A hedonic regression analysis of house asking-prices in Aruba[*]

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Abstract

Over the past seven years, the asking prices for houses in Aruba have increased moderately, on average by 2 percent per year. This price buildup was in tandem with an improvement in the quality of the housing stock, i.e., a rise in the number of bedrooms and bathrooms per house and the introduction of amenities such as a garage. We examine the determinants of prices for houses in Aruba, using quarterly data from real estate agencies' websites over the period 2012Q3 to 2019Q2. Using a hedonic price analysis, we identify the impact of housing characteristics on prices for houses, controlling for fixed effects of regional location, real estate agency, and time. Results indicate that housing characteristics such as number of rooms, construction size, and the presence of specific amenities, are significant price determinants.

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1.   Introduction

Household financial positions are directly affected by housing market developments, as the household's residential property is one of the most important items on a household's balance sheet. As such, the prices at which houses are purchased or sold by households, can have substantial financial consequences both for household finance and for the economy as a whole.

Motivated by the aforementioned and the lack of literature on this topic for Aruba, this paper serves as an investigation on the development and heterogeneity in Aruban house prices across a set of different characteristics and an investigation of the determinants of house prices.

The structure of this paper is as follows. Section 2 describes our data source. Section 3 and 4 discusses the composition and development of housing supply in terms of housing characteristics, respectively. Section 5 sketches price developments on the Aruban real estate market. Section 6 presents a hedonic regression analysis of the determinants of the asking price for houses. This regression model is used in Section 7 to adjust house price developments for house quality improvement. Section 8 concludes.

2. Data

The Central Bank of Aruba (CBA) has been conducting a 'Real Estate Demand Price Survey' (REDPS) since the third quarter of 2012. For each quarter, data on the price and on a set of characteristics of randomly selected houses on the market are collected from real estate websites. To maintain a margin of error of 5 percent, 400 observations are recorded for each quarter through a controlled random sampling method, indicating that approximately 25 observations are gathered from each real estate website.

The following housing characteristics have been gathered:
(1) **T**he asking price of the house, quoted in Aruban florin (Afl.).
(2) The number of bedrooms in the house.
(3) **T**he number of bathrooms in the house.
(4) Regional dummy: the region where the house is located.
     Noord/ Tanki Leendert;
     Oranjestad West;
     Oranjestad Oost;
     Paradera;
     Santa Cruz;
     Savaneta;
     San Nicolas Noord;
     San Nicolas Zuid.

(5) Own Property Land: This is a dummy variable taking the value "1" when the house is built on own property land and "0" when on lease land.

(6) Total Property Size: This is the property's land size m².

(7) Total Construction Size: the size of the house in squared meters (m²).

(8) Additional Floor: a dummy variable which takes the value "1" if a house has more than 1 floor and "0" otherwise.

(9) Garage: a dummy variable which takes the value "1" if a house has a garage and "0"otherwise.

(10) Swimming Pool: a dummy variable which takes the value "1" if a house has a pool and "0" otherwise.

(11) Other Amenities: a dummy variable which takes the value "1" if a house has other amenities besides the ones indicated in the above mentioned variables and "0" otherwise. Other amenities are, for example, a great view, office, porch, apartments, patio, garden, hot tub, etc.

3. Housing characteristics

Table 1 depicts the descriptive statistics on the characteristics of the houses, using the latest sample of 2019Q2. On average, the houses had an asking price of Afl. 654,424.50, 3.55 bedrooms and 2.60 bathrooms, a total property size of 846.36m² and a total construction size of 253.49m². The range between the minimums and the maximums indicate high dispersions in all characteristics which could also be indicative of outliers (for example, for 2019 Q2, the lowest level of Price recorded was Afl. 160,000, while the highest was Afl. 3,200,000). To mitigate the effects of outliers, the median is also presented, which in the case of outliers gives a better indication of central tendency.

Table 1: Characteristics houses (2019 Q2)

General characteristics	Median	Mean	Min.	Max.
Price in Afl.	575,000.00	654,424.50	160,000.00	3,200,000.00
Bedroom	3.00	3.55	1.00	8.00
Bathroom	2.00	2.60	1.00	7.50
Total property size	705.00	843.36	103.00	9,940.00
Total construction size	234.00	253.49	59.00	1,187.00

Figure 1 illustrates the distribution among districts. The majority of the houses are located in Noord/Tanki Leendert, followed by Oranjestad Oost and Santa Cruz. San Nicolas (both San Nicolas Noord and San Nicolas Zuid) has the lowest share of houses on the market.

Figure 1: Distribution among regions (2019 Q2)
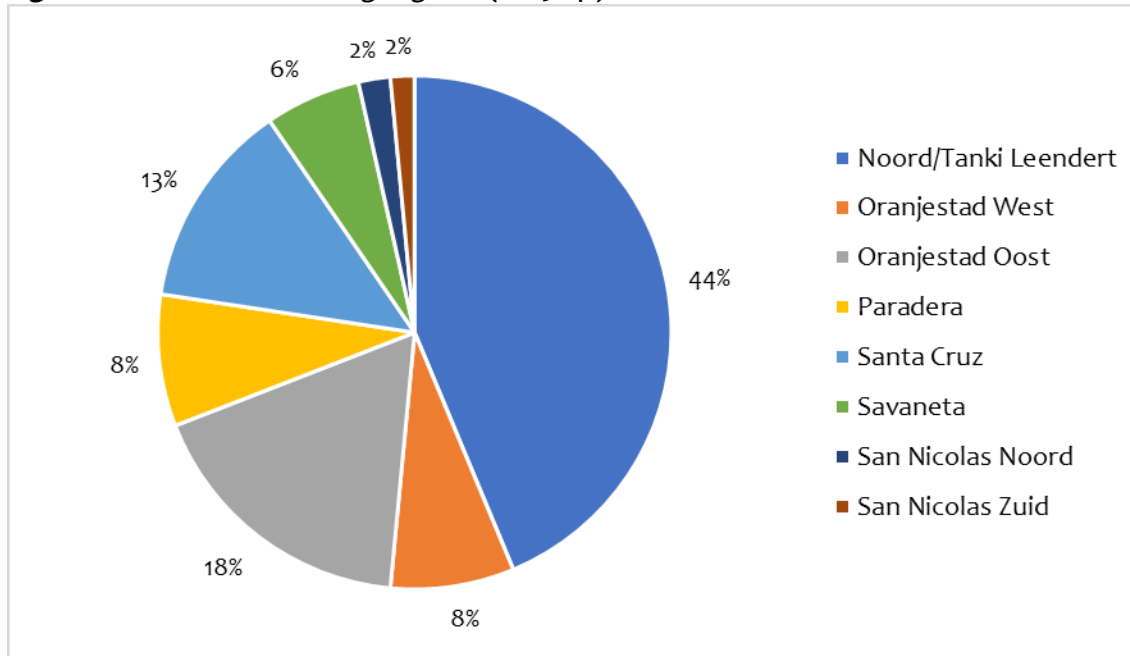
The proportion of houses built on own property land amounts to approximately 55 percent, and those built on lease land amounts to approximately 45 percent. The distribution is thus close to being evenly distributed.

Table 2 gives the percentages of houses having a particular amenity. A minority of 16 percent of houses has an additional floor, and about 40 percent has a garage. About 22 percent has a swimming pool while 40 percent has other amenities (e.g. patio, great view, maid's room, office; apartment).

Table 2: Share of houses with certain amenities

Amenities	Percent of total
Additional floor	16%
Garage	40%
Swimming pool	22%
Other amenities	40%

4. Development of housing characteristics over time

This section describes the changes over the past seven years in the market with respect to the characteristics discussed above.

As depicted in Figure 2, the average number of bedrooms per house has been increasing over the years, from 3.21 in 2012Q3 to 3.55 in 2019Q2. This represents an increase of 10.6 percent.

Figure 2: _Average number of bedrooms per house_
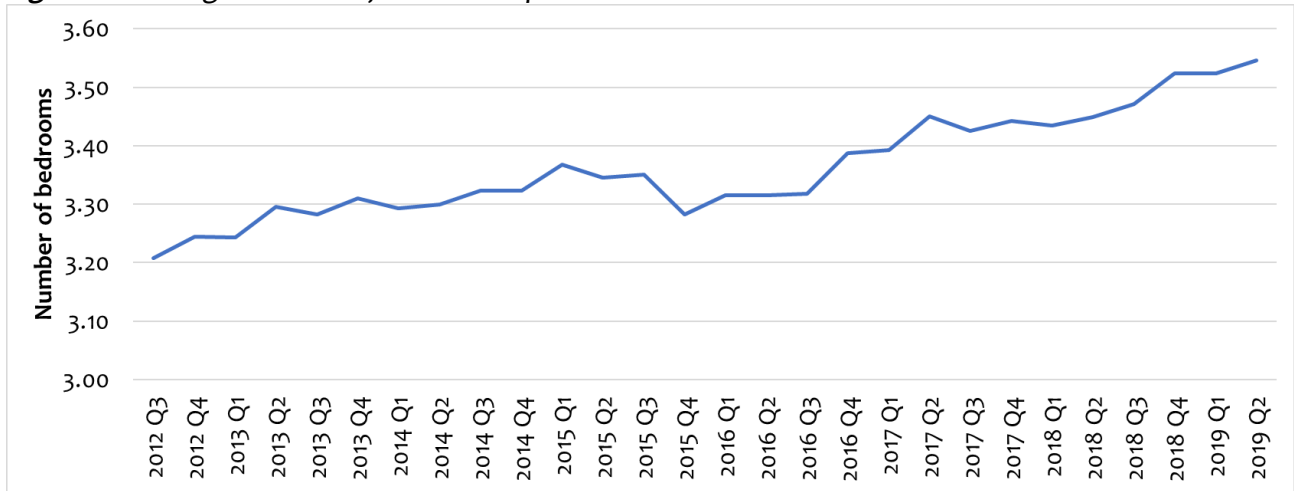
The development of the average number of bathrooms (Figure 3) shows an increase of 11.6 percent between 2012Q3 and 2019Q2. Hence, the development in Figure 3 is similar to that in Figure 2, which indicates that the number of bathrooms is correlated with the number of bedrooms. This correlation reflects the fact that in Aruba most bedrooms have their own bathroom.

Figure 3: _Average number of bathrooms per house_
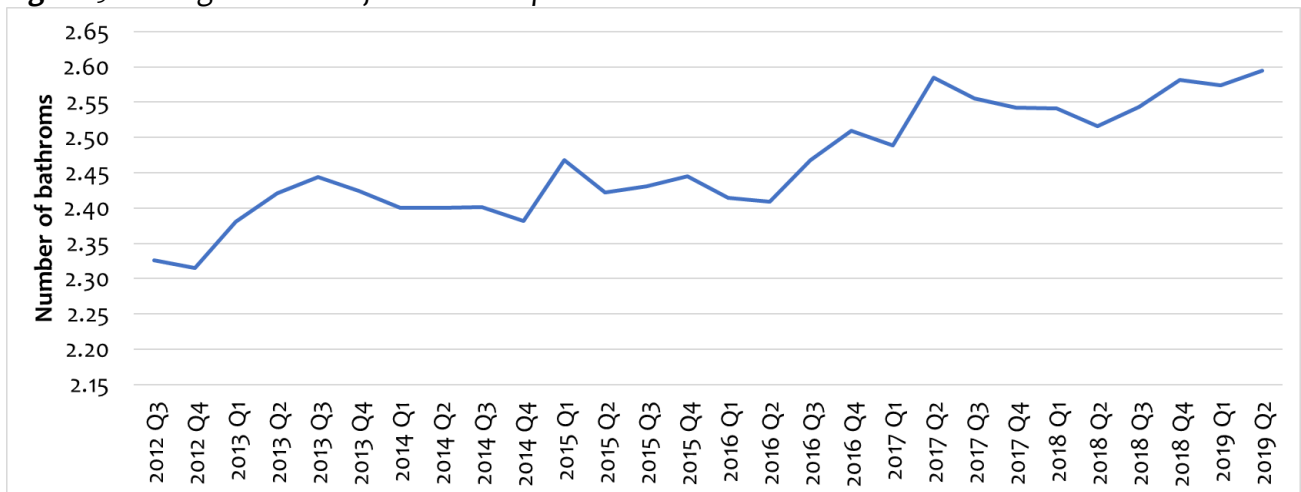
The development of the average total property size per house is plotted in Figure 4. The development indicates a slight decrease in total property size, especially when comparing the first quarters to the last quarters of the survey. The highest mean recorded for total property size was in 2012 Q3, at 889.8m². For 2019 Q2 the mean was 843.4m², hence a decrease of 5.3 percent.

Figure 4: *Average total property size per house*
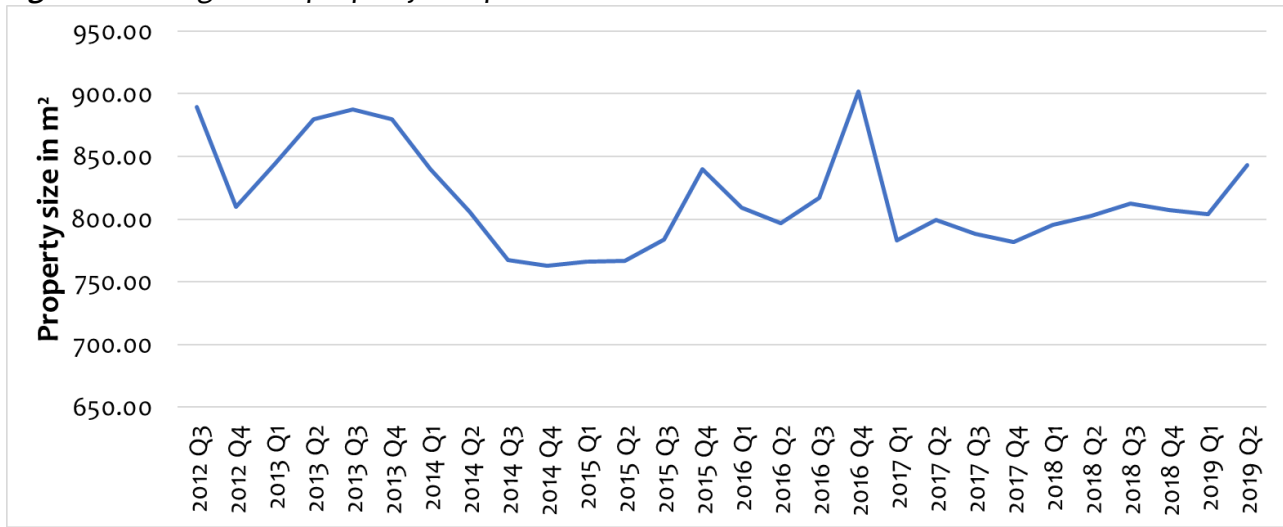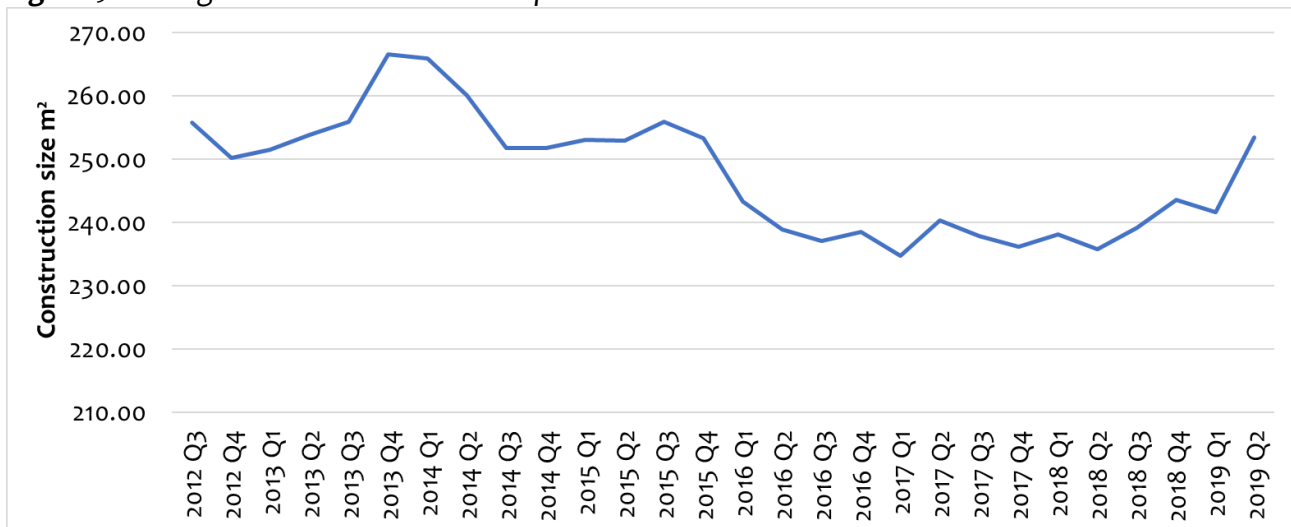

Figure 5 illustrates the development in the average construction size per house. A downward trend is also observed, which seems to be partially related to the development in Figure 4.

Figure 5: *Average total construction size per house*

The development of the distribution of houses among regions, as shown in Figure 6, indicates that the shares in the sample for most regions were quite stable over the years. Noord/Tanki Leendert has the highest share and San Nicolas Noord and San Nicolas Zuid the lowest.

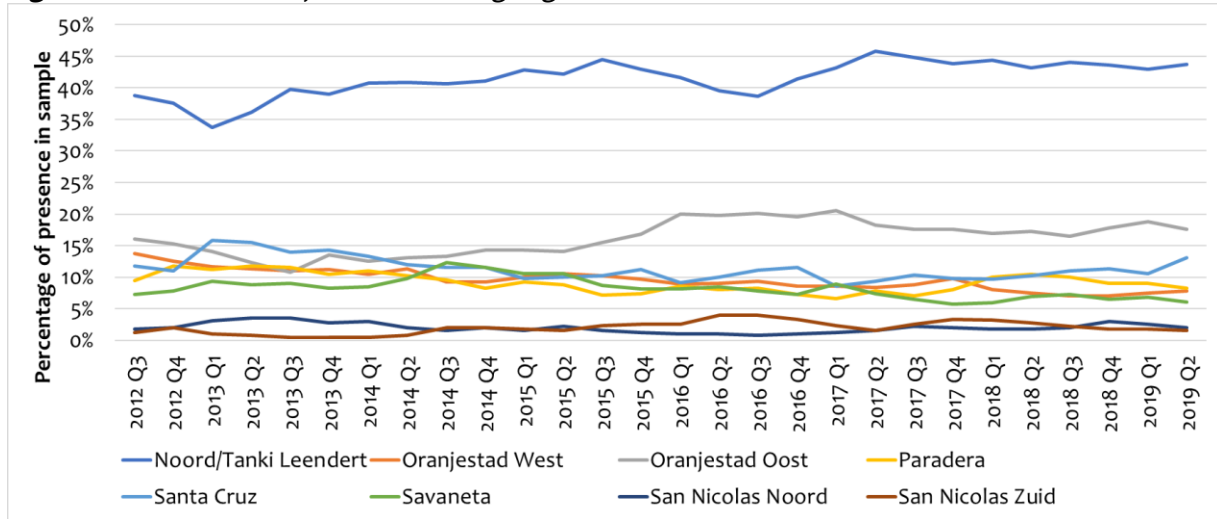**Figure 6:** *Distribution of houses among regions*

Figure 7 gives the percentages of houses built on lease land and on own property land. Houses are about evenly distributed between lease land and own property land.

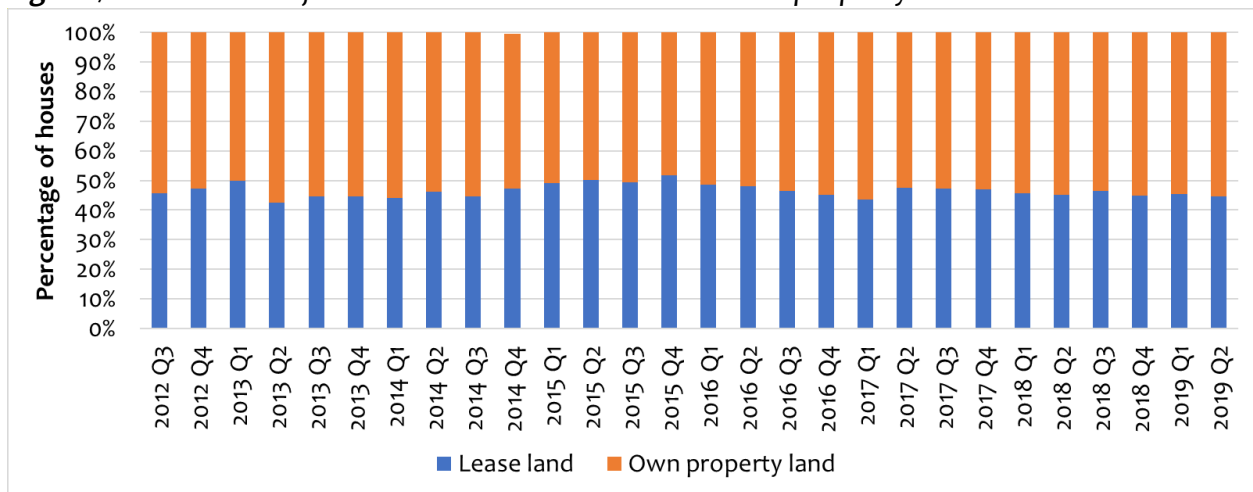**Figure 7:** *Distribution of houses between lease land and own property land*

Figure 8 illustrates the development in the presence of amenities in houses, i.e., having an additional floor, a garage, a swimming pool or 'other amenities' (such as a patio). Over time, there is a decrease in the percentage of houses with other amenities and an increase in the percentage of houses with a garage. The share of houses with an additional floor and a swimming pool remained quite stable.

*Figure 8:* Share of houses with amenities
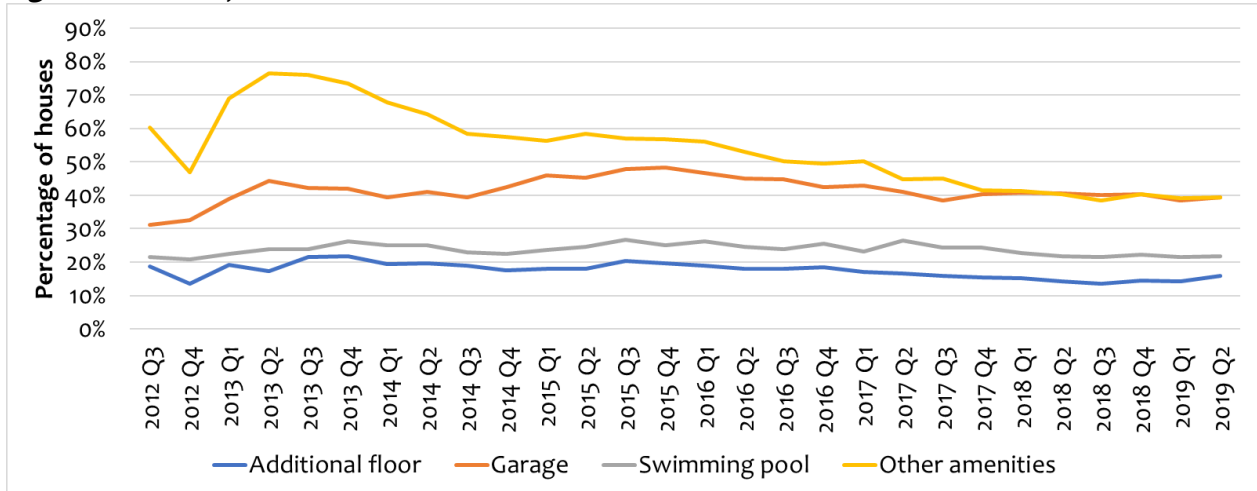
5. Price developments

In this section, we look at the housing price development over time, to gain insight into the housing market conditions in Aruba. The period covered is 2012Q3 till 2019Q2.

To mitigate the effects of possible outliers, we look at the median. Figure 9 depicts the median price development for each region.

Figure 9: *Median price per region*
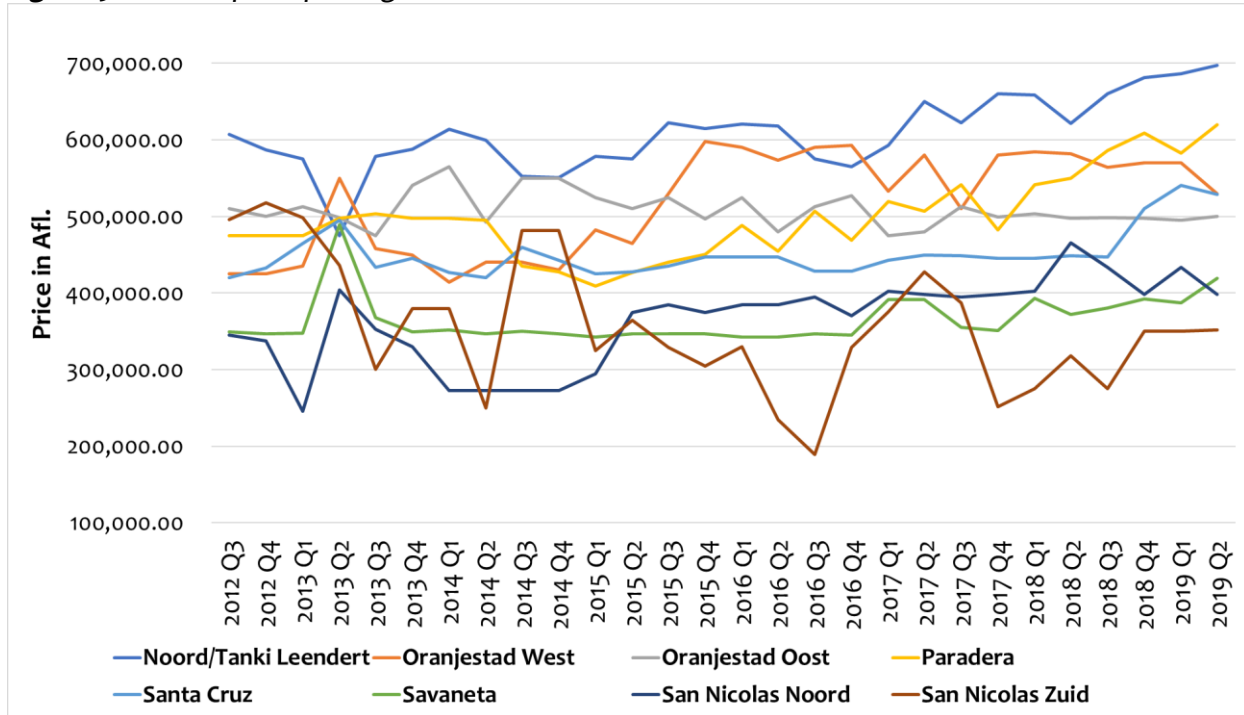
As shown in Figure 9, Noord/Tanki Leendert is the region with the highest median house price.[1] Savaneta, San Nicolas Noord and San Nicolas Zuid are the regions with the lowest median prices. All regions show a slow but steady increase in prices. The median price for San Nicolas Zuid moves erratically. To determine if these erratic movements in prices of San Nicolas Zuid affects the median price for the whole sample, we calculated the median for the whole sample both including and excluding San Nicolas Zuid. As illustrated in figure 10, movements in prices of San Nicolas Zuid do not substantially affect the overall development of the median price over time for the whole sample.

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[1] In Section 6, an econometric analysis of price differences between regions will be presented including an adjustment for regional house quality differences

Figure 10: *Median price for whole sample (including and excluding San Nicolas Zuid)*
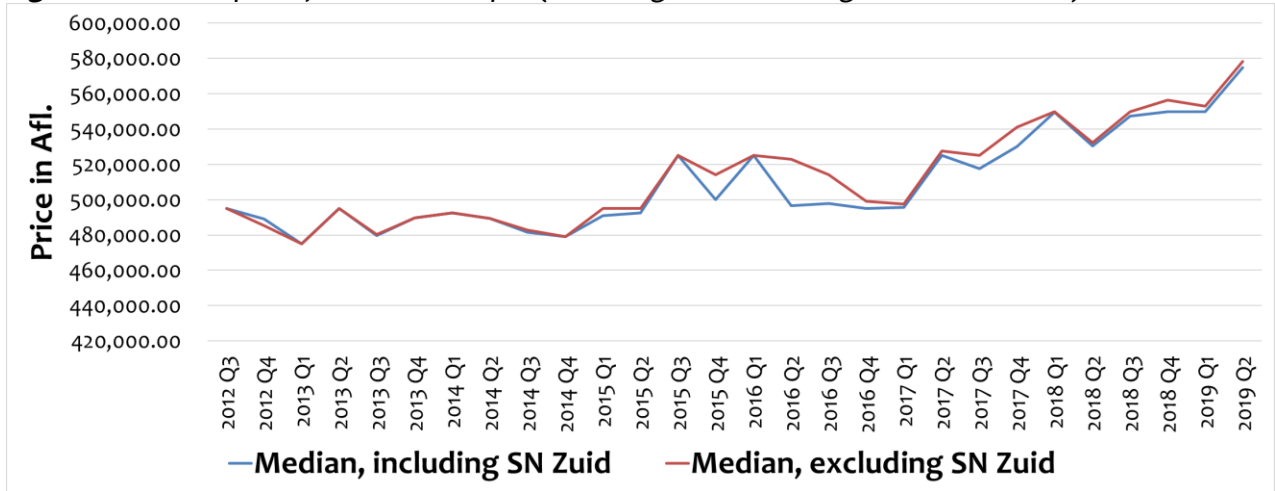
Therefore, further analysis involving the price development for the market will be based on the whole sample including San Nicolas Zuid. Figure 11 shows the median for the whole sample, as well as the 25th and 75th percentiles (the average of the median price series amounts to Afl. 509,307.00, and has a standard deviation of Afl. 26,779.71. The average interquartile range is Afl. 361,115.00). According to the median series, the housing market price increased by 16 percent between 2012Q3 and 2019Q2, that is an average increase of 2 percent per year. Compared to house price developments in rural areas of other countries around the world (e.g., Clerc, 2019), Aruba has a steady and moderate rate of price increase.

Figure 11: *Median, 25th- and 75th percentile of house prices*
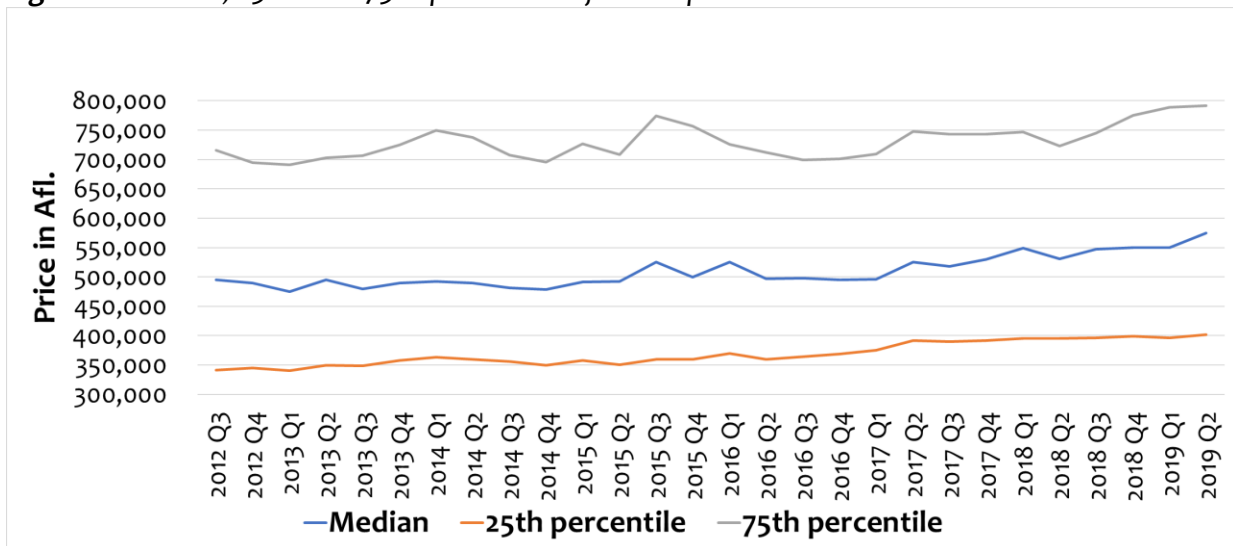
6. Regression analysis

For the regression analysis, we clean and merge the survey data as follows. First, we drop outliers by deleting the lowest and highest 5 percentiles of the house asking price distribution for each period. Second, the data for all 28 periods are stacked into one panel data set. As the houses in each survey have been randomly selected, some houses are present in more periods than others. In order to obtain a panel dataset with a useful longitudinal dimension, we drop houses with less than 5 observations. This leaves us with an unbalanced dataset consisting of 493 houses with a total of 4,339 observations (i.e., on average 8.8 observations per house, with a minimum of 5 and a maximum of 22).

We take the logarithm of the house asking price (in 1,000 Afl.) as dependent variable. Log transformation of house prices is common as their distribution is typically skewed (e.g., Gnagey and Tans, 2018). We regress the dependent on the set of potential determinants, introduced in Section 2. We include 8 regional dummy variables for the 8 regions in Aruba. We also add 11 dummy variables for the 11 real estate agencies with a market share above 2.5%. We log-transform property size and construction size. We interact number of rooms with number of bathrooms, following Pardoe (2008).

For robustness, we run three types of regressions. The first is a random effects panel regression[2] without time effects. The second is the same regression including time effects. The third is a two-step Fama-MacBeth regression; its first step consists of running an OLS regression for each period separately, and the second step is taking the average of the results. The regression results are presented in Table 3. The Wald test of the time effects in the random effects model including time effects (column 2) reveal that time effects are not significantly different from zero. The estimated coefficients for the explanatory variables are almost identical between the random effects regressions with and without time effects. The coefficients between the random effects model and the Fama-McBeth model are qualitatively similar. As the estimates are similar across the three models, we further use the Fama-MacBeth estimates (column 3) for further calculations and analysis. The advantage of this model is that it also generates cross section estimates per year, which will be used in Section 7 to derive quality adjusted price index.

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[2] We cannot run a fixed effects panel regression, as the variables are mostly time-invariant per house so that these variables would be dropped due to collinearity with the fixed effects.

Table 3. *Regression results. Dependent variable is log of house asking price*

|	Random effects		Fama-MacBeth
	(1)	(2)	(3)
Number of rooms	0.065***	0.065***	0.076***
Number of bathrooms	0.149***	0.150***	0.194***
(Number of rooms) x (number of bathrooms)	-0.022***	-0.022***	-0.028***
Own property land dummy	0.013	0.013	0.030**
log(land property size in m^2)	0.109***	0.109***	0.105***
log(construction size in m^2)	0.263***	0.263***	0.250***
Additional floor dummy	0.047	0.047	0.047***
Garage dummy	0.121***	0.123***	0.112***
Swimming pool dummy	0.192***	0.192***	0.155***
Other amenities dummy	0.076***	0.072***	0.086***
Regional effects	YES	YES	YES
Real estate agency effects	YES	YES	YES
Time effects	NO	YES	n.a.
R^2	0.479	0.478	0.608
Number of houses	493	493	493
Number of observations	4,339	4,339	4,339
Wald test Region (p-value)	31.2***	34.31***	16.88***
Wald test Agency (p-value)	42.89***	41.35***	27.20***
Wald test Time fixed effects (p-value)	n.a.	24.31	n.a.

Explanatory note: ***/**/* denote significance at the 1%/5%/10% level. For the coefficients significance levels have been based on (unreported) standard errors, which are robust for clustering in the random effects estimation. Wald tests give Chi-square values with their significance levels.

As the dependent variable is in logarithms, the coefficients cannot directly be translated in price effects in terms of florins. Therefore, for convenience, we also present charts showing the price effects of the main explanatory variables in thousands of florins.

Figure 12 shows how the price for a house with otherwise average properties differs between the regions. As already observed in Section 5, house prices in Noord/Tanki Leendert are the highest. However, they differ only significantly from Savaneta (and region 'unknown'); their 95% confidence bands do not coincide. Hence, after adjusting for house property differences, regional differences are not always significant at the 5% level. In other words, the regional

differences in average price are already explained by differences in house properties. Or, houses in Noord apparently have more valuable features.

Figure 12. In-sample predicted asking price for a house with otherwise average properties, by region
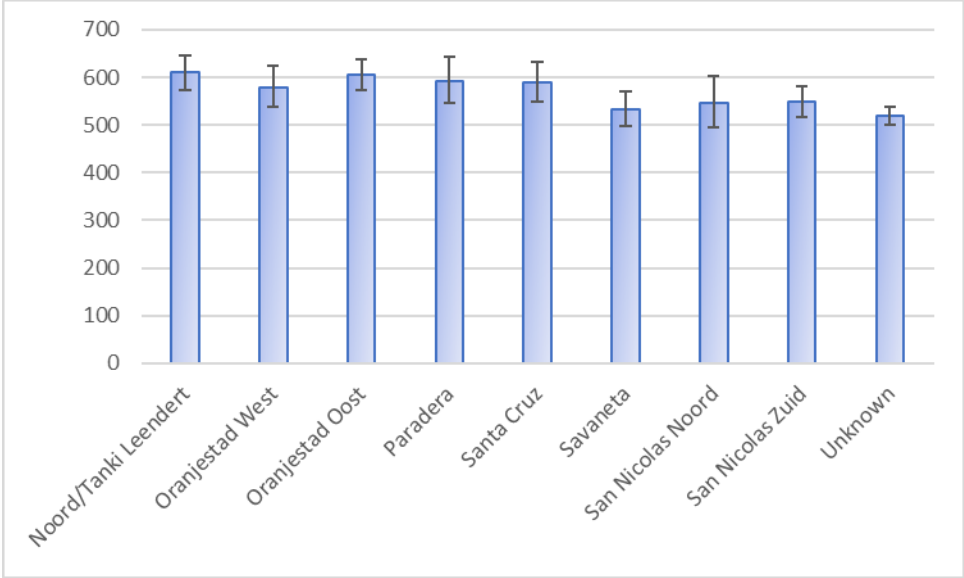
Explanatory note: The vertical bars denote 95% confidence bands.

Also, the asking price differs between real estate agencies but not always significantly (Figure 13). Only agency 7 and 11 differ significantly in price when prices have been adjusted for house property differences.
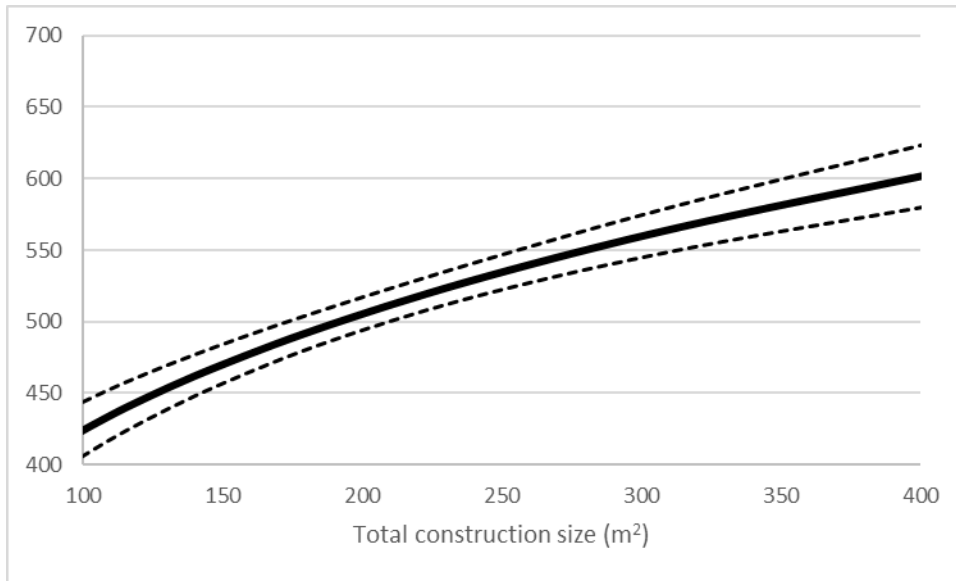
Figure 13. In-sample predicted asking price for a house with otherwise average properties, by real estate agency
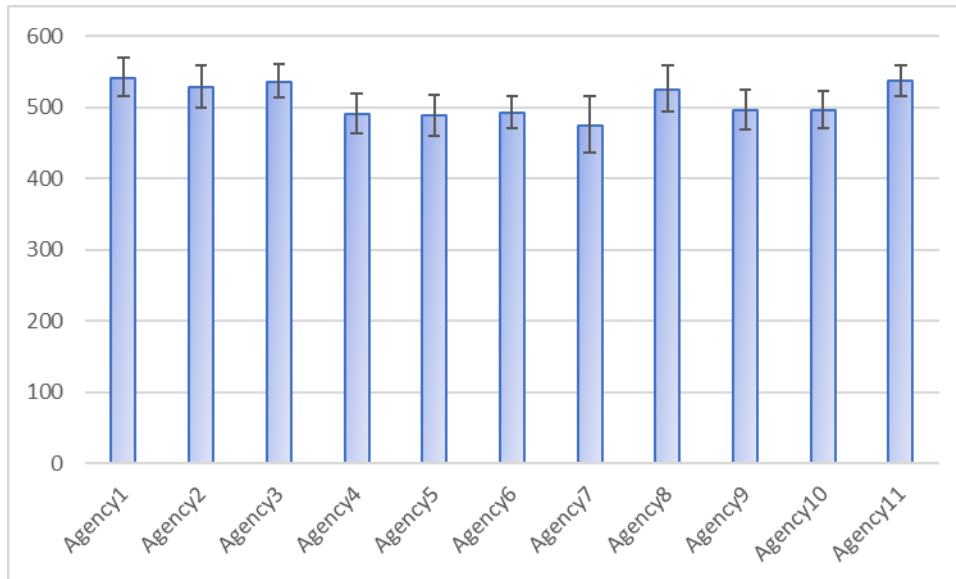
Explanatory note: The vertical bars denote 95% confidence bands.

As the construction size is also in logarithms, its coefficient (0.250) is directly interpretable in terms of elasticities. Hence, a 1% increase of the property size increases the price by 0.25%. This means that the price effect measured in florins of an increase in construction size in m^2 is diminishing with the construction size. For example, 1 additional m^2 of construction size increases the price of an otherwise average house by Afl. 1.0 thousand when the construction size is 90 m^2, by Afl. 0.7 thousand at a construction size of 150 m^2, and only by Afl. 0.4 thousand at a construction size of 300 m^2 (Figure 14).
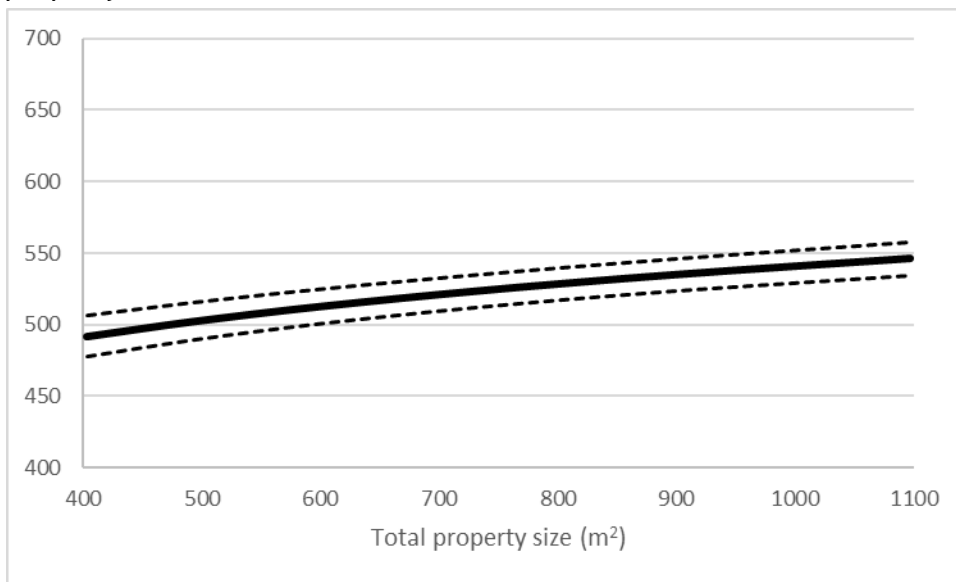
Figure 14. *In-sample predicted asking price for a house with otherwise average properties, by construction size*

Explanatory note: The dotted lines denote the 95% confidence band.

The price effect of the property size is smaller than that of the construction size (elasticity is +0.105). An additional m² of property size increases the price by Afl. 0.1 thousand at a property size of 400 m², and by Afl. 0.05 thousand at a property size of 900 m² (Figure 15).

Figure 15. *In-sample predicted asking price for a house with otherwise average properties, by property size*

Explanatory note: The dotted lines denote the 95% confidence band.

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The price effects of the number of rooms and bathrooms is complicated due to the interaction term between these two variables. For convenience, Figure 16 presents their combined effects in florins. An additional room increases the asking price by around Afl. 30 thousand if there is one bath room, and by Afl. 50 to 60 thousand if there are 4 bath rooms. The marginal value of bath rooms is increasing: an additional bath room in a house with 2 rooms increases the asking price by Afl. 76 thousand if there is one bath room and by Afl. 93 thousand if there are three bath rooms. In a house with 5 rooms these effects are Afl. 96 and Alf. 117 thousand, respectively.

Figure 16. *In-sample predicted asking price for a house with otherwise average properties, by number of rooms and bathrooms*
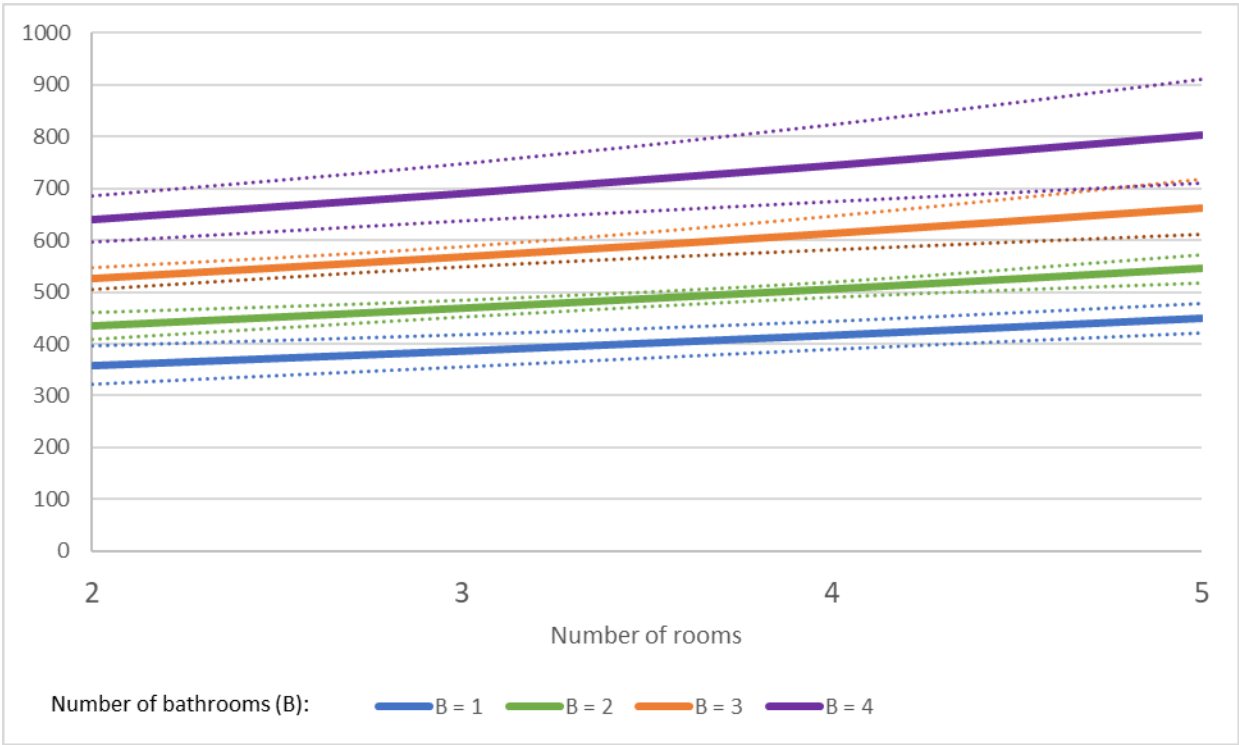
Explanatory note: The dotted lines denote the 95% confidence bands.

Taking exponentials of the coefficients of the dummy variables and subtracting 1, gives their price effects in percentages. An additional floor raises the price by 4.8%, a garage by 11.9%, and a swimming pool by 16.8%. The presence of other amenities have an effect of around 9%.

7. Price development adjusted for quality improvement

In Section 5, we used the median price to show the development of the housing market price. In this section, we use the hedonic regression results found in Section 6 to adjust the price development for quality improvement. That enables us to assess the price development for a constant quality stock of houses.

We calculate the Fisher index, which is the root of the Laspeyres index multiplied by the Paasche index:

$$I_{Fisher} = \sqrt{I_{Laspeyres} \times I_{Paasche}}$$

where:

$$I_{Laspeyres} = \frac{\alpha_t + \sum_k \beta_{kt} Q_{kt_0}}{\alpha_{t_0} + \sum_k \beta_{kt_0} Q_{kt_0}}$$

$$I_{Paasche} = \frac{\alpha_t + \sum_k \beta_{kt} Q_{kt}}{\alpha_{t_0} + \sum_k \beta_{kt_0} Q_{kt}}$$

with:

|	
t_0	= base period subscript;
t	= current period subscript;
Q_k	= mean of housing characteristic k = 1, ..., K;
α_{t_0} and β_{kt_0}	= regression coefficients from the base period;
α_t and β_{kt}	= regression coefficients from the current period t.

The Laspeyres index uses the characteristics from the base period while the Paasche index uses the characteristics from the current period. The Fisher index takes their average.

The Central Bank of Aruba has calculated a Fisher index using a model similar to Jaramillo (2006) and using the survey data. However, the CBA model is somewhat differently specified than ours and the data used have not been cleaned for outliers (Arends and Upegui, 2015). Therefore, we present our version of the Fisher index, based on our estimated model as described in Section 6 (Figure 17). According to these estimates, the housing price has increased by 2 percent in seven years, that is 0.3 percent per year. Hence, the housing price in Aruba adjusted for quality showed only a minor increase. Most of this increase took place since 2017.

Hence, the housing market in Aruba in the period under review did not show any tendency for overheating or formation of price bubbles, in contrast to developments in several other

countries during the past decade (e.g., Clerc, 2019). Aruban housing prices were relatively stable and moved in tandem with improvements of the quality of the housing stock. When house price bubble formation is absent, there is also low risk of the occurrence of house price crashes. This is good for macroeconomic stability, as boom-bust cycles in house prices can end with large contractions in consumer spending.[3] However, the downside of a sluggish house price development is that there is little scope for an increase of households' housing wealth positions.

Figure 17. *Fisher index of house prices Aruba*
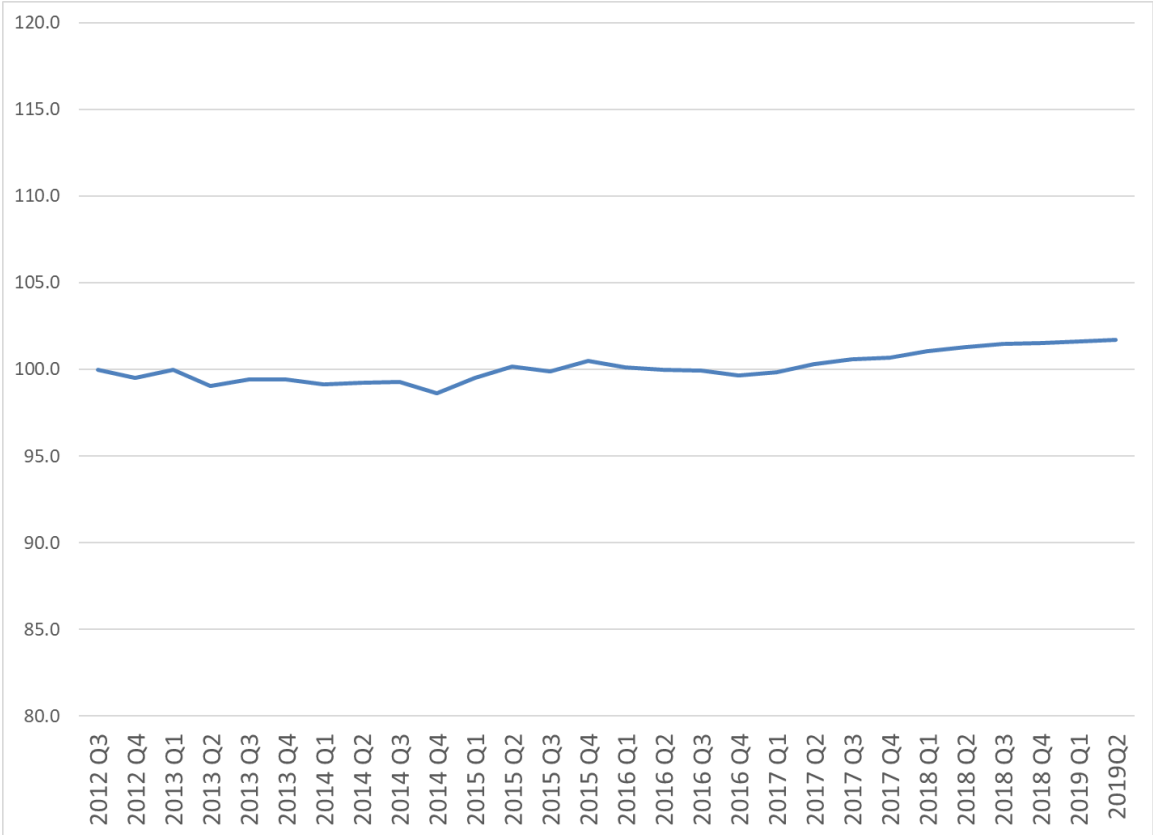
8. Conclusion

The asking-price development in Aruba over the past seven years has, with an average of 2 percent per year, been quite moderate and steady. Most of this price increase reflected an improvement in quality of the housing inventory, as a result of an increase in the number of bedrooms and bathrooms per house and the presence of amenities such as a garage. Adjusting for quality improvement, the price increase over the past seven years was only 0.3

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[3] See, e.g., Mian et al. (2013).

percent per year. The estimation results of a hedonic regression model for house prices shows that house prices are positively related with the number of bed rooms and bath rooms, the construction and property size, and the presence of amenities such as an additional floor, a garage and a swimming pool.

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