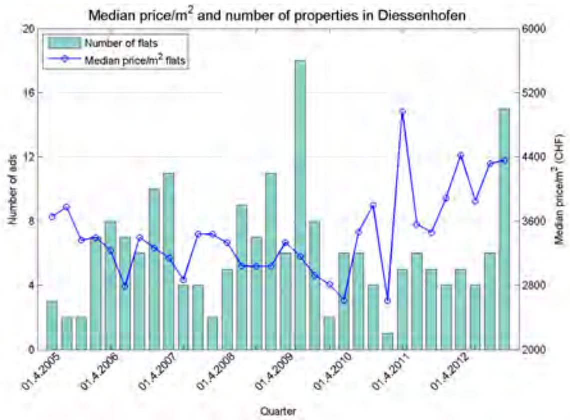


(b) Medium size apartments.

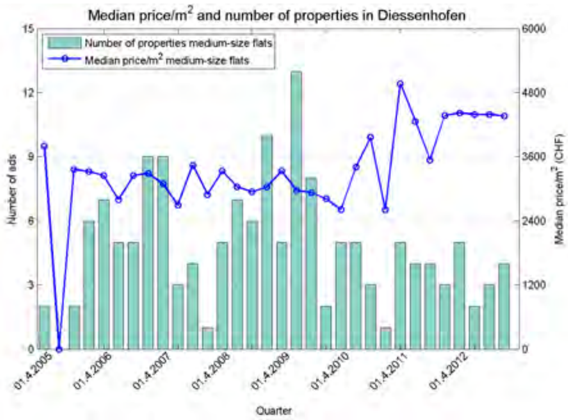


(c) Medium size houses.

Figure D.119: Development of prices in Bischofszell.



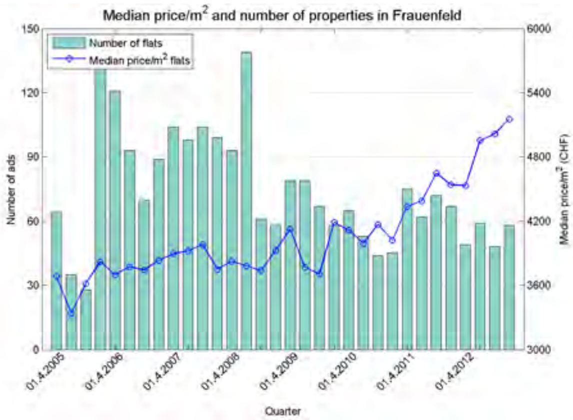
(a) All apartments.



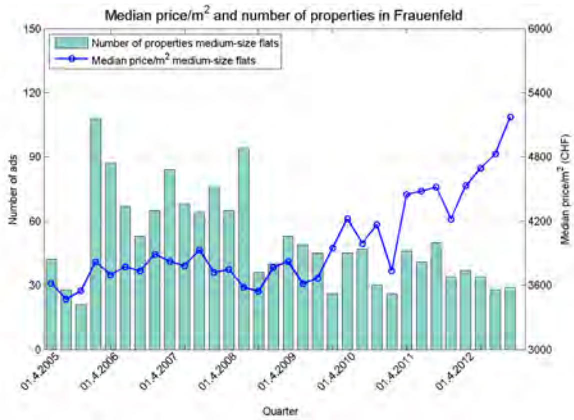
(b) Medium size apartments.

(c) Medium size houses.

Figure D.120: Development of prices in Diessenhofen.



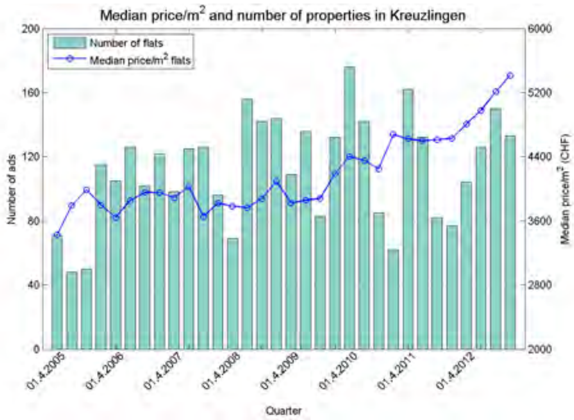
(a) All apartments.



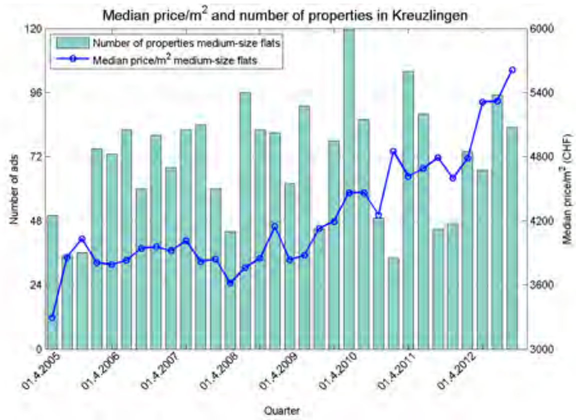
(b) Medium size apartments.

(c) Medium size houses.

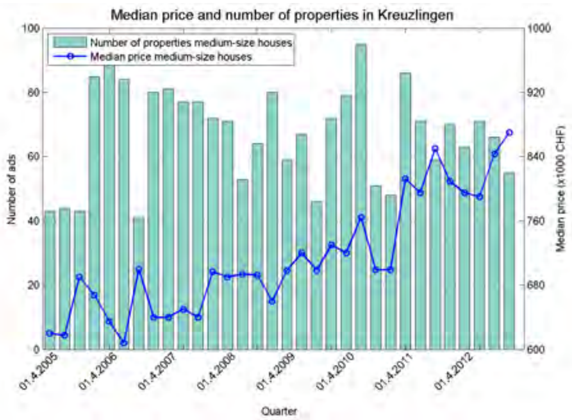
Figure D.121: Development of prices in Frauenfeld.



(a) All apartments.

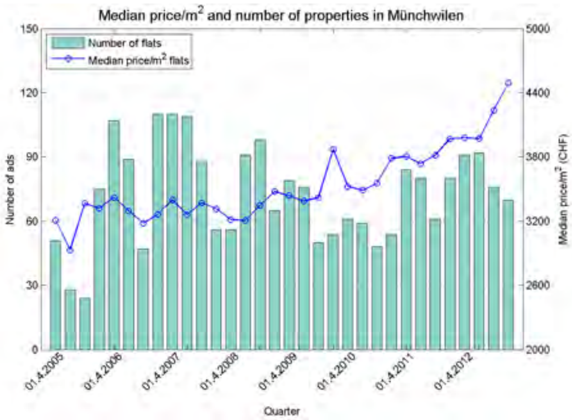


(b) Medium size apartments.

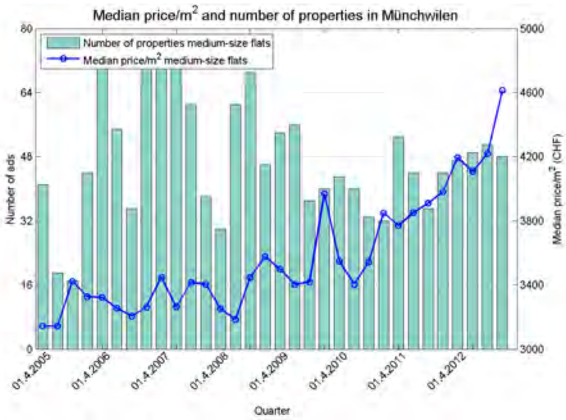


(c) Medium size houses.

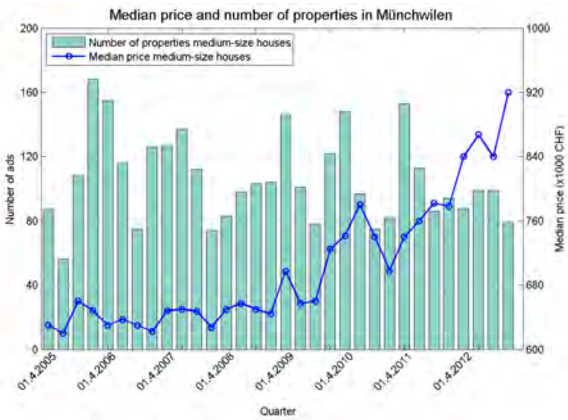
Figure D.122: Development of prices in Kreuzlingen.



(a) All apartments.

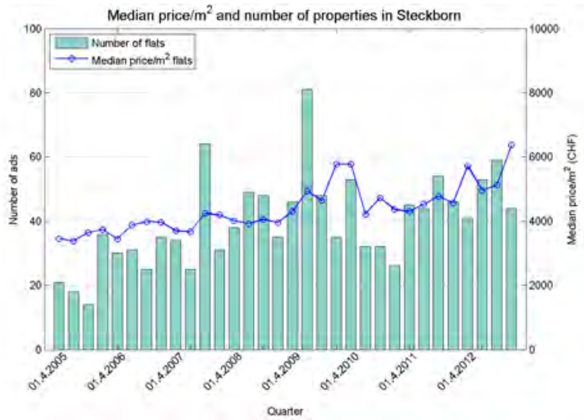


(b) Medium size apartments.

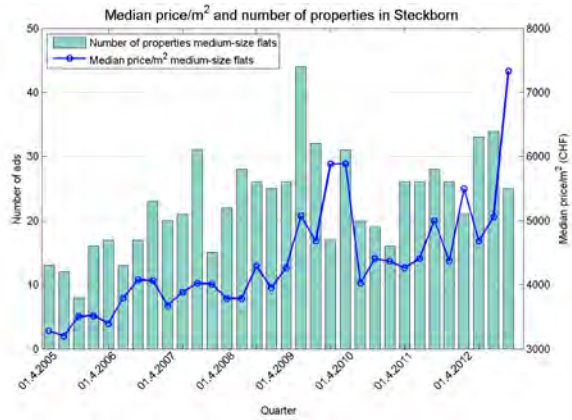


(c) Medium size houses.

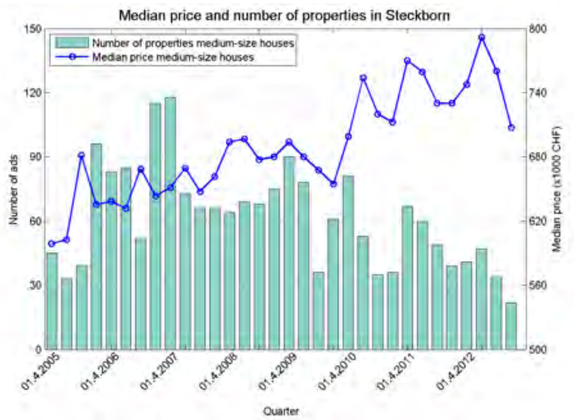
Figure D.123: Development of prices in Münchwilen.



(a) All apartments.

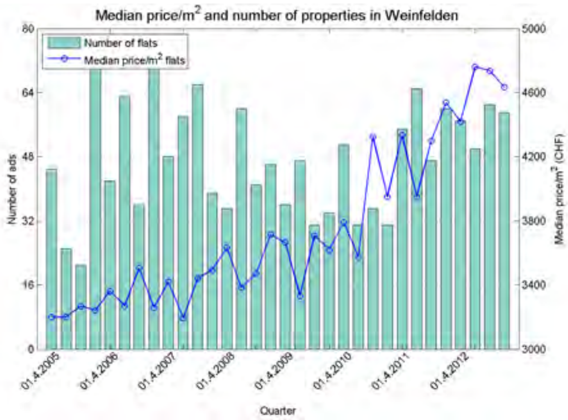


(b) Medium size apartments.

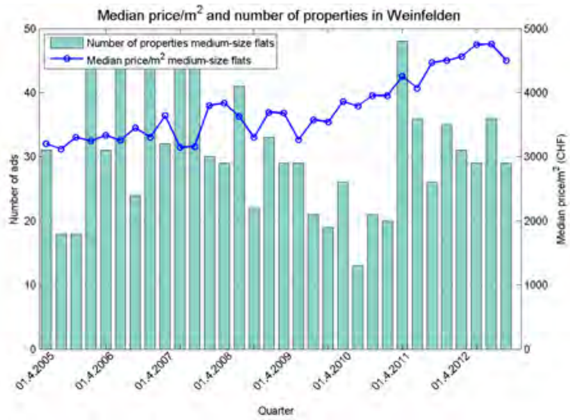


(c) Medium size houses.

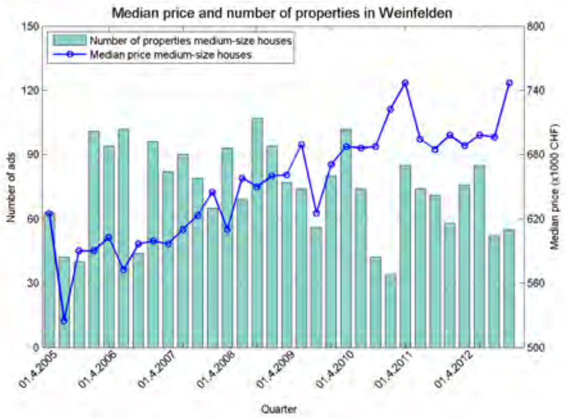
Figure D.124: Development of prices in Steckborn.



(a) All apartments.

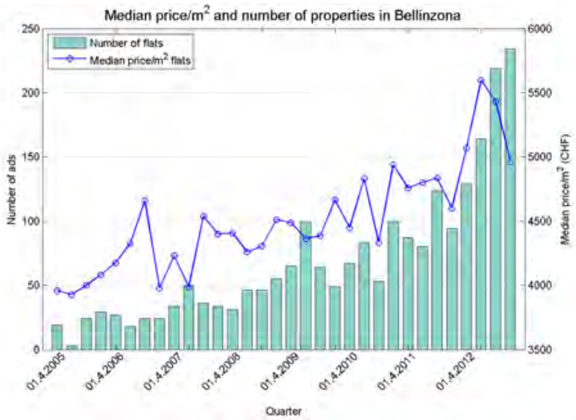


(b) Medium size apartments.

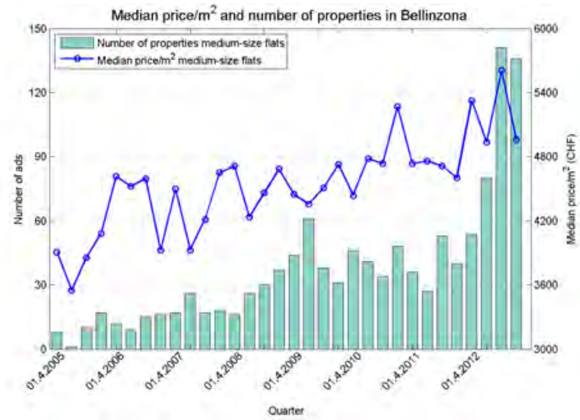


(c) Medium size houses.

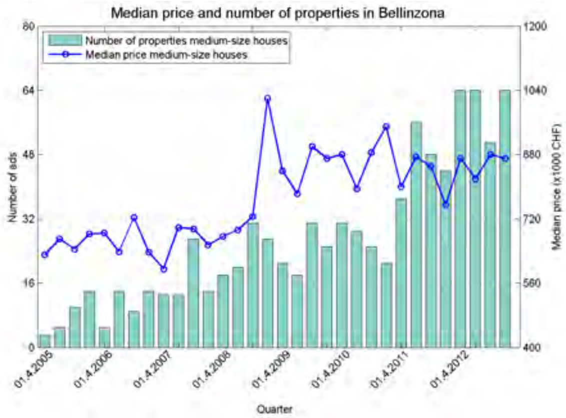
Figure D.125: Development of prices in Weinfelden.



(a) All apartments.

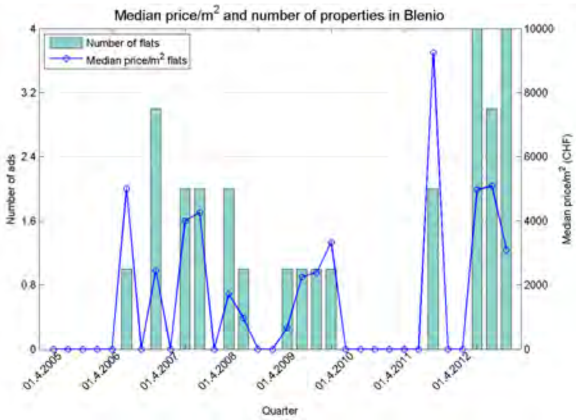


(b) Medium size apartments.

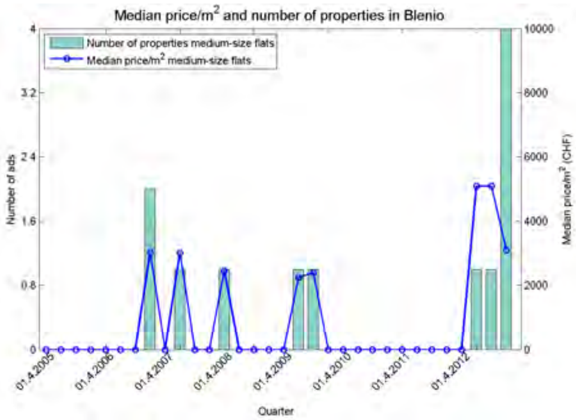


(c) Medium size houses.

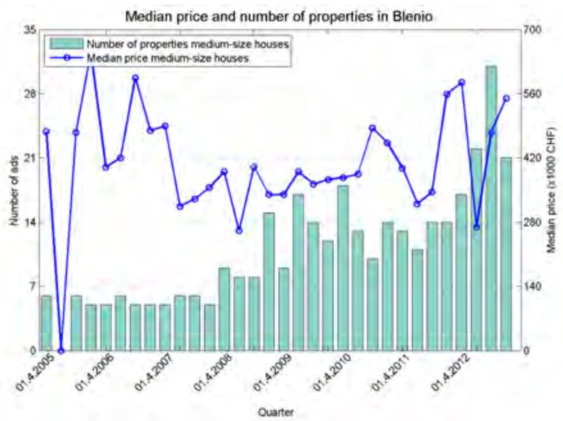
Figure D.126: Development of prices in Bellinzona.



(a) All apartments.

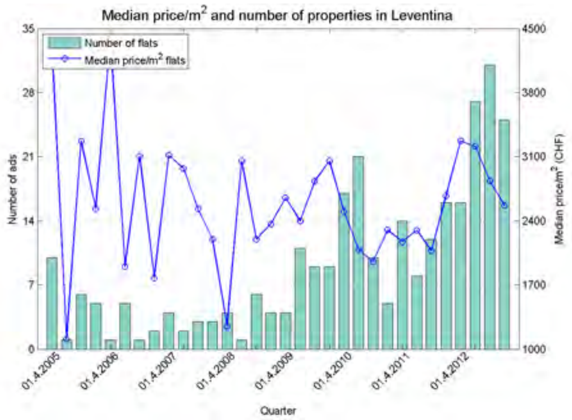


(b) Medium size apartments.

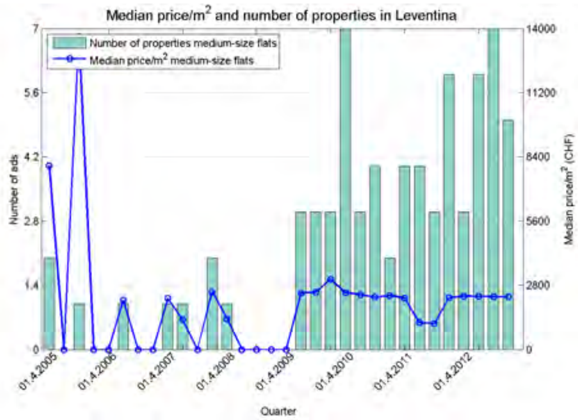


(c) Medium size houses.

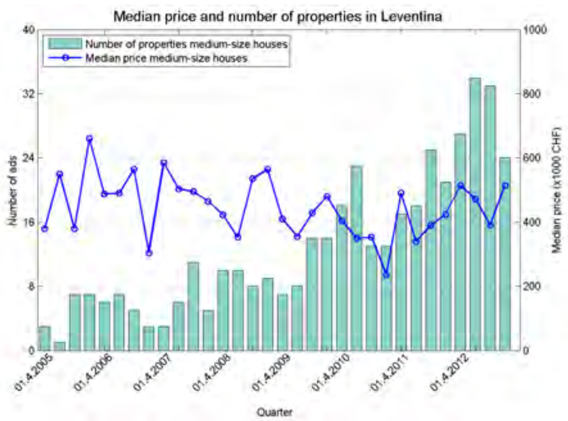
Figure D.127: Development of prices in Blenio.



(a) All apartments.

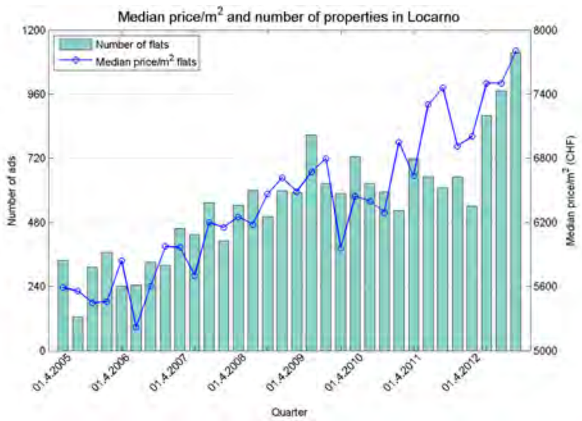


(b) Medium size apartments.

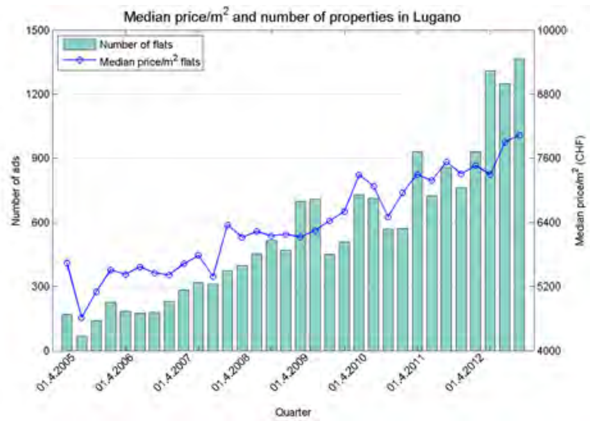


(c) Medium size houses.

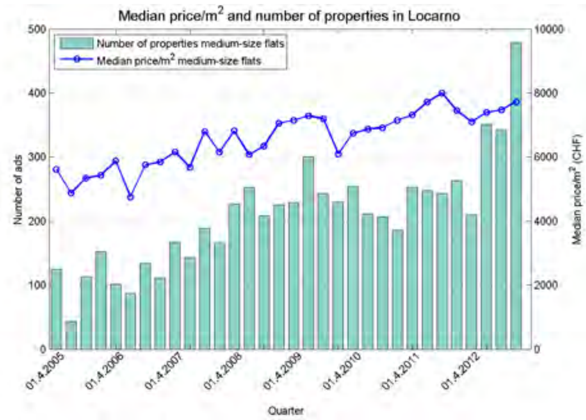
Figure D.128: Development of prices in Leventina.



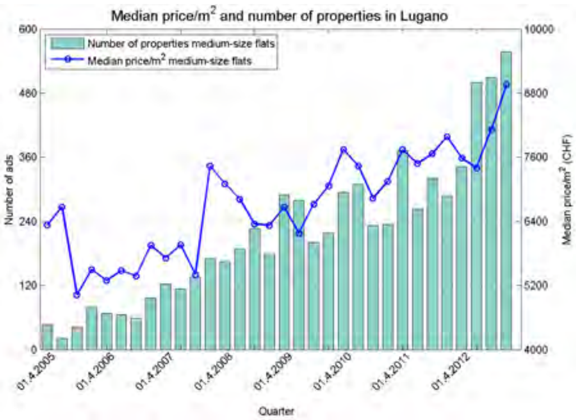
(a) All apartments.



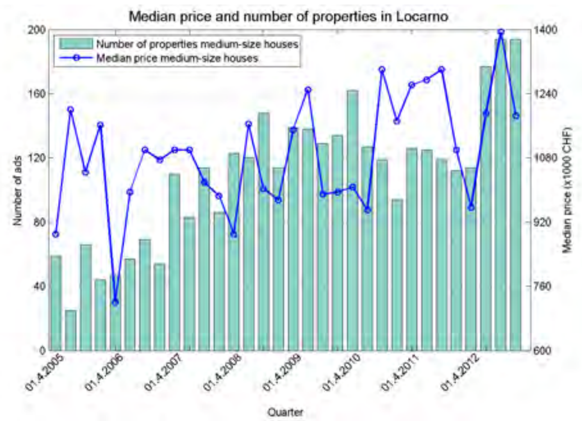
(a) All apartments.



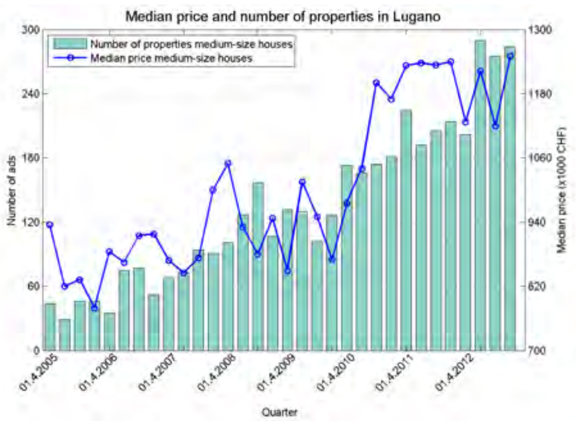
(b) Medium size apartments.



(b) Medium size apartments.



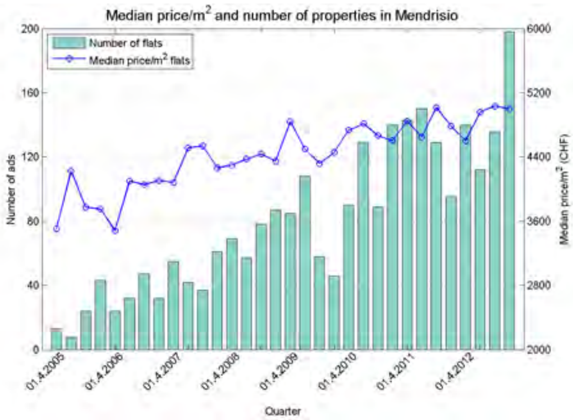
(c) Medium size houses.



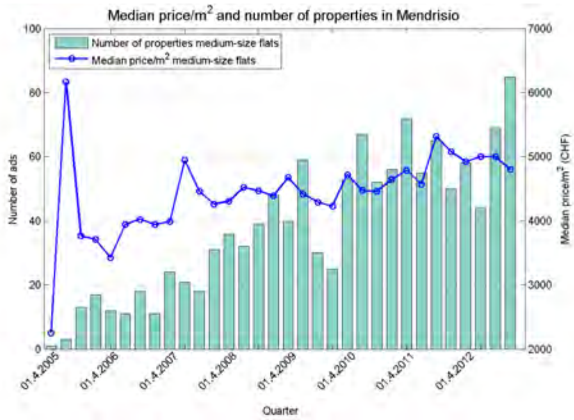
(c) Medium size houses.

Figure D.129: Development of prices in Locarno.

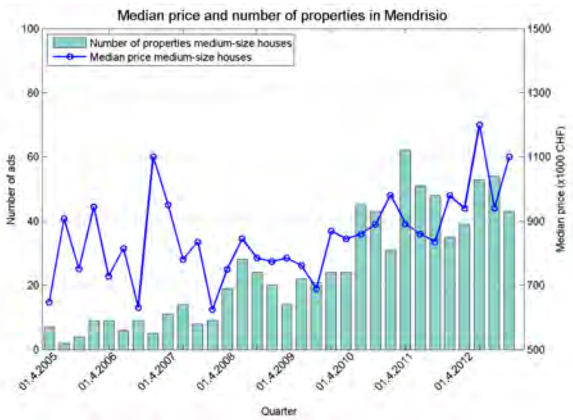
Figure D.130: Development of prices in Lugano.



(a) All apartments.

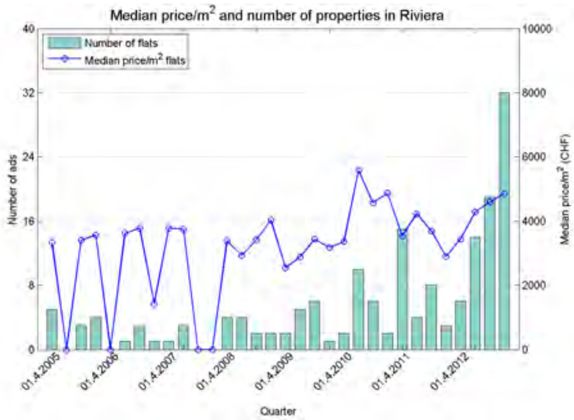


(b) Medium size apartments.

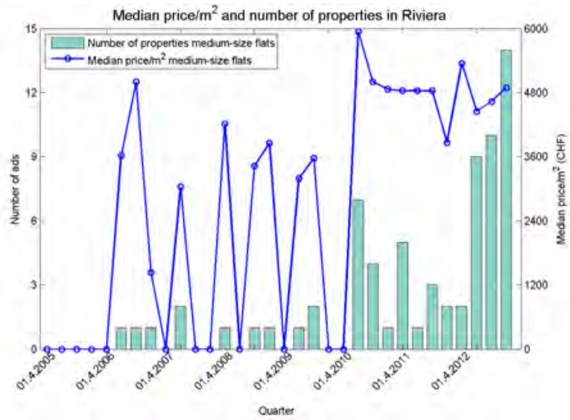


(c) Medium size houses.

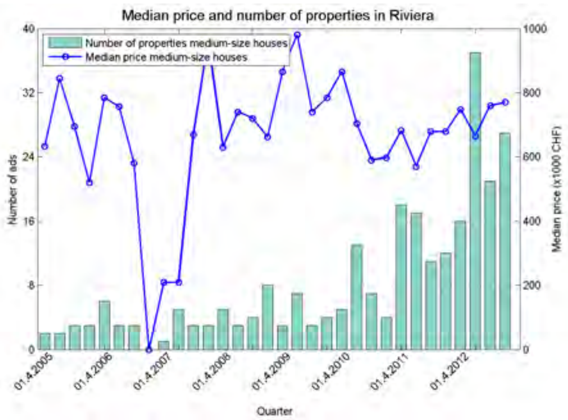
Figure D.131: Development of prices in Mendrisio.



(a) All apartments.

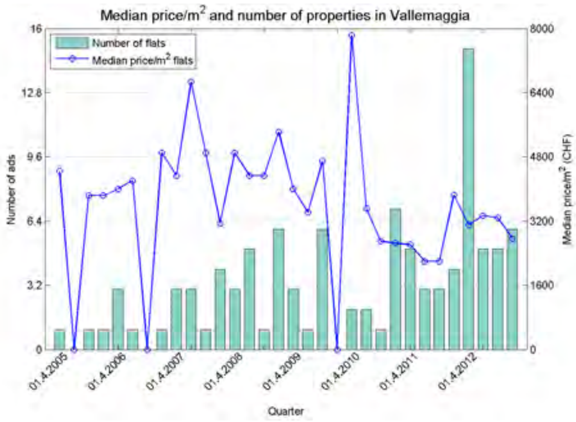


(b) Medium size apartments.

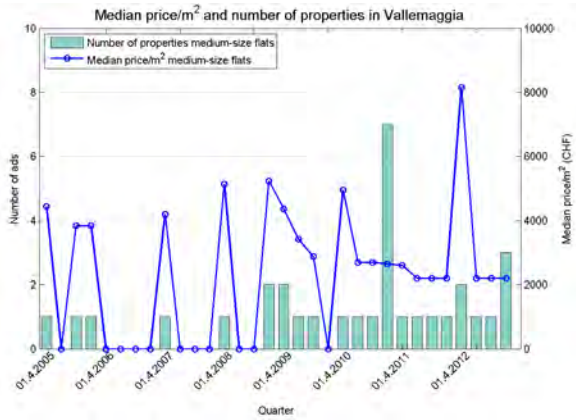


(c) Medium size houses.

Figure D.132: Development of prices in Riviera.



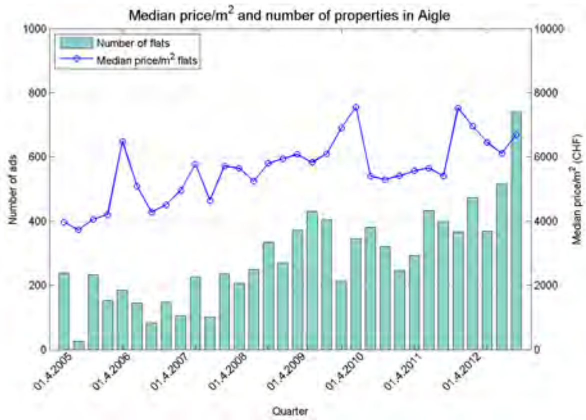
(a) All apartments.



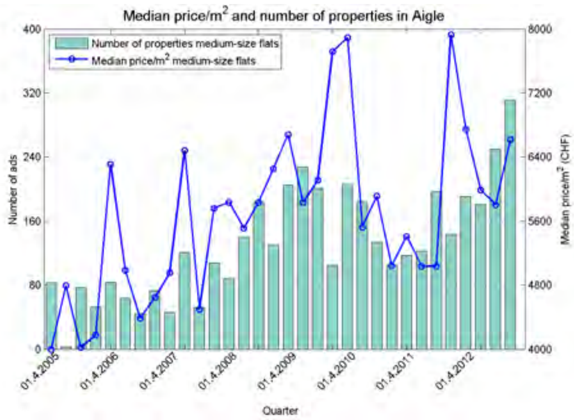
(b) Medium size apartments.

(c) Medium size houses.

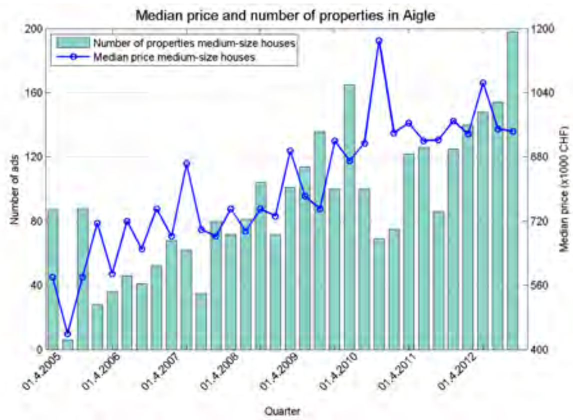
Figure D.133: Development of prices in Vallemaggia.



(a) All apartments.

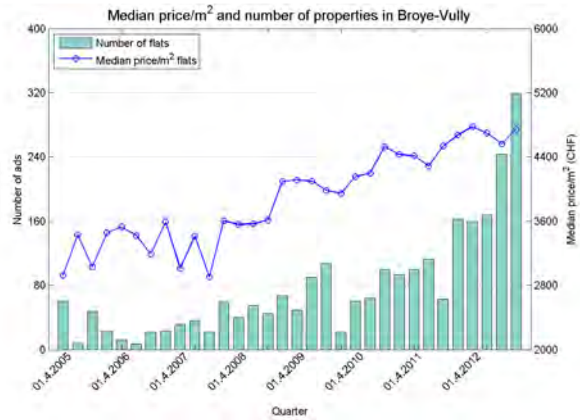


(b) Medium size apartments.

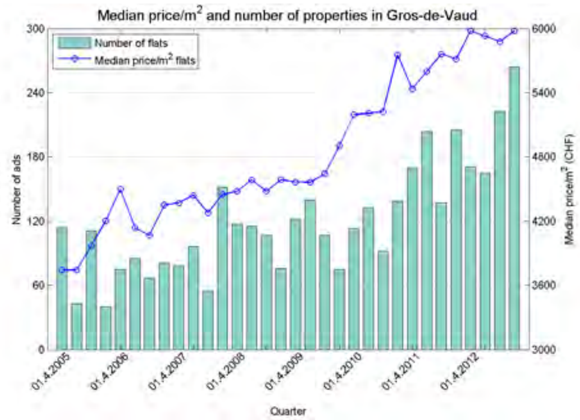


(c) Medium size houses.

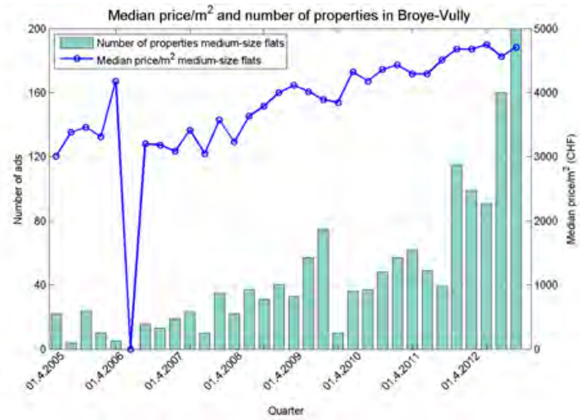
Figure D.134: Development of prices in Aigle.



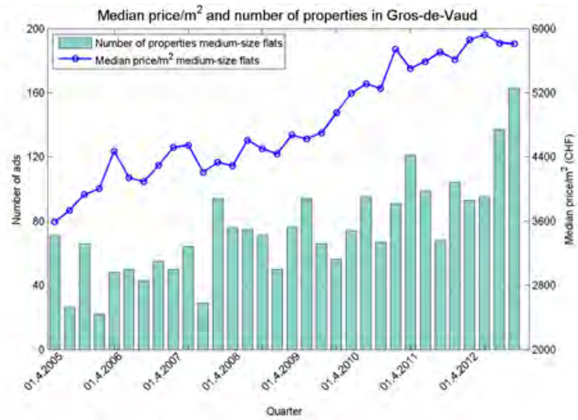
(a) All apartments.



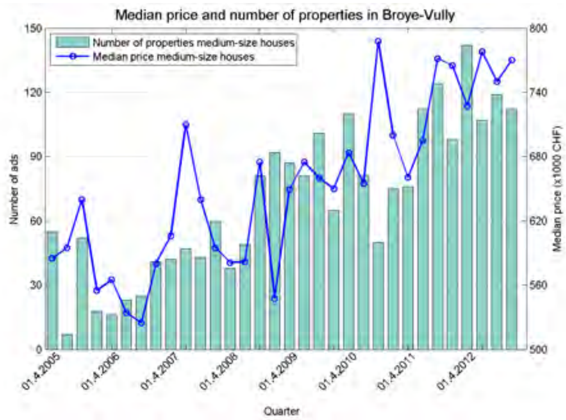
(a) All apartments.



(b) Medium size apartments.



(b) Medium size apartments.

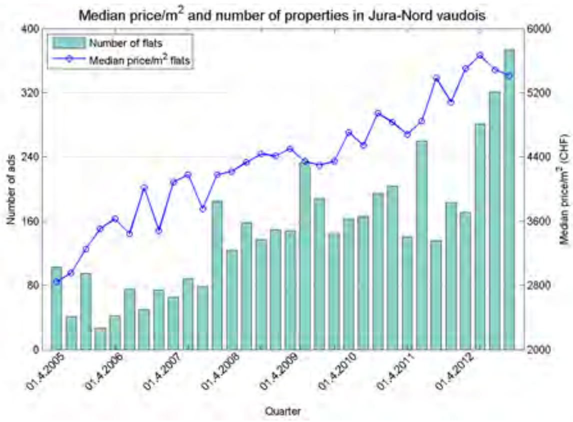


(c) Medium size houses.

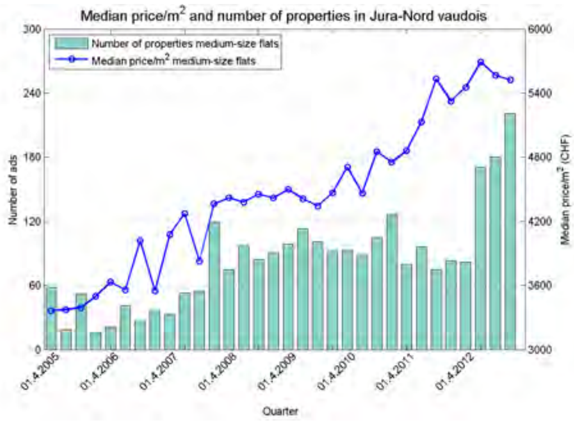
(c) Medium size houses.

Figure D.135: Development of prices in Broye-Vully.

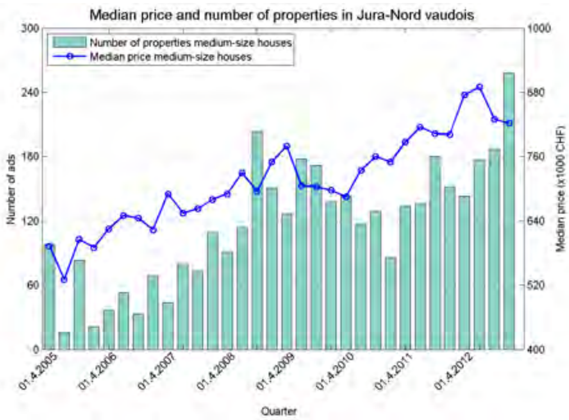
Figure D.136: Development of prices in Gros-de-Vaud.



(a) All apartments.

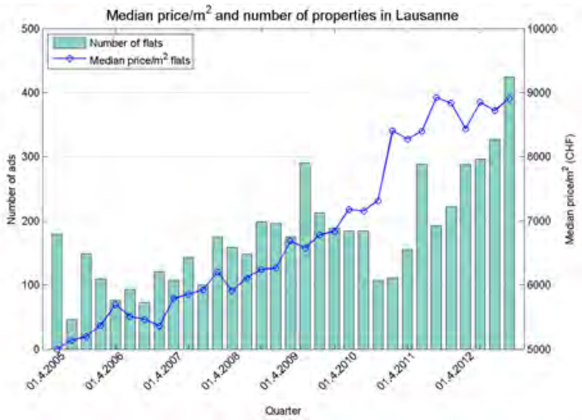


(b) Medium size apartments.

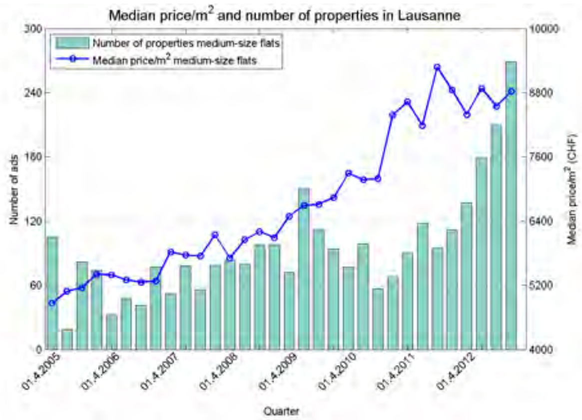


(c) Medium size houses.

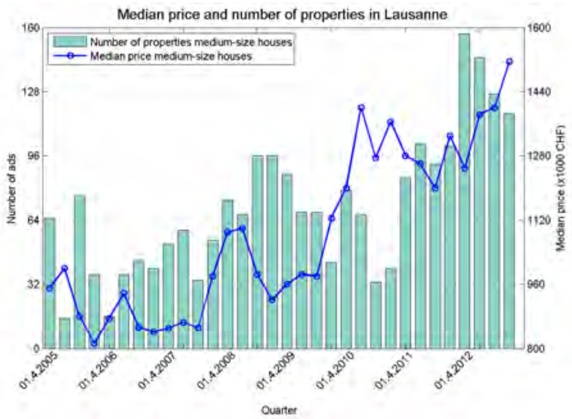
Figure D.137: Development of prices in Jura-Nord vaudois.



(a) All apartments.

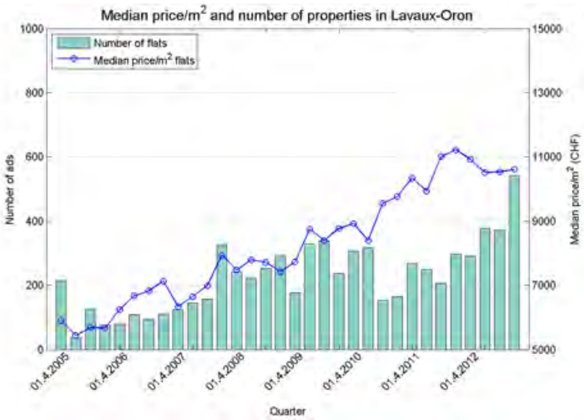


(b) Medium size apartments.

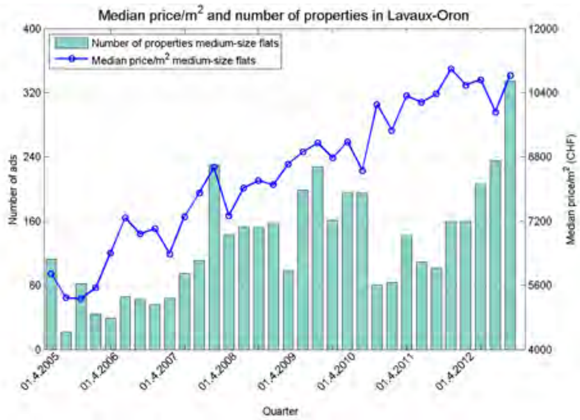


(c) Medium size houses.

Figure D.138: Development of prices in Lausanne.



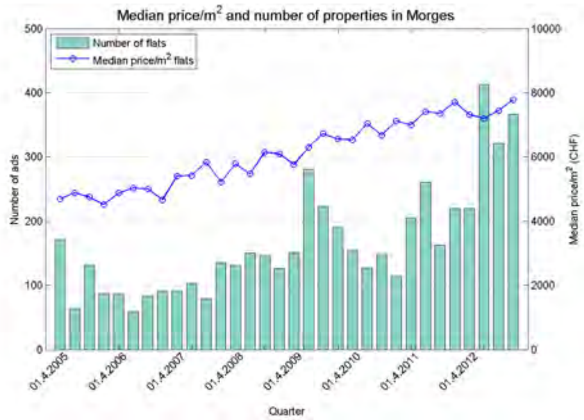
(a) All apartments.



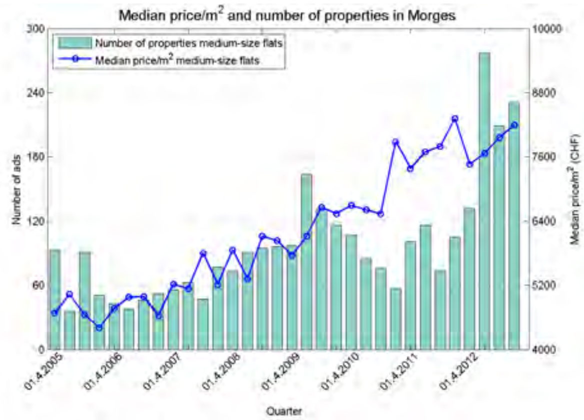
(b) Medium size apartments.

(c) Medium size houses.

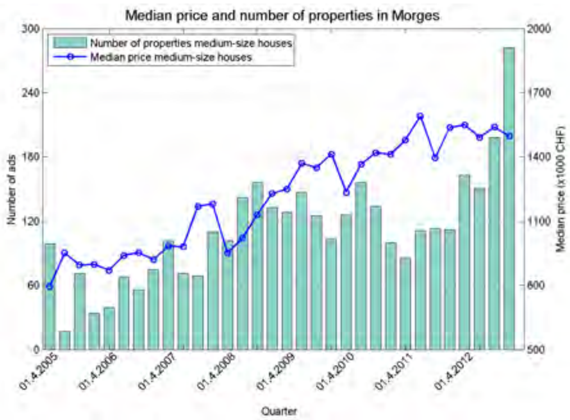
Figure D.139: Development of prices in Lavaux-Oron.



(a) All apartments.

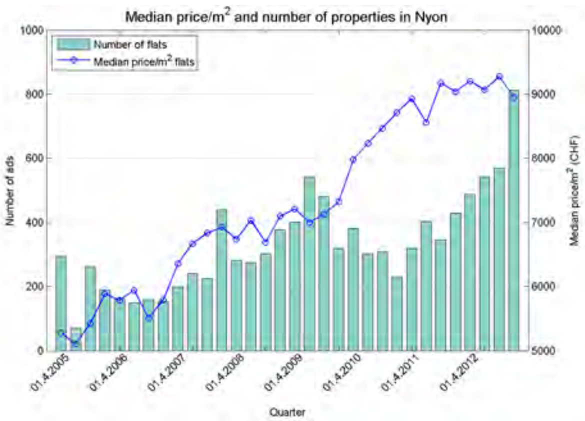


(b) Medium size apartments.

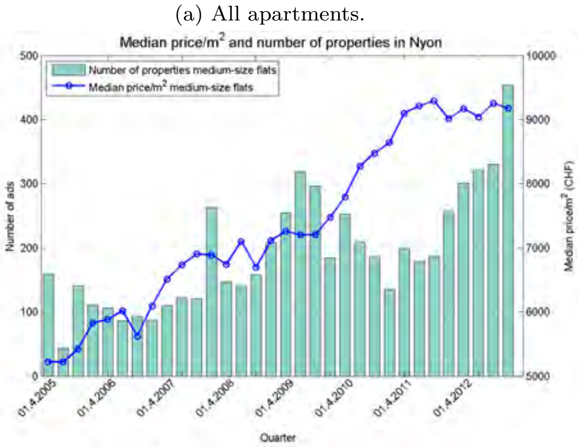


(c) Medium size houses.

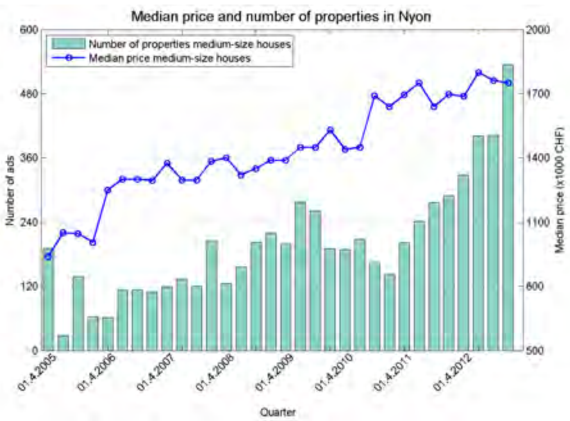
Figure D.140: Development of prices in Morges.



(a) All apartments.

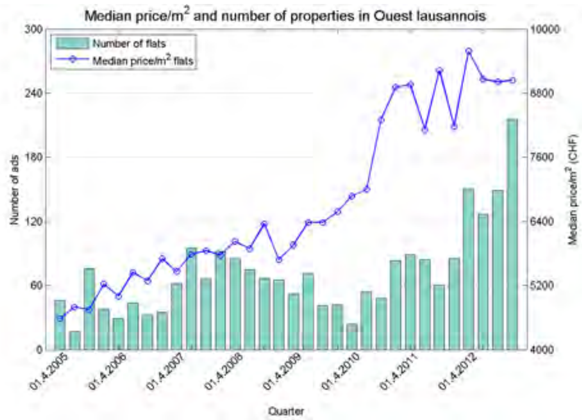


(b) Medium size apartments.

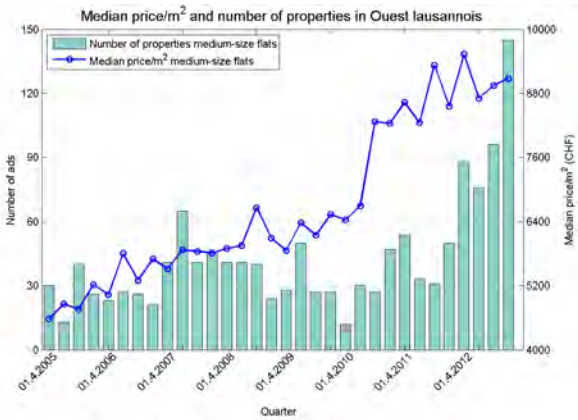


(c) Medium size houses.

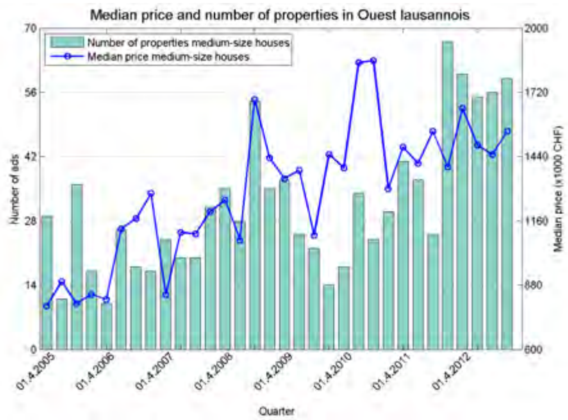
Figure D.141: Development of prices in Nyon.



(a) All apartments.

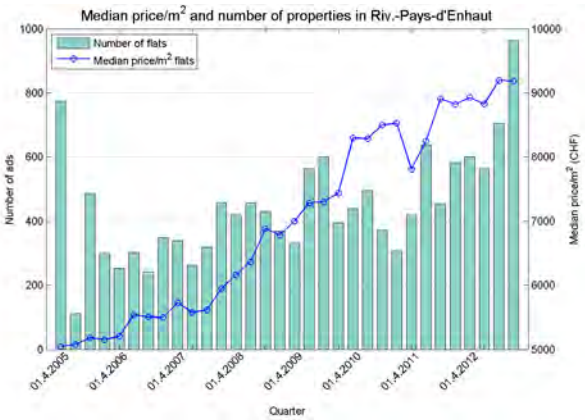


(b) Medium size apartments.

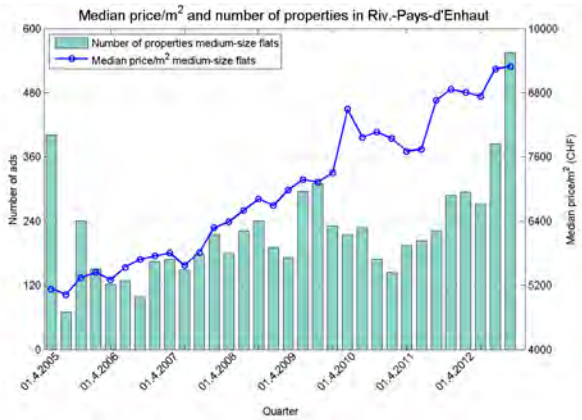


(c) Medium size houses.

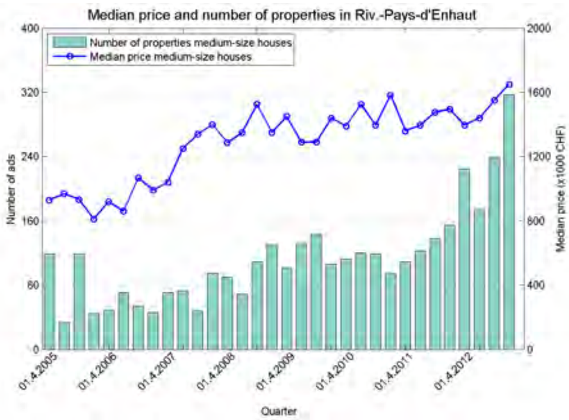
Figure D.142: Development of prices in Ouest lausannois.



(a) All apartments.

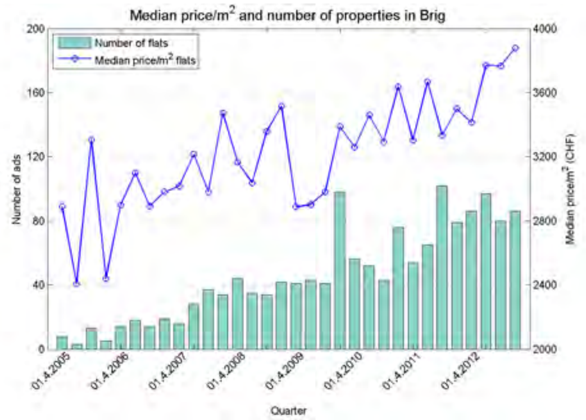


(b) Medium size apartments.

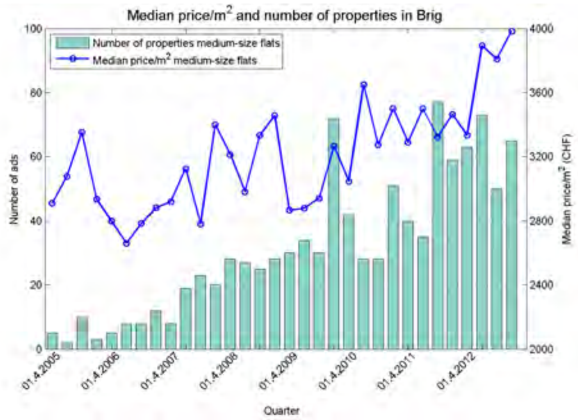


(c) Medium size houses.

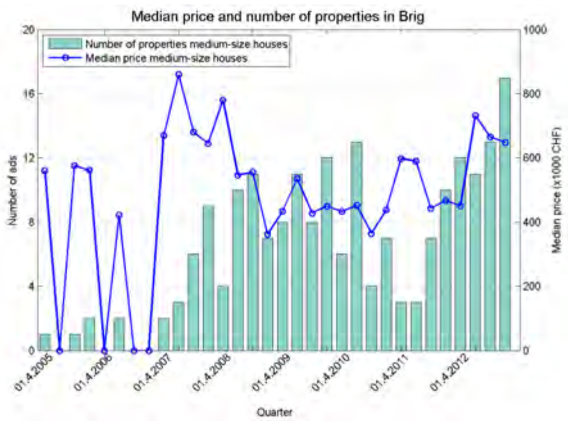
Figure D.143: Development of prices in Riv.-Pays-d'Enhaut.



(a) All apartments.

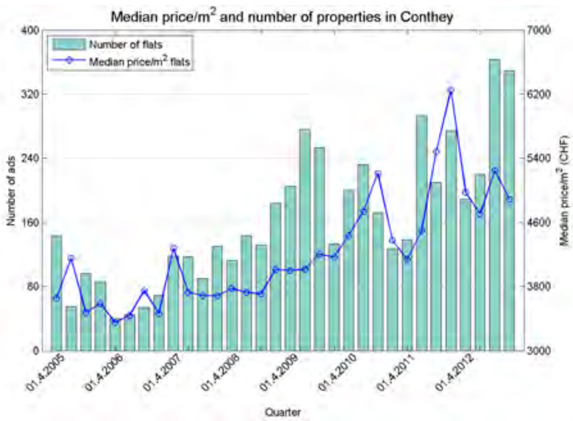


(b) Medium size apartments.

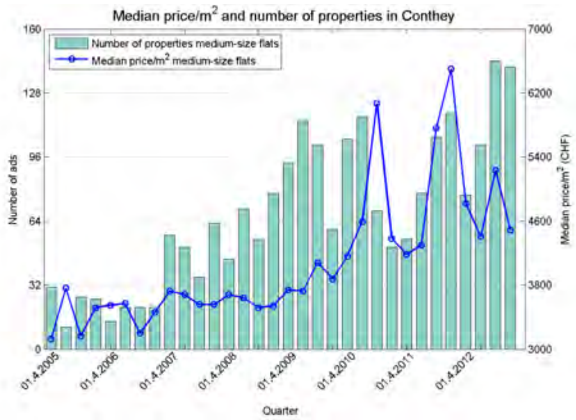


(c) Medium size houses.

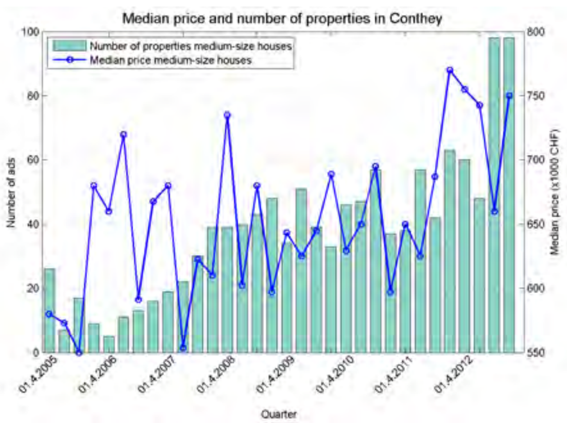
Figure D.144: Development of prices in Brig.



(a) All apartments.

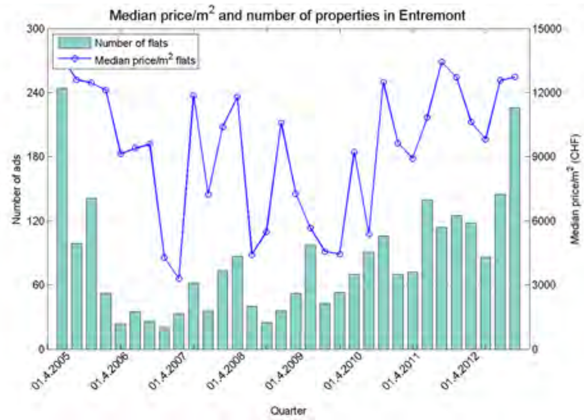


(b) Medium size apartments.

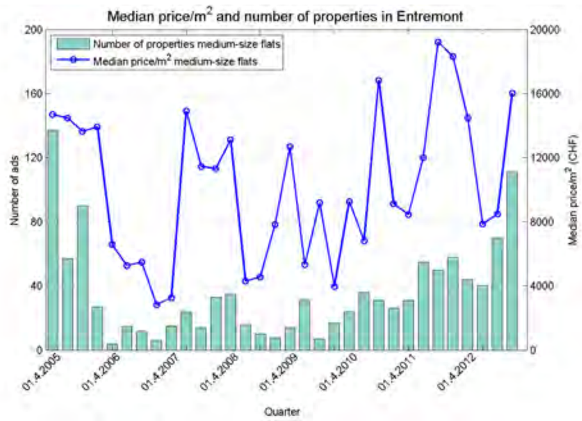


(c) Medium size houses.

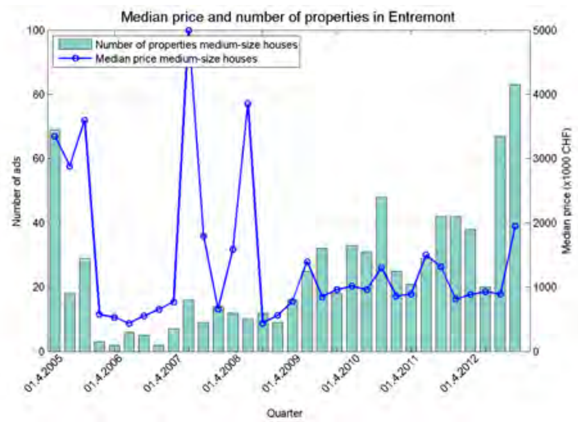
Figure D.145: Development of prices in Conthey.



(a) All apartments.

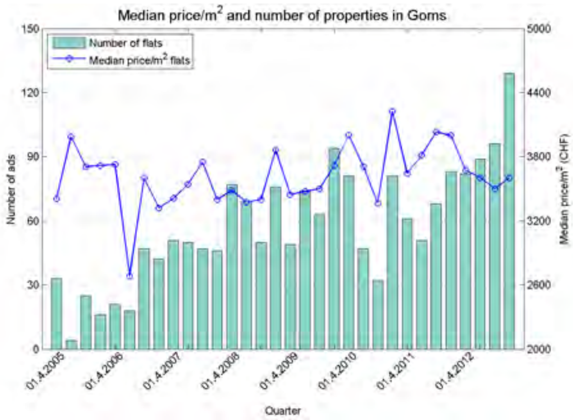


(b) Medium size apartments.

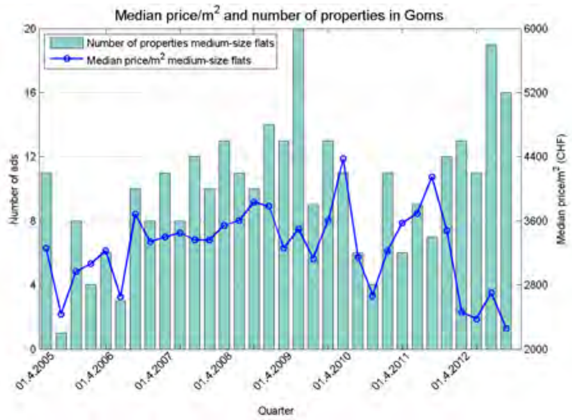


(c) Medium size houses.

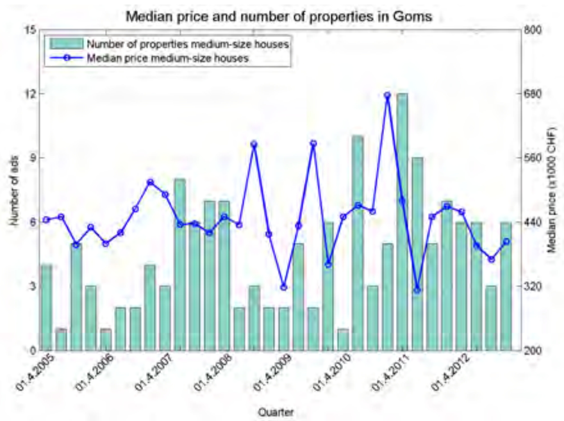
Figure D.146: Development of prices in Entremont.



(a) All apartments.

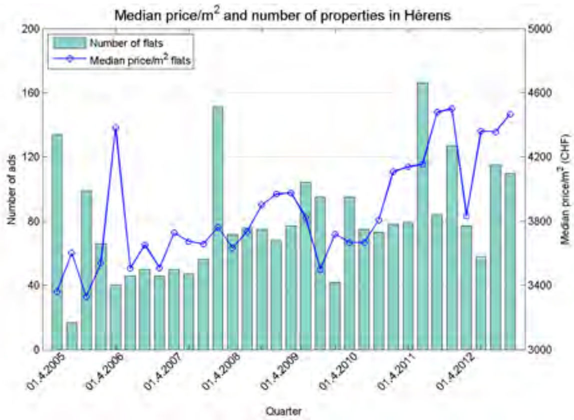


(b) Medium size apartments.

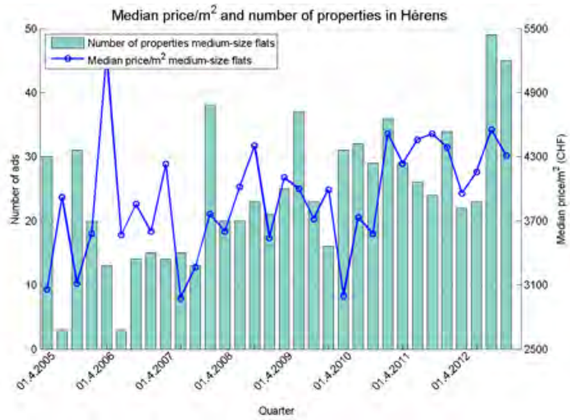


(c) Medium size houses.

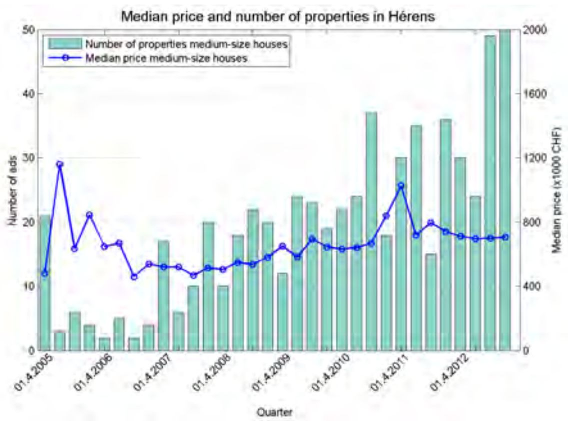
Figure D.147: Development of prices in Goms.



(a) All apartments.

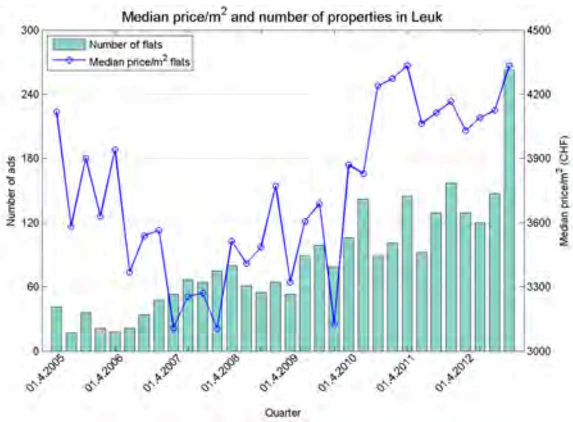


(b) Medium size apartments.

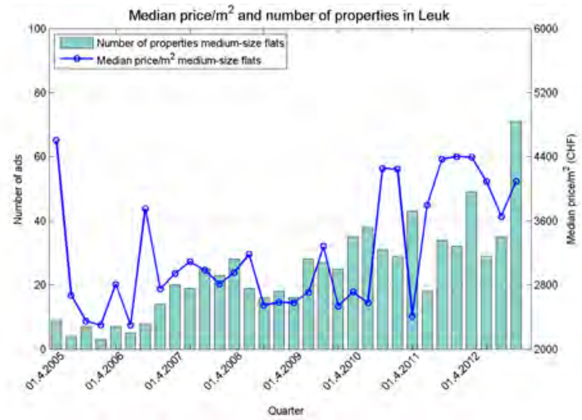


(c) Medium size houses.

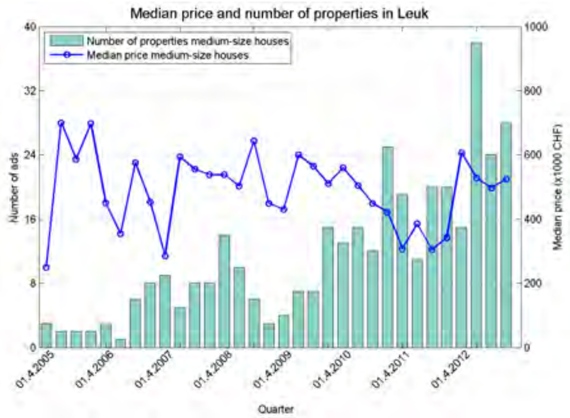
Figure D.148: Development of prices in Hérens.



(a) All apartments.

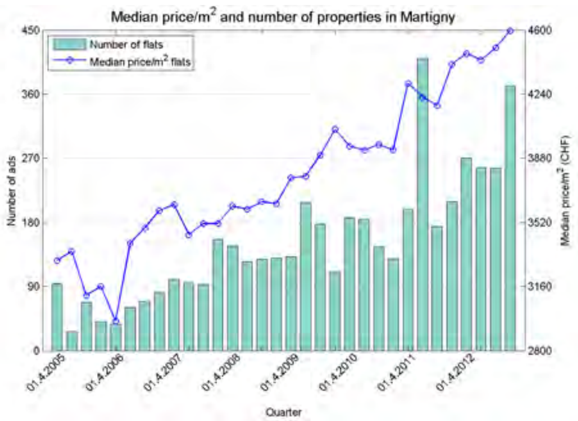


(b) Medium size apartments.

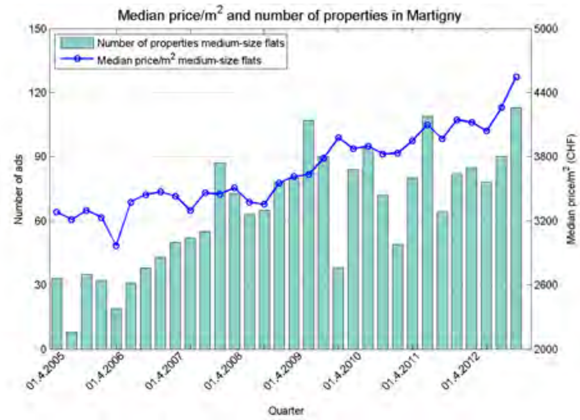


(c) Medium size houses.

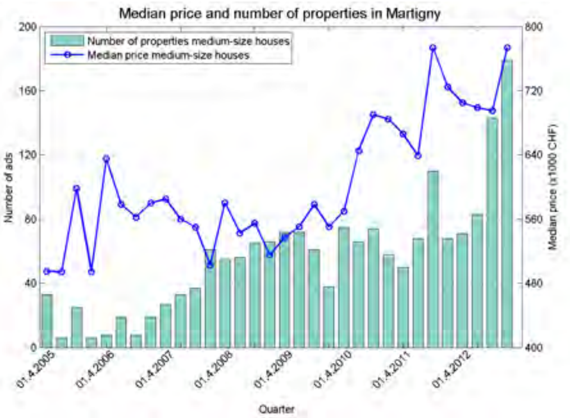
Figure D.149: Development of prices in Leuk.



(a) All apartments.

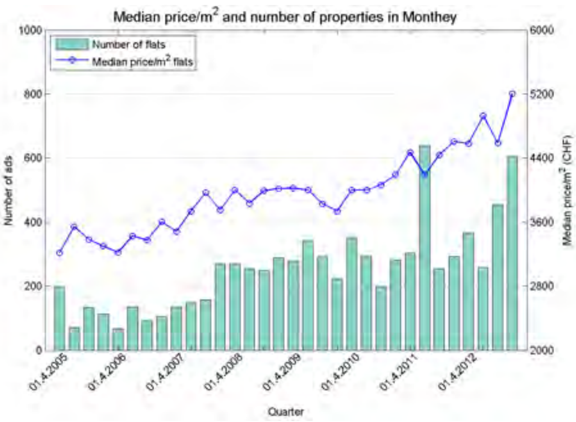


(b) Medium size apartments.

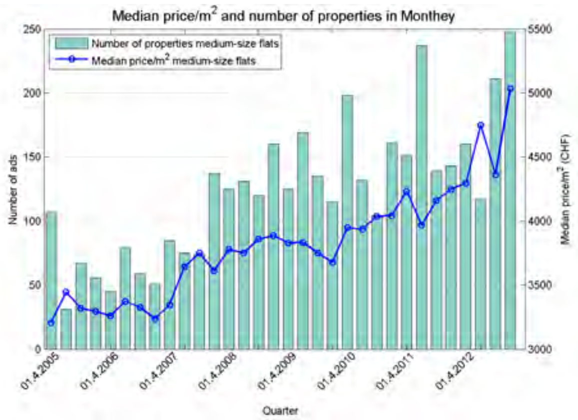


(c) Medium size houses.

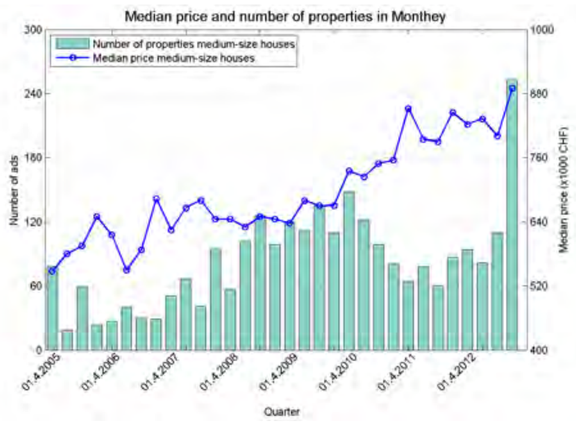
Figure D.150: Development of prices in Martigny.



(a) All apartments.

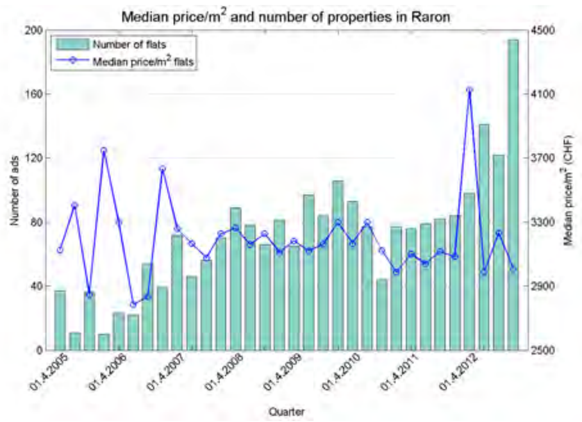


(b) Medium size apartments.

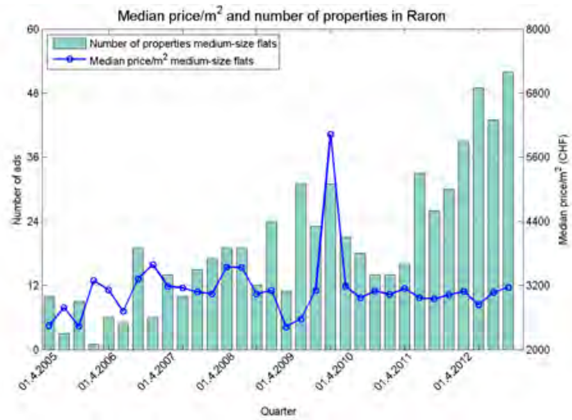


(c) Medium size houses.

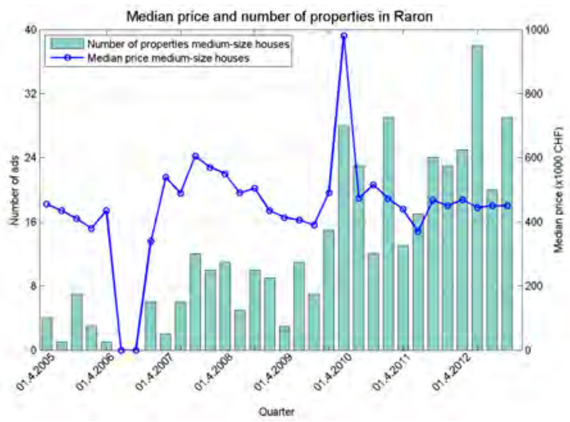
Figure D.151: Development of prices in Monthey.



(a) All apartments.

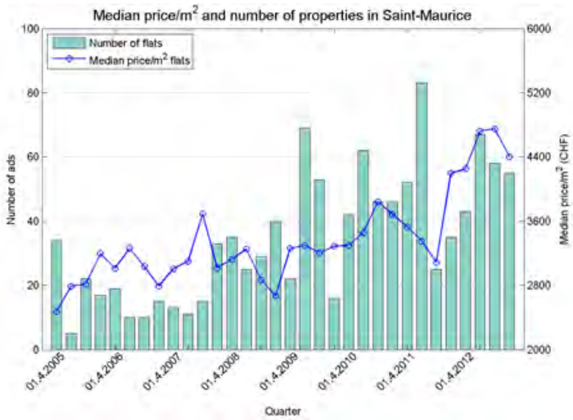


(b) Medium size apartments.

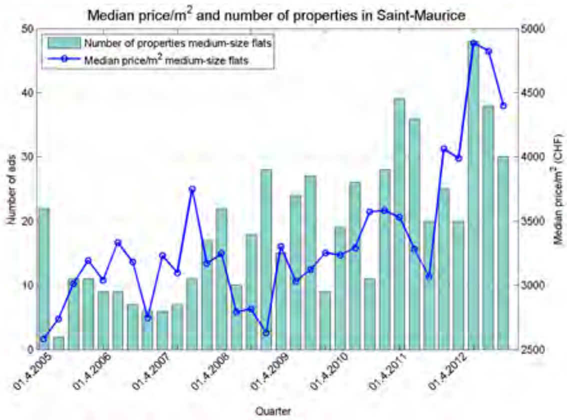


(c) Medium size houses.

Figure D.152: Development of prices in Raron.



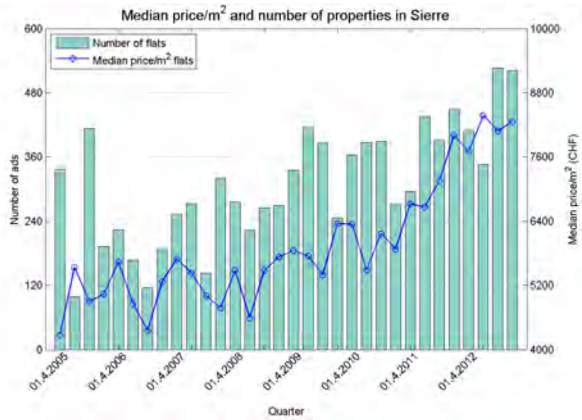
(a) All apartments.



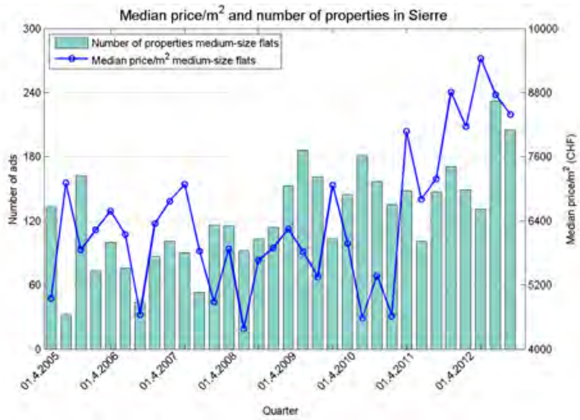
(b) Medium size apartments.

(c) Medium size houses.

Figure D.153: Development of prices in Saint-Maurice.



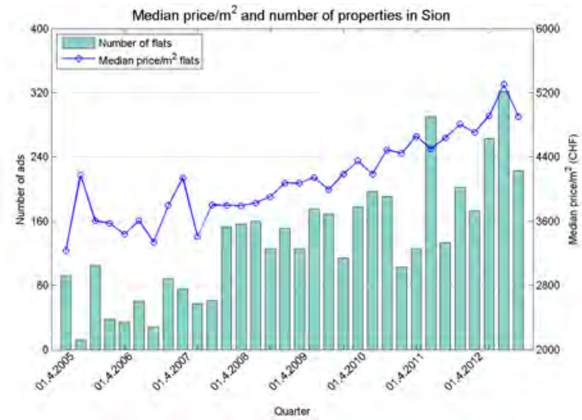
(a) All apartments.



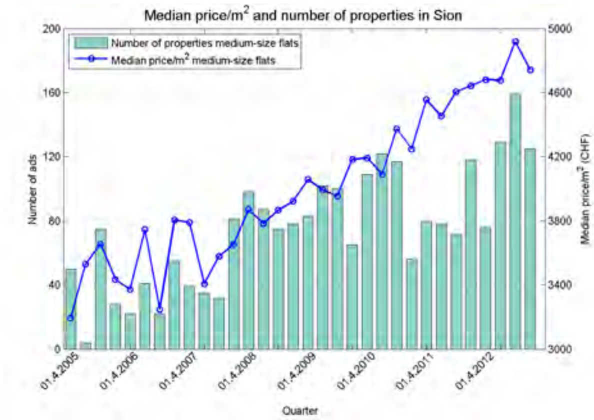
(b) Medium size apartments.

(c) Medium size houses.

Figure D.154: Development of prices in Sierre.



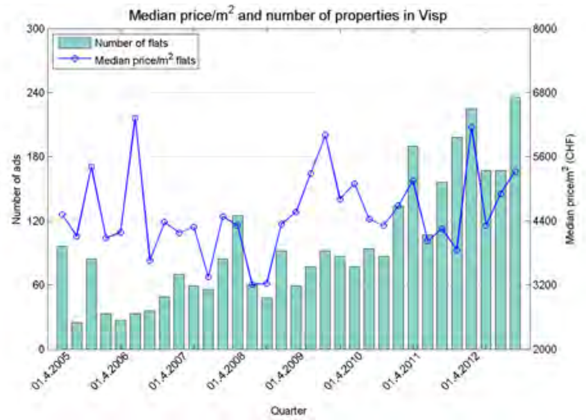
(a) All apartments.



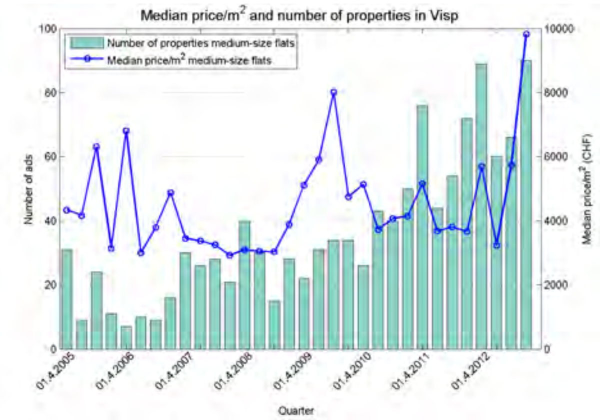
(b) Medium size apartments.

(c) Medium size houses.

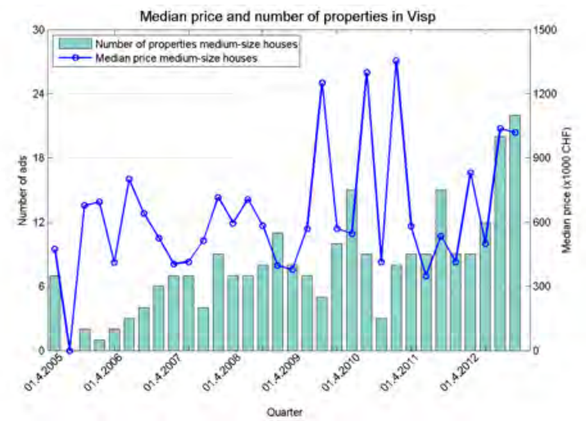
Figure D.155: Development of prices in Sion.



(a) All apartments.

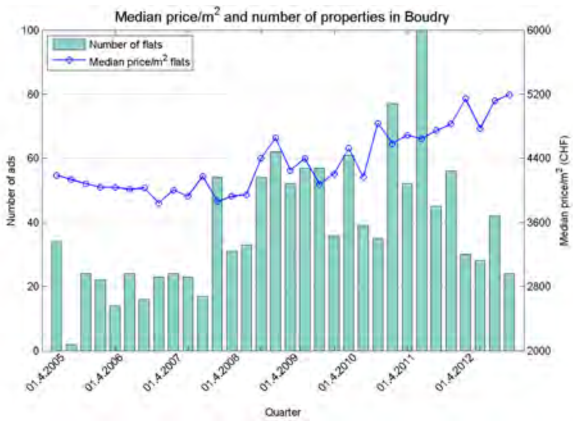


(b) Medium size apartments.

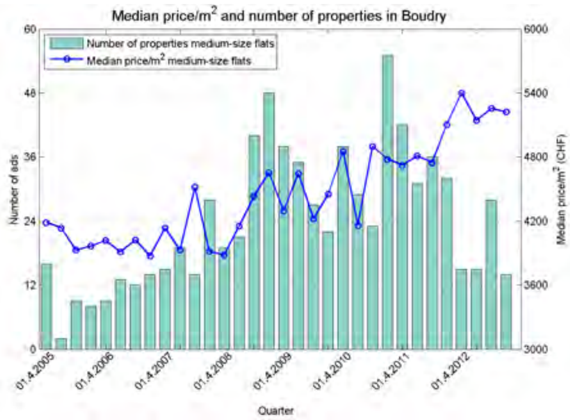


(c) Medium size houses.

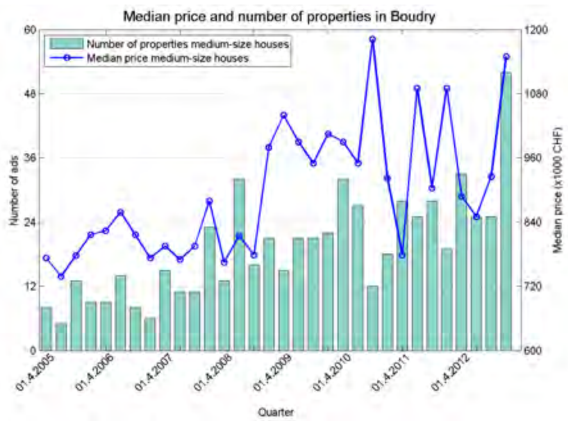
Figure D.156: Development of prices in Visp.



(a) All apartments.

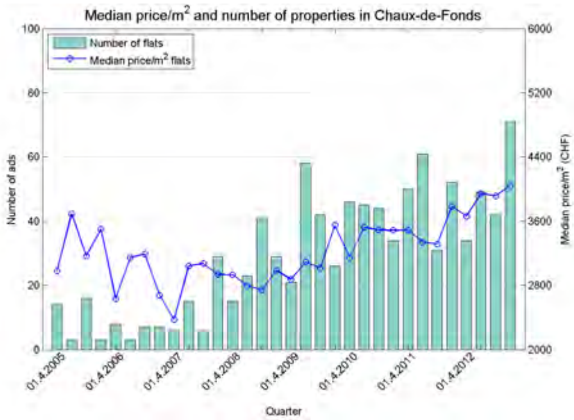


(b) Medium size apartments.

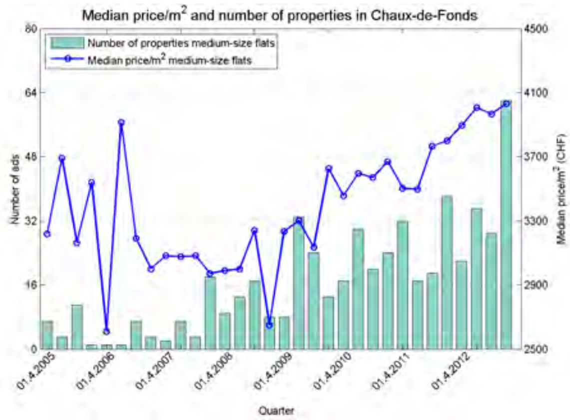


(c) Medium size houses.

Figure D.157: Development of prices in Boudry.



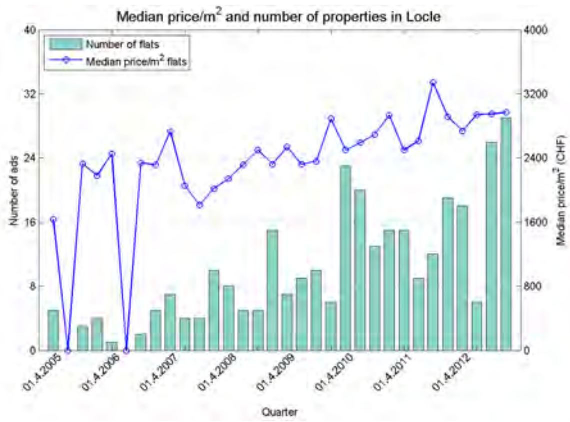
(a) All apartments.



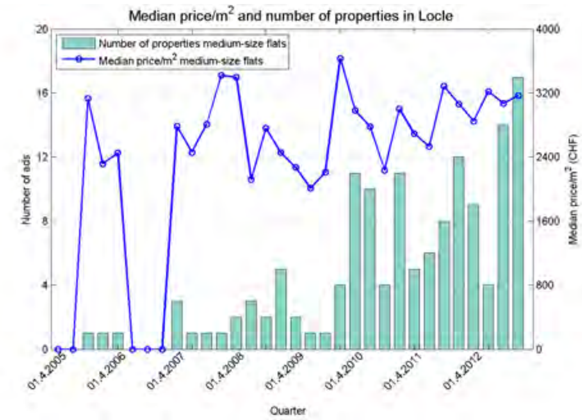
(b) Medium size apartments.

(c) Medium size houses.

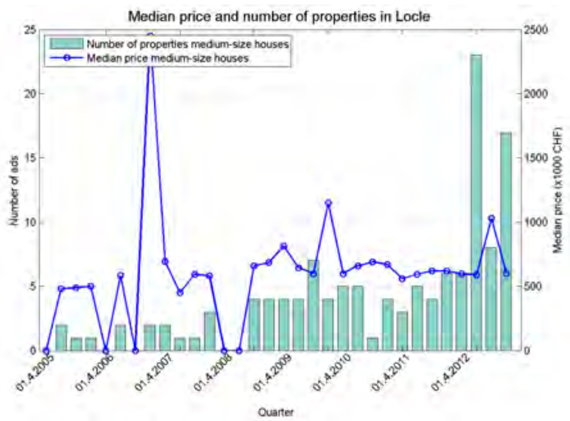
Figure D.158: Development of prices in Chaux-de-Fonds.



(a) All apartments.

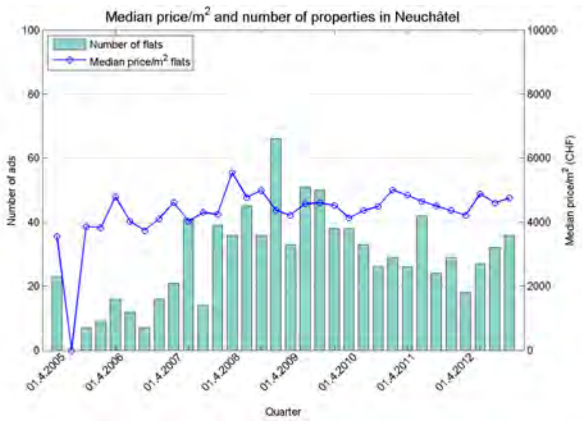


(b) Medium size apartments.

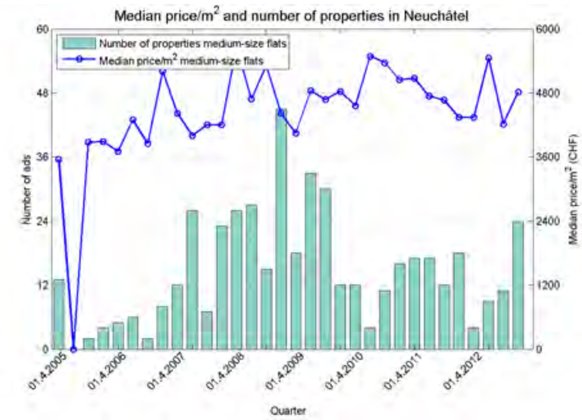


(c) Medium size houses.

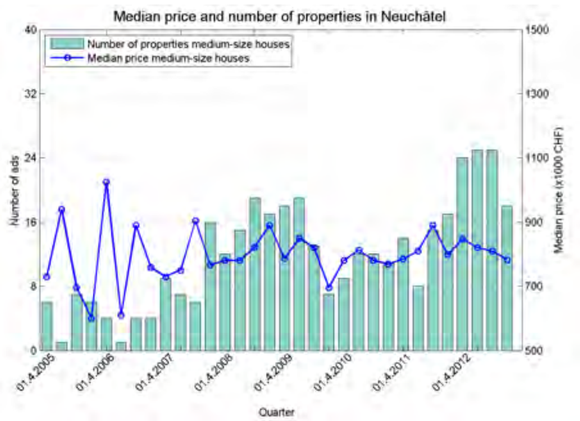
Figure D.159: Development of prices in Locle.



(a) All apartments.

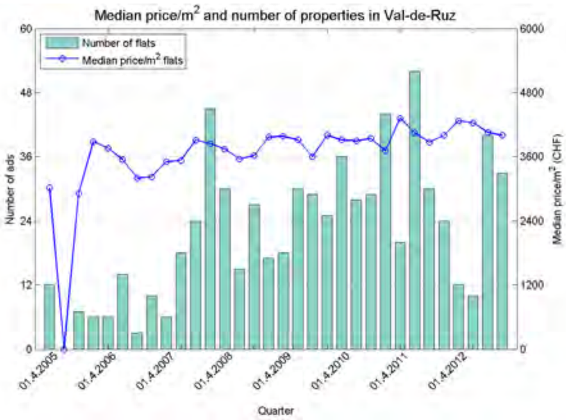


(b) Medium size apartments.

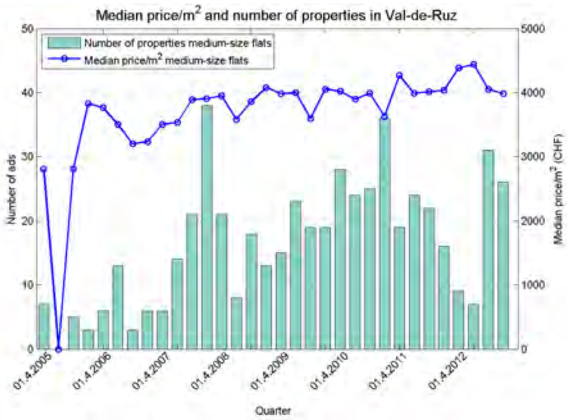


(c) Medium size houses.

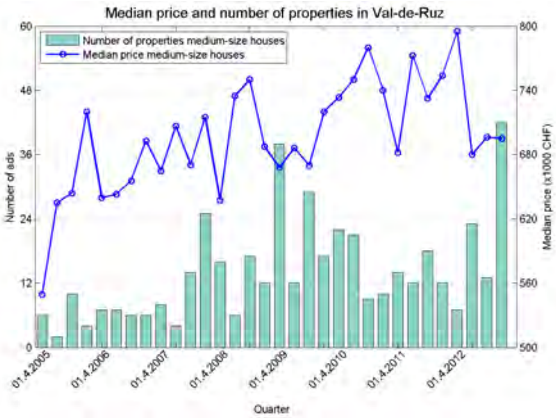
Figure D.160: Development of prices in Neuchâtel.



(a) All apartments.

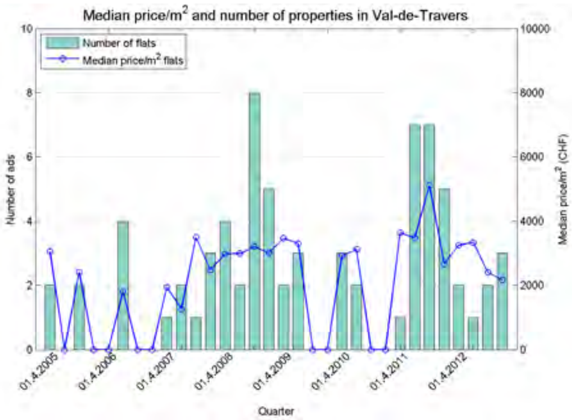


(b) Medium size apartments.

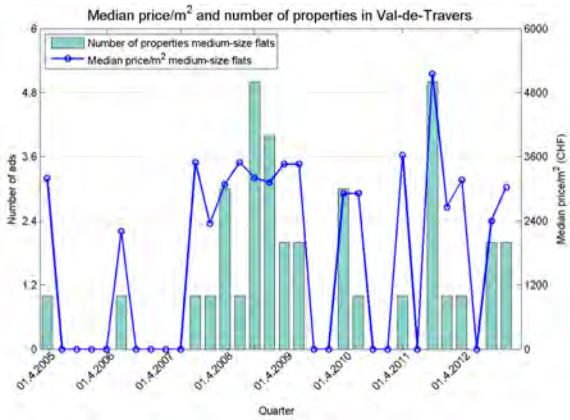


(c) Medium size houses.

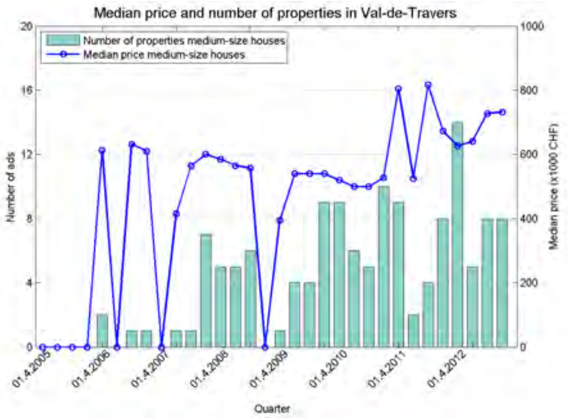
Figure D.161: Development of prices in Val-de-Ruz.



(a) All apartments.

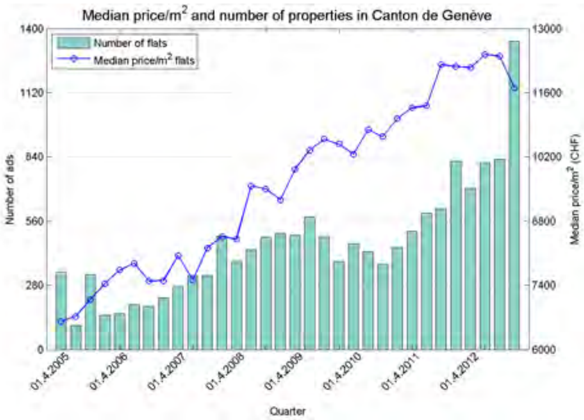


(b) Medium size apartments.

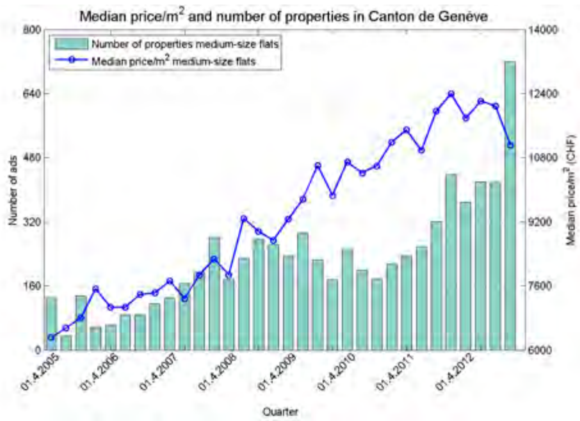


(c) Medium size houses.

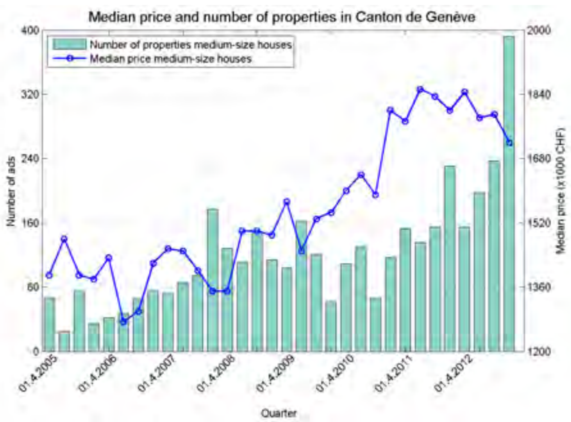
Figure D.162: Development of prices in Val-de-Travers.



(a) All apartments.

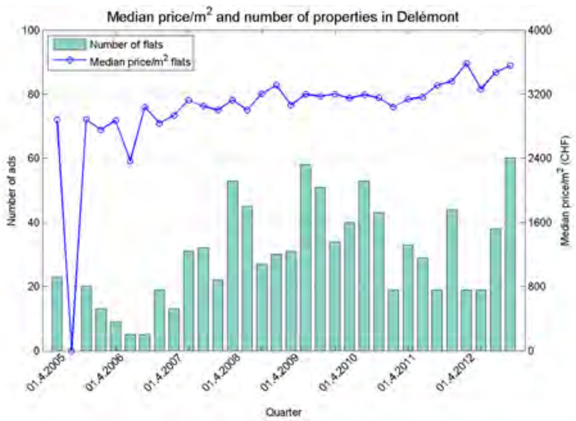


(b) Medium size apartments.

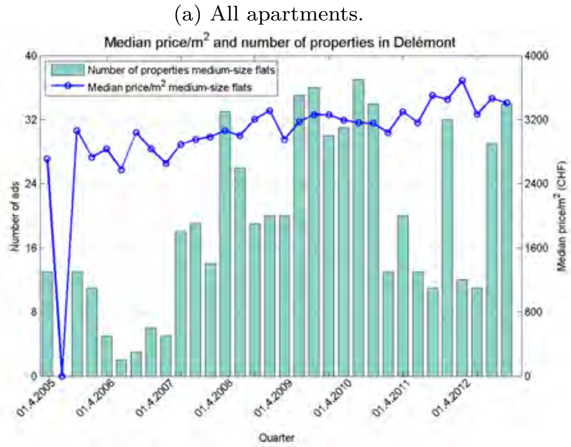


(c) Medium size houses.

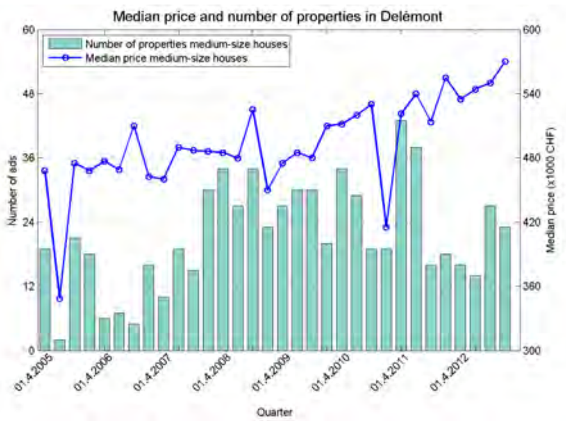
Figure D.163: Development of prices in Canton de Genève.



(a) All apartments.

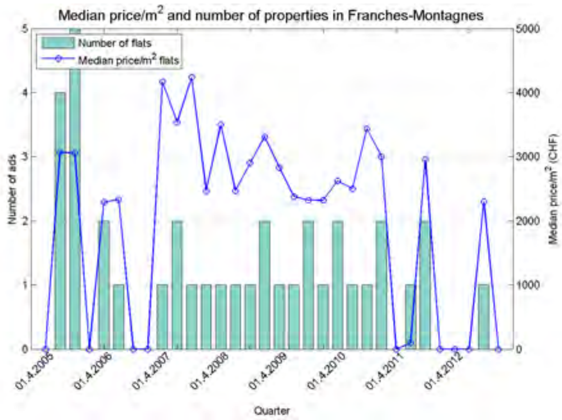


(b) Medium size apartments.

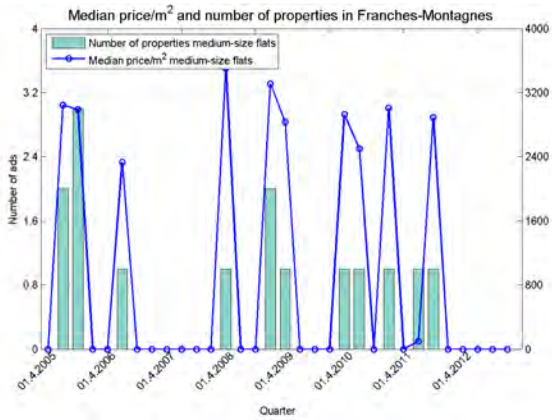


(c) Medium size houses.

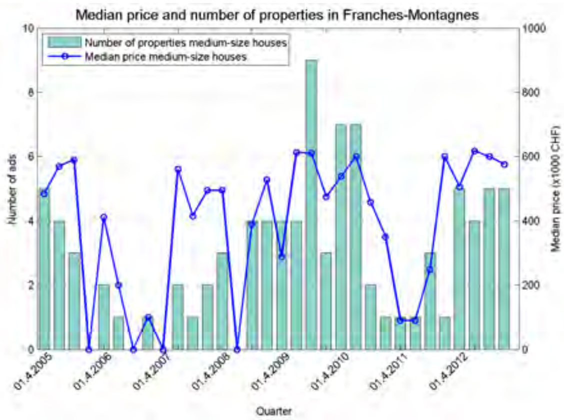
Figure D.164: Development of prices in Delémont.



(a) All apartments.

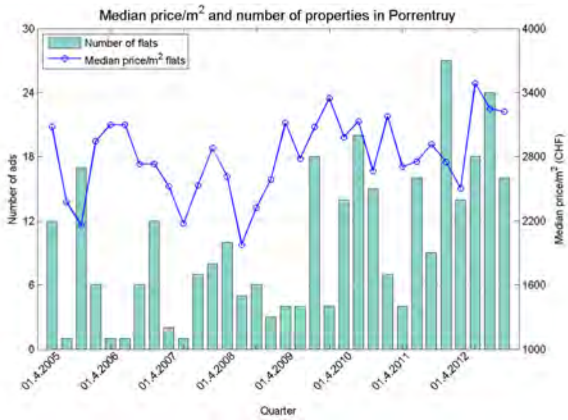


(b) Medium size apartments.

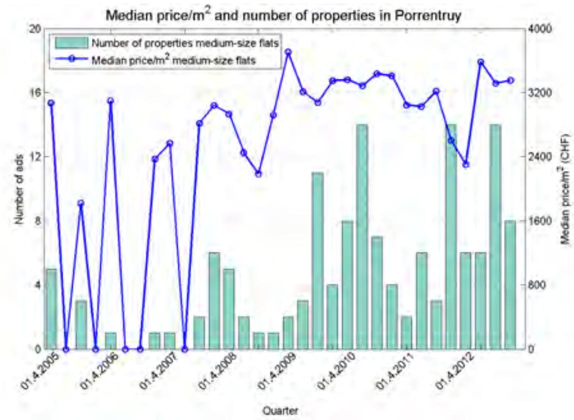


(c) Medium size houses.

Figure D.165: Development of prices in Franches-Montagnes.



(a) All apartments.



(b) Medium size apartments.

(c) Medium size houses.

Figure D.166: Development of prices in Porrentruy.

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