UNIVERSITY OF TWENTE.

waarderingskamer
netherlands council for real estate assessment

Topic: **The Netherlands Study into Discrepancy Between Assessed Values and Market Prices**

Date: 25 April 2024

Authors: Luc D. Hermans
Ruud M. Kathmann
Marija Bockarjova
Jacob A. Zevenbergen

1. Introduction

The current Dutch system for real estate assessment is based on the Special Act for Real Estate Assessment (Wet WOZ). This act has been in effect since 1995. The initial act provided that every real estate property received a assessment every four years. Since 2008 assessments are to be done annually (Gieskes and Kathmann, 2010). The Special Act for Real Estate Assessment transformed the Dutch property tax system from a more or less area-based system to an ad valorem system or in other words, a system based on the market value of the property on the value reference date. This value reference date is always January 1st on the year before the active tax year (Bervoets et al, 2016). The assessed value serves as the tax base for several local and national taxes in the Netherlands. The approximated levied taxes based on the assessed value are about 11 billion euros yearly. Besides taxation the assessed values are also used for several other formal purposes. Therefore, the Netherlands Council for Real Estate Assessment places importance on the quality of the assessments and the discrepancies between the assessed values and the market prices.

Under current legislation oversight on the quality of the assessments is done by the Netherlands Council for Real Estate Assessment (NCREA). NCREA is an independent self-governing body under responsibility of the ministry of finance. The assessment process is a responsibility of the municipalities. The Netherlands currently has 342 municipalities. The assessment processes are sometimes carried out jointly by multiple municipalities who cooperate in shared service centers to benefit from economies of scale.

To ensure the quality of the assessments the Netherlands Council of Real Estate Assessment carries out annual audits at the municipalities to investigate the quality of the assessments as well as the processes underlying the assessments. Furthermore, the Netherlands Council for Real Estate Assessment engages in (recurrent) thematic research. Once every five years a thematic research project is done on the discrepancy between the assessed values of residential properties and

the observed market values, i.e. the sales price. This thematic research project is done in one central analysis for all residential properties in the Netherlands.

The current reiteration of this thematic research is done in collaboration with the University of Twente (UT) and forms the base for this paper. So far, the research has yielded the results for the comparison of sale prices and property value assessments. But the project is still ongoing and not all results needed to answer all the sub questions are available at this moment. This paper will present the preliminary findings as well as the approach, theory, and methodology for the complete research.

The current iteration of the Netherlands study into discrepancy between assessed property values and market prices is done for the period between 2018 and 2023. This period has been characterized by dynamic market development including sharp increases in housing prices as well as short but impactful corrections. The effects in the market have been influenced by the COVID-19 pandemic and the influence of accompanying developments on the financial markets such as low interest rates, and changes in underlying housing preferences.

The structure of the paper is as follows: the next section will introduce the research outline as well as the main research question and the sub questions. Afterwards, the theory and methodology needed to answer the main research question and the accompanying sub research questions will be addressed. In the fourth section, the data used in this research will be briefly elaborated on. Subsequently, the preliminary results of the research project will be presented. Finally, conclusions on the available information from this research project will be drawn up alongside a short discussion on the research project itself.

2. Research outline

The current iteration of the Netherlands study into discrepancy between annually assessed values and market prices is concerned with the sales prices and assessed values in the period 2018 up to 2022. The research is focused on both the sold and unsold residential properties in the Netherlands. Since the transaction price is the closest indicator for market value available, and the knowledge that only a small fraction off the residential properties sells within a five-year period, the majority of the residential real estate properties included in this study have no direct indicator for market value. This study aims to overcome this limitation with several different approaches. These approaches will be elaborated in the methodology section of this paper.

Research questions:

Main research question:

To what extent do the assessed values (WOZ-values) of homes in the Netherlands for the value reference dates 1 January 2018 to 1 January 2022 correspond to the market price level in the same period (sales prices from 1 January 2017 to 31 December 2022)?

The main research question can be broken down into five sub-questions, these sub-questions are listed below.

Sub-questions:

a. To what extent are assessed values of sold privately owned homes valued at market level? This question focusses on the homes that were sold in the period mentioned, so that a direct comparison can be made between this sales price and one or more assessed values.

b. To what extent are assessed values of unsold homes valued at market level?

c. To what extent is there a bias in the alignment of the assessed values with the market level?

d. To what extent is there a difference between privately owned homes and homes owned by large-scale landlords in terms of the alignment of the WOZ values?

e. If the previous questions reveal that the WOZ values of homes are insufficiently aligned with market levels or that there are incorrect mutual value ratios, what are the underlying causes?

3. Theory and methodology

The theory for answering sub-question a is straightforward and is based on the Standard on Ratio Studies (2013) published by the International Association of Assessing Officers (IAAO). The direct comparison is made based on the assessment to sales price ratio (ASR), the formula to calculate this ratio is provided in equation 1 below:

$$ASR = \frac{Assessed\ Value}{Observed\ Sale\ Price}$$

An ASR of 1 indicates a perfect alignment between the assessed value and the observed sale price. An ASR above 1 suggests a situation of overassessment whereas an ASR below 1 suggests a situation of underassessment. To give a good indication of how the ASR behaves over a group, each of the sales is compared to the respective

assessment and broken down by both the year and financial quarter in which the sale has occurred.

The theory concerned with answering sub-question b is slightly more complicated since there is no direct indicator of market value. Based on the Standard on Ratio Studies (2013), this research question can be answered by two approaches. The first approach is by comparing the value increases after a new revaluation between the sold and unsold properties. The second approach is by comparing the unit value averages (assessed value per square meter) between the sold and unsold properties included in the study.

This research will deploy a third approach where a direct market indicator for the unsold properties is estimated using an independent automated valuation model (AVM). Based on this new market indicator a new ratio can be constructed, the assessment to model value ratio (Hermans et al., 2022). The formula to calculate this ratio is provided in equation 2 below:

$$AMR = \frac{Assessed\ Value}{Model\ Value}$$

The AMR provides an indicator for all residential properties included in the research. Based on this AMR and the ASR, properties will be categorized and conclusion on the sub-question can be drawn. The use of a second automated valuation model has been used in the Netherlands to evaluate model performance of primary valuation models and yield usable results when the secondary validation models are of good quality. Earlier applications of this approach have been used to investigate impact of certain policy as well as to evaluate the efficiency of alternative valuation methods (Allen and Dare, 2009; Davis et al., 2012). Both of these applications have however been limited on the comparison of the ratio study results which only indicate on the model performance as a whole. This research will go beyond this level by applying the Assessment to Model value Ratio to get insights on the discrepancy between the assessed values and the estimated market value for unsold properties.

There are three main statistical categories of approaches to build AVMs. The first uses the traditional regression approach, which is based on minimizing the least squares error. Traditional regression approaches can have a linear or nonlinear character, with location often incorporated as a dummy variable (Field, 2018). The second category consists of a wide range of artificial intelligence (AI) and machine learning (ML) approaches. In general, these approaches are computationally intense but show improvement in model performance and are more suited to big data (Beimer and Francke, 2019). A few of the most promising AI/ML approaches with regards to real estate assessment are classification and regression trees (CART), random forests, neural networks, and gradient boosting methods (Hermans et al., 2022; IPTI, 2021).

However, practical application of these techniques has been limited by the nature and extent of the “black box” problem. This is the phenomenon where an AI/ML-based approach produces satisfactory results, but there is no way to trace back the influence of certain independent variables on those results. That said, this “black box” problem has become less obscure with the “importance”, or “normalized importance” weightings related to attributes becoming visible, but this still presents challenges for transparency and limits the possibility of explaining the results of the model to the taxpayer, for instance. For the use of an AVM as a secondary model to evaluate the performance of a primary valuation model or the evaluate the quality of assessed values the “black box” problem is less problematic.

The last category of AVMs consists of spatial models that place special emphasis on location variables. While a wide range of spatial models exists, the spatial lag model (SLM), spatial error model (SEM) and geographically weighted regression (GWR) are most promising. They too can be very computationally intense, but they do overcome problems related to the modifiable areal unit problem (MAUP) (Borst, 2014). The MAUP occurs when point data, for instance real estate objects, gets aggregated into polygons, for instance postal code areas or neighborhood areas. The descriptive statistics such as the mean and the standard deviation of a given area are influenced by how we define the areal unit. Therefore, by not aggregating data into polygons, spatial models overcome this issue.

The secondary automated valuation model used in this research to do the analysis on the assessment to model value ratio has not been configured at this moment. However, given the data available the secondary automated valuation model will most likely be a spatially aware automated valuation model. The preferred spatially aware automated valuation model will be a geographically weighted regression-based model. Geographically weighted regression models were first introduced by Fotheringham et al. (2002) but are now widespread practice in academic research for the assessment of real estate (Bidanset and Rakow, 2022).

The third sub-question is concerned with bias. Mainly, vertical inequity will be analyzed in this research. Vertical inequity occurs when ratios change by a statistically significant amount across price ranges (IAAO 2013). Vertical inequity can occur in two forms. Firstly, regressive vertical inequity: homes in the lower market segments bear relatively higher tax burdens. In other words, model-based valuation has resulted in relatively higher ratios in the lower segment, while ratios in the higher segment are lower. Secondly, progressive vertical inequity: homes in the higher market segment bear relatively higher tax burdens. In other words, model-based valuation has resulted in relatively lower ratios in the lower segment, while ratios in the higher segment are higher. Most mass appraisal systems tend to deliver results with regressive vertical inequity.

Vertical inequity has a longstanding history in the academic literature. This paper will use visual representations to identify possible inequities. Especially looking at the median assessment to sales price ratio over the different deciles of the data will give an indication on if vertical inequity is present and if so, in what form (Rakow, 2023). Both the median ASR and median AMR per decile will be presented to gain a visual insight into the possible vertical inequities present in the assessments in the Dutch system of property tax assessment.

Sub question d can be answered in a similar fashion by a combination of the insights gained from analyzing the ASR and AMR for the properties broken down by their type of ownership situation. Again, looking at the developments of the ASR and AMR over the consecutive deciles.

4. Data

The data used for this research is made available by the Dutch Central Bureau of Statistics (CBS). CBS has access to all sales prices registered by the Netherlands Cadaster and the assessed values of all properties registered in de base register of assessed values in the Netherlands. The data contains all transactions made on residential real estate in the period between 2017 and 2023.

Furthermore, the data contains information on the ownership situation of each of the properties as well as a limited set of property characteristics such as floor space and building age for each residential property in the Netherlands. The property characteristics are limited for an accurate valuation model but are considered sufficient for a secondary valuation model to evaluate the quality of the assessed values of unsold properties in comparison with the sold properties.

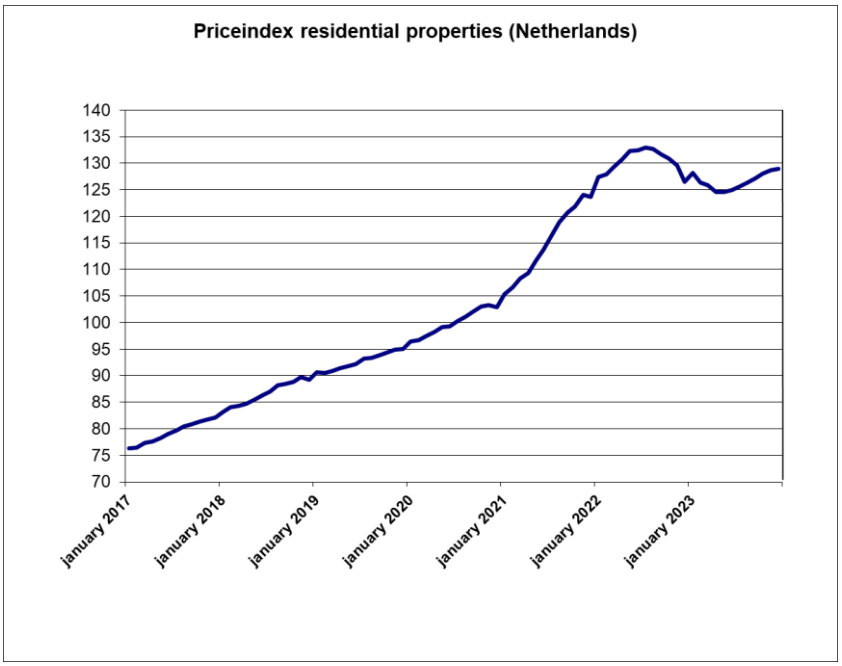

Image 1. Price index residential properties

The period analyzed in this research shows a complex market development with a period with steep market increase followed by a period of decreasing prices, see image 1. This complex market not only gave challenges for the valuers for the appraisal but also makes it difficult to use the sales prices from a longer period of time to calculate the assessment to sales ratio.

5. Results

The results will be presented by order of the sub-questions in the research and the insights will be presented for each year in the study separately as well as the period as a whole. As stated not all required results to answer every sub-question individually have been collected yet. This limitation will be elaborated on in the subsequent discussion section.

Sub question a:

To what extent are assessed values of sold private homes valued at market level?

This concerns the homes that were sold in the period mentioned, so that a direct comparison can be made between this sales price and one or more assessed values.

The first sub question can be answered by looking at the progression of the median assessment to sale price ratio for each of the years included in the study. In the analysis for each value reference date an ASR is calculated for alle sales prices in the year prior to the value reference year and the year after. To form insights into the

progression the median assessment to sale price ratio is calculated for each quarter of a year. This two-year period ranges from Q1 of the year (t-1) to Q4 of the year (t+1). Because of the even distribution of this period around the value reference date these median assessment to sale price ratios give a good insight whether assessments are in accordance with sales prices. But all these sales can also be used by municipalities for the appraisal of the properties. For that reason as an “out of sample” check also the ASR is calculated for te next year, so Q1 to Q4 of (t+2).

The results of these calculations are presented below in table 1.

value reference date	2018	2019	2020	2021	2022
Q1 (t-1)	1,0605	1,0611	1,0533	1,0717	1,1355
Q2	1,0407	1,0400	1,0367	1,0500	1,0897
Q3	1,0229	1,0207	1,0198	1,0277	1,0400
Q4	1,0026	1,0004	1,0000	1,0024	1,0015
Q1 (t+1)	0,9909	0,9899	0,9868	0,9820	0,9723
Q2	0,9707	0,9722	0,9664	0,9458	0,9398
Q3	0,9484	0,9534	0,9440	0,8952	0,9218
Q4	0,9247	0,9333	0,9176	0,8495	0,9268
Q1 (t+2)	0,8949	0,9040	0,8779	0,8001	0,9402
Q2	0,8810	0,8819	0,8355	0,7752	0,9516
Q3	0,8603	0,8585	0,7806	0,7699	0,9408
Q4	0,8466	0,8369	0,7474	0,7915	0,9231

Table 1. progression of median ASR per fiscal quarter.

Ideally, in a very stable market development the mean between the median ASR for the four quarters (Q1 of (t-1) to Q4 of (t+1) is equal to 1. But to be less depending on the stability of the market for a longer period we look mainly to the quarters just before and after the value reference date so Q4 of (t-1) and Q1 of (t+1) The mean of these two quarters is expected to be equal or close to 1.

The results of this analysis are presented below in table 2.

Year	Median ASR at value reference date
2018	0.9968
2019	0.9952
2020	0.9934
2021	0.9922
2022	0.9869

Table 2. Median ASR at value reference date

The results presented in table 1 show more information in whether the assessed values are in line with sale prices on the market. By visualizing the results of the median ASR, the calculated median ASR's can better be interpreted.

For 2018 the visualization is presented in image 2. below:

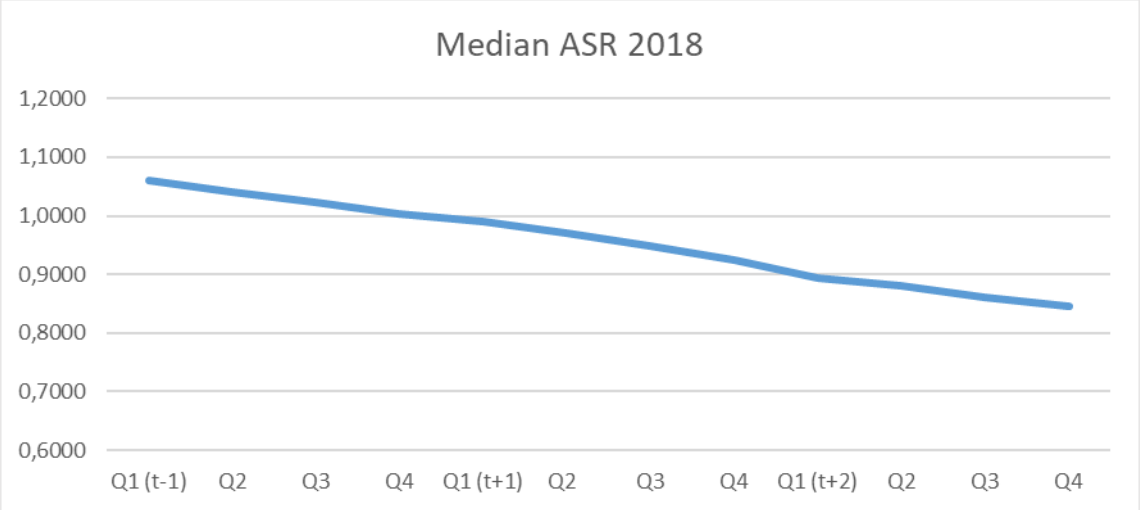

Image 2. Median ASR progression for assessments for value reference date 2018.

The line visualized in image 2 shows the natural progression of the median ASR for each of the twelve quarters in the analysis, starting from Q1 of 2017 to Q4 of 2019. As expected, the calculated median ASR is under influence of the market development. With a steeper increase in the market, the values for the median ASR will deviate further from 1 the further the line gets from the halfway point between Q4(t-1) and Q1(t+1). At this halfway point the median ASR has a value of 0.99675 or about 0.4% under market value. This is an important indicator that the assessed values are on market level. The fact that the line in this image is rather continuously declining is in accordance with the fact that during this period there was a constant increase in sales prices as can be seen in image 1.

For 2019 the visualization is presented below in image 3.

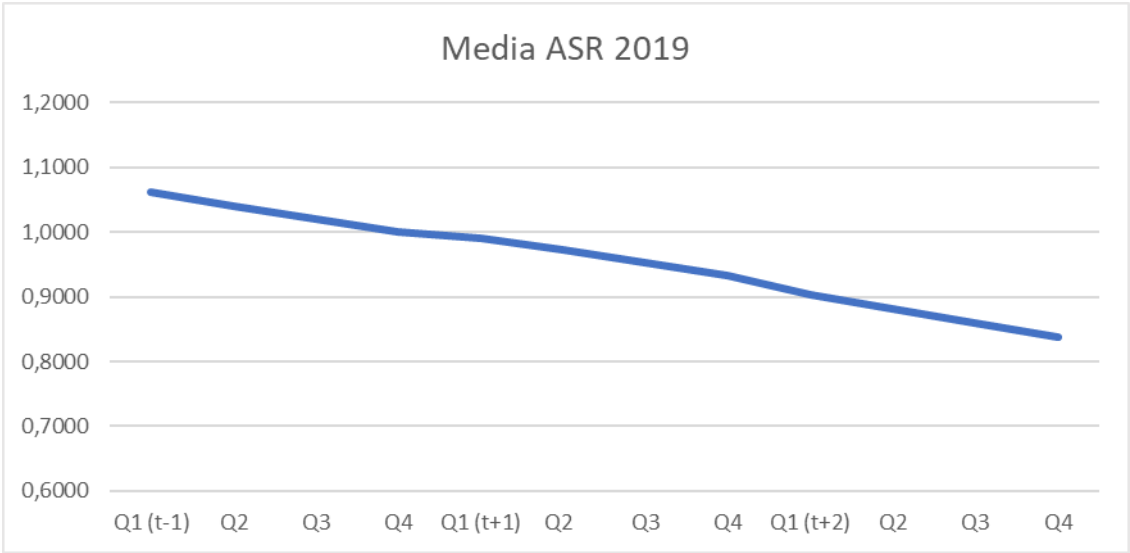

Image 3. Median ASR progression for assessments for value reference date 2019.

The line visualized in image 3 shows for value reference date 2019 a rather comparable result. At this halfway point between Q4 of (t-1) and Q1 of (t+1) the median ASR has a value of 0.99515 or about 0.5% under market value. The line is also in accordance with the market developments in the period 2018 to 2020 as can be seen in image 1.

For 2020 the visualization is presented below in image 4.

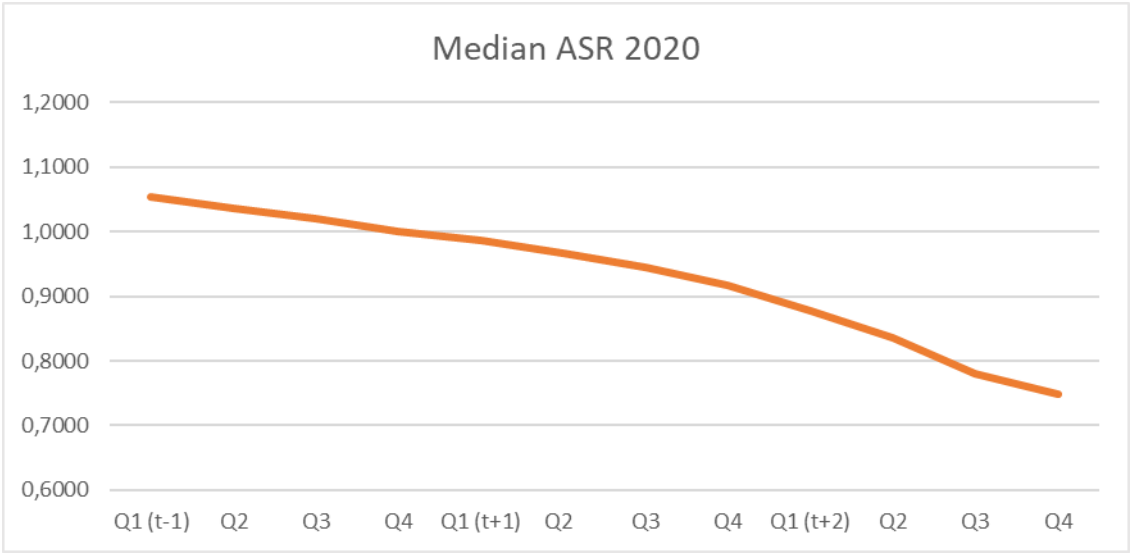

Image 4. Median ASR progression for assessments for value reference year 2020.

The line visualized in image 4 shows for value reference date 2020 a steeper decrease of the median ASR in the year (t+2) When we compare this with image 1 for the period 2019 to 2021 this is in accordance with the steep increase of sale prices in the year 2021. At the halfway point between Q4 of (t-1) and Q1 of (t+1) the median ASR has a value of 0.9934 or about 0.7% under market value.

For 2021 the visualization is presented below in image 5.

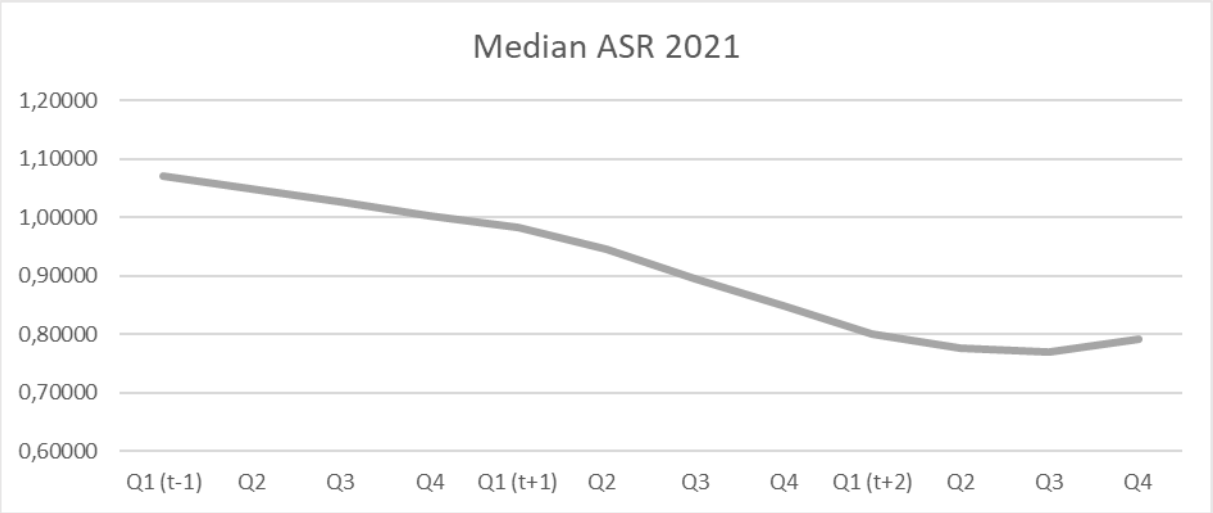

Image 5. Median ASR progression for assessments for value reference date 2021.

The line visualized in image 5 shows for value reference date 2021 the effect on the ASR when the sale prices are decreasing. The period 2020 to 2022 in image 1 show a top in the market in the midst of 2022 after which sales prices decreased.

At the halfway point between Q4 of (t-1) and Q1 of (t+1). the median ASR has a value of 0.9922125 or about 0.8% under market value.

For the last reference date in this research, 2022, the visualization is presented below in image 6.

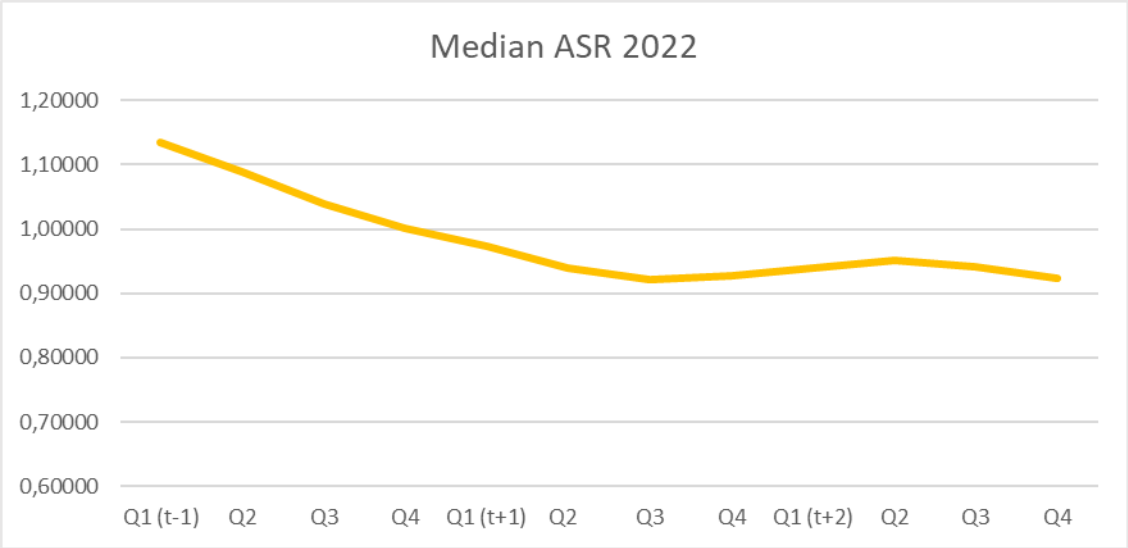

Image 6. Median ASR progression for assessments for value reference date 2022.

The line visualized in image 6 shows for value reference date 2022 the effect of a mix of increasing and decreasing sales prices in the period 2021 to 2023. At the halfway point between Q4 of (t-1) and Q1 of (t+1) the median ASR has a value of 0.9869315 or about 1.3% under market value.

So we see that the calculated difference between the assessment and the sales prices has increased for the consecutive value reference dates, but also for the date the median ASR is still acceptable.

Image 7. Presents the lines compared to each other below.

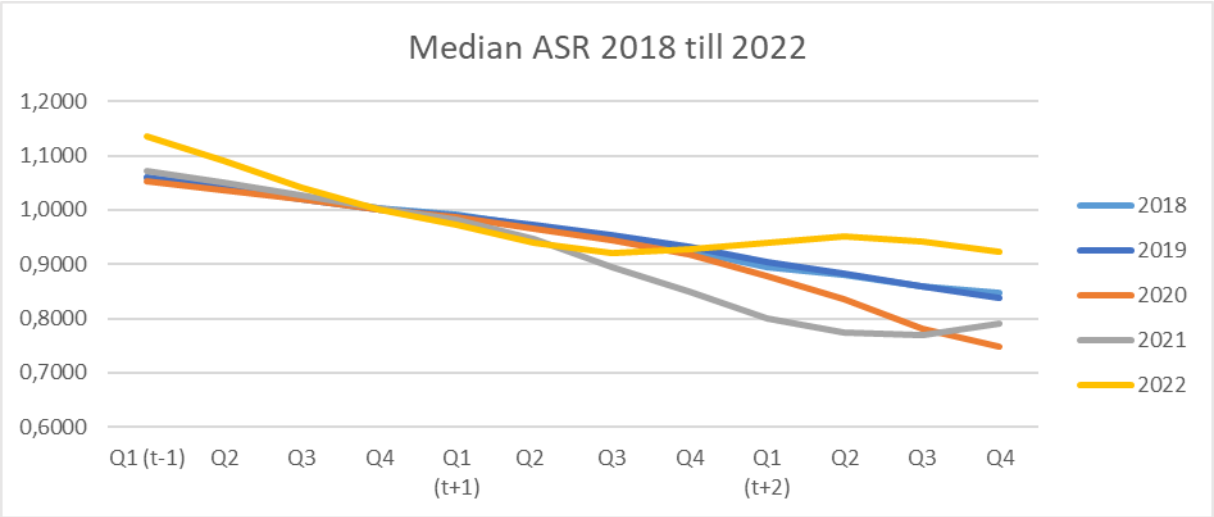

Image 7. Median ASR progression for the value reference dates in the study.

When we look at the spot of the value reference year all lines are very close to each other and also very close to 1. This is an important indicator that assessments in the whole period are in accordance with market prices.

Interestingly the lines before 2020 behave along the same pattern where there is a distinct downward trend. This is normal for a continuously increasing market. The lines after 2020 behave differently where their downward progression is followed by a slight upward trend after the initial downward progression. This is visualized in image 8 and 9 below. The comparison with image 1 explains these lines very well.

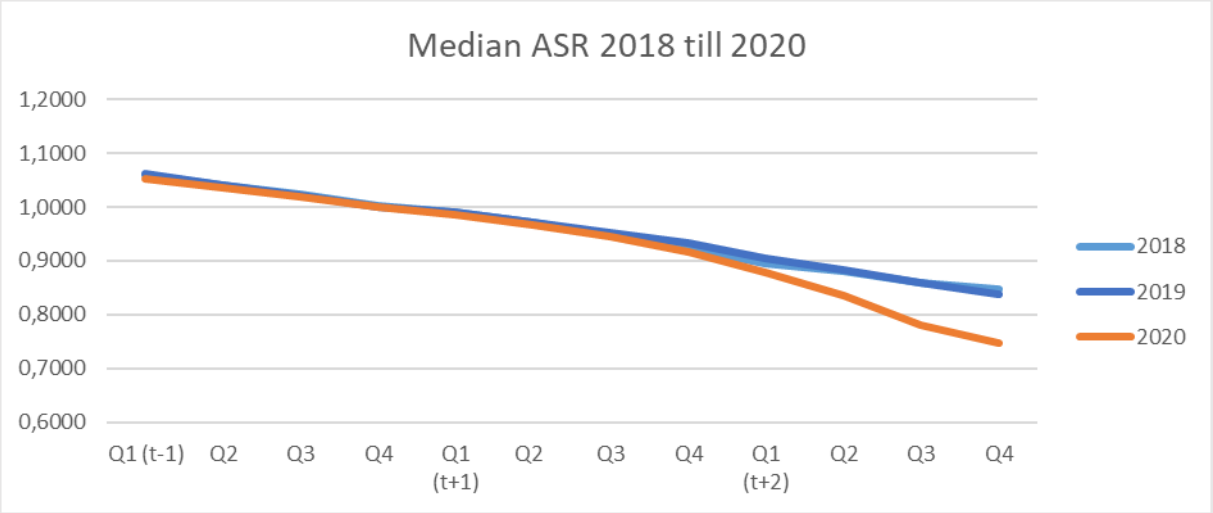

Image 8. Median ASR progression for the years 2018 till 2020.

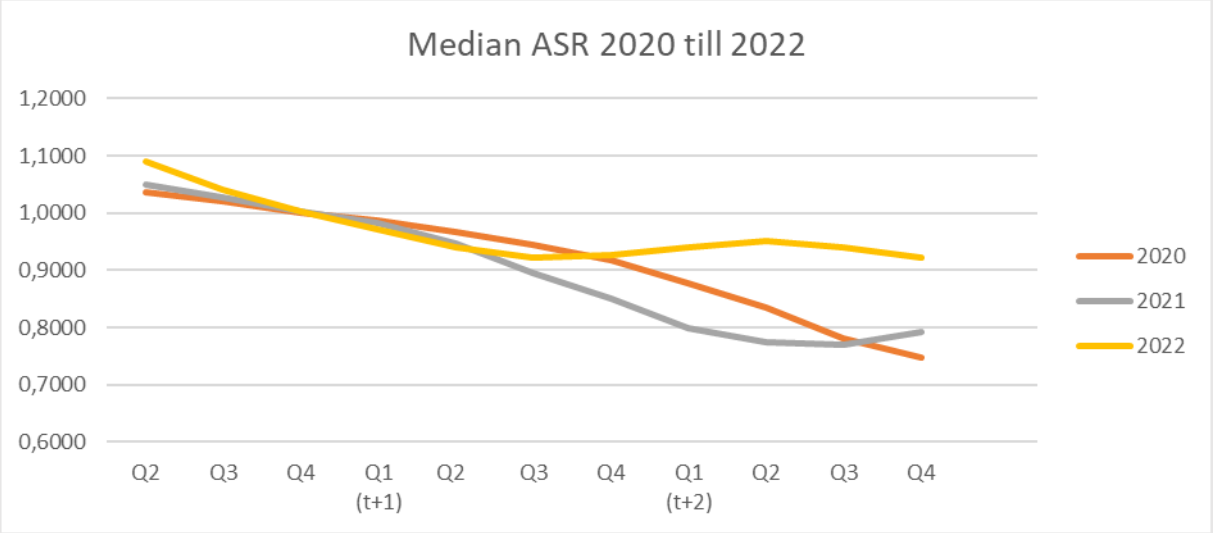

Image 9. Median ASR progression for the years 2020 till 2022.

Sub-question b:

To what extent are assessed values of unsold homes valued at market level?

The results for answering sub-question b are not yet available. A comparison of the percentage value change, the percentage value change per unit measure and an analysis of the progression of the median assessment to model value ratio over the quarters for each year in the study will give insights with which an answer can be formulated to this sub-question.

Sub-question c:

To what extent is there a bias in the alignment of the assessed values with the market level?

This sub-question will be answered by visualizing and interpreting the median assessment to sales price ratio for each decile of the sales prices for each year in the study. D1 therefore stands for the 10% percent f the sales with the lowest sale prices and so on to D10 the consist of the 10% sales with the highest prices. For this analysis the median assessment to sale price ratios are used for the whole year(t-1) and (t+1). The mean of median ratios in these years forms the indicator which needs to be presented in order to make a correct comparison at the value reference date.

This sub-question will also be addressed from the AMR perspective to form more encompassing results also for the unsold properties. However, since these results are not yet available, these results are not included in this paper.

The results for 2018 are presented in table 3. below

2018	ASR(t-1)	ASR(t+1)	Mean median ASR
D1	1,0584	0,9784	1,0184
D2	1,0361	0,9697	1,0029
D3	1,0313	0,9676	0,9994
D4	1,0306	0,9636	0,9971
D5	1,0271	0,9607	0,9939
D6	1,0262	0,9600	0,9931
D7	1,0255	0,9574	0,9914
D8	1,0252	0,9560	0,9906

2018	ASR(t-1)	ASR(t+1)	Mean median ASR
D9	1,0235	0,9579	0,9907
D10	1,0204	0,9575	0,9889

Table 3. the median assessment to sale price ratio per decile in 2018.

The visualization of the mean median assessment to sale price ratios per decile for 2018 is presented below in image 10.

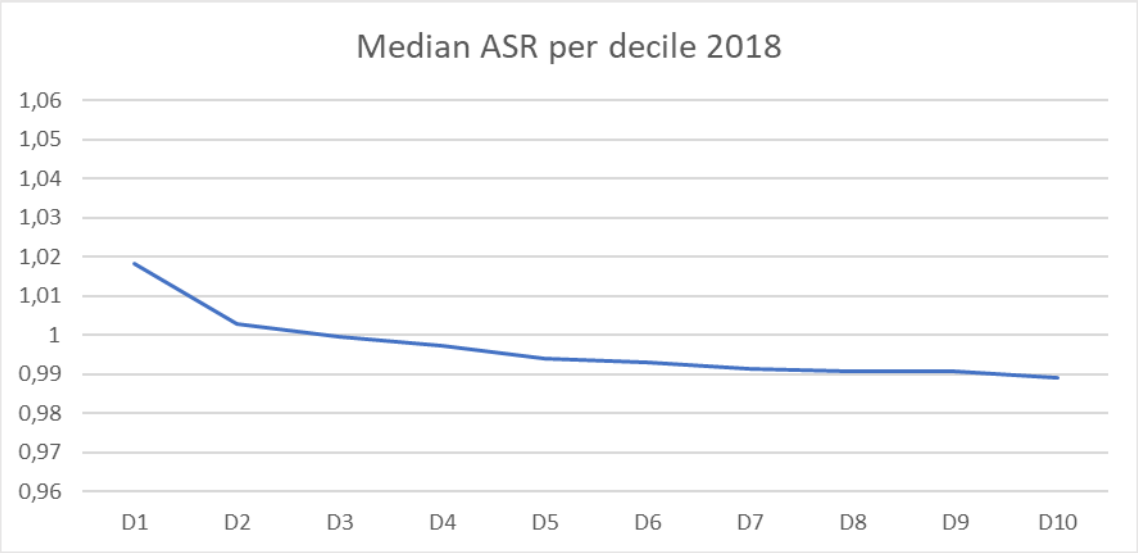

Image 10. The mean median assessment to sale price ratios per decile for 2018

The visualization shows for this value reference date that the lower side of the market has an indication of overassessment. Thereby indicating a slight occurrence of regressive vertical inequity. However, it is necessary to indicate that none of the mean median ASRs are in violation with the IAAO threshold of 0.97 to 1.03. Therefore, based on these preliminary, there is no indication of problematic vertical inequity.

The results for 2019 are presented in table 4. Below:

2019	ASR(t-1)	ASR(t+1)	Mean median ASR
D1	1,0593	0,9739	1,0166
D2	1,0381	0,9667	1,0024
D3	1,0339	0,9632	0,9986
D4	1,0300	0,9604	0,9952

2019	ASR(t-1)	ASR(t+1)	Mean median ASR
D5	1,0286	0,9609	0,9948
D6	1,0264	0,9594	0,9929
D7	1,0244	0,9600	0,9922
D8	1,0222	0,9595	0,9909
D9	1,0213	0,9630	0,9921
D10	1,0161	0,9643	0,9902

Table 4. the median assessment to sale price ratio per decile in 2019.

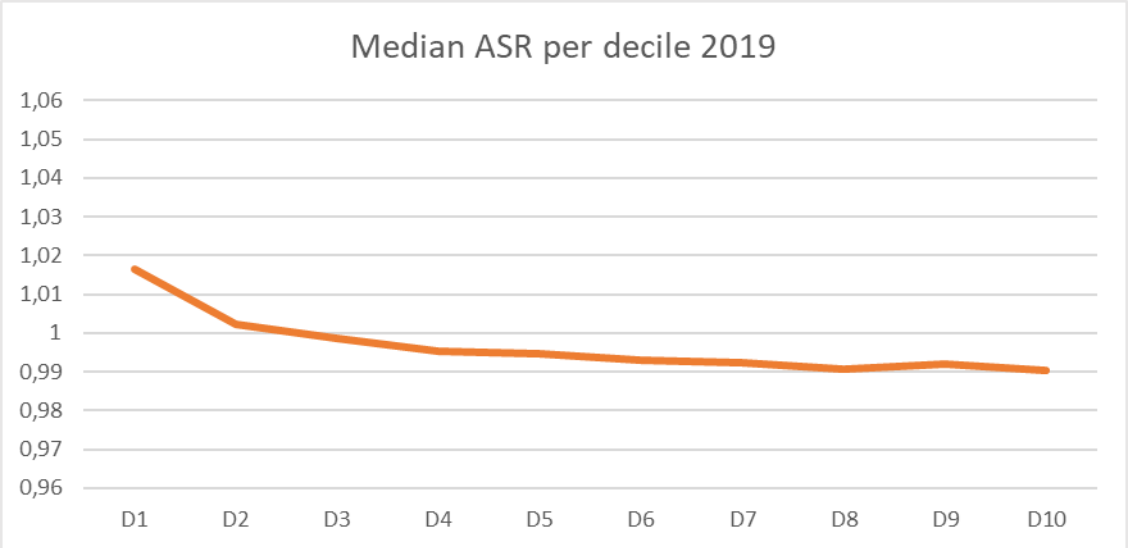

Image 11. The mean median assessment to sale price ratios per decile for 2019

The visualization shows also for this value reference date that the lower side of the market has an indication of overassessment. Thereby indicating a slight occurrence of regressive vertical inequity. But also for this year none of the mean median ASRs are in violation with the IAAO threshold of 0.97 to 1.03. Therefore, based on these preliminary, there is no indication of problematic vertical inequity.

The results for 2020 are presented in table 5. Below:

2020	ASR(t-1)	ASR(t+1)	Mean median ASR
D1	1,0522	0,9695	1,0108
D2	1,0328	0,9577	0,9953
D3	1,0300	0,9520	0,9910
D4	1,0253	0,9520	0,9887
D5	1,0245	0,9527	0,9886
D6	1,0220	0,9515	0,9867
D7	1,0209	0,9511	0,9860
D8	1,0179	0,9516	0,9848
D9	1,0171	0,9534	0,9853
D10	1,0133	0,9569	0,9851

Table 5. the median assessment to sale price ratio per decile in 2020.

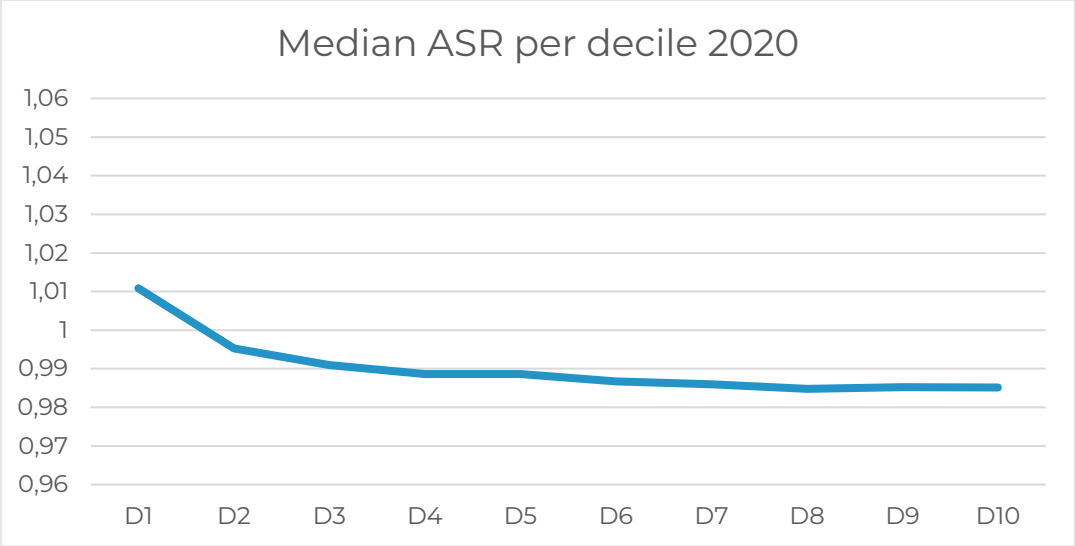

Image 12. The mean median assessment to sale price ratios per decile for 2020

The visualization shows also for this value reference date comparable results with comparable conclusions.

The results for 2021 are presented in table 6. Below:

2021	ASR(t-1)	ASR(t+1)	Mean median ASR
D1	1,0733	0,9645	1,0189
D2	1,0461	0,9395	0,9928
D3	1,0386	0,9350	0,9868
D4	1,0366	0,9311	0,9839
D5	1,0364	0,9258	0,9811
D6	1,0327	0,9246	0,9786
D7	1,0295	0,9231	0,9763
D8	1,0269	0,9232	0,9751
D9	1,0238	0,9226	0,9732
D10	1,0176	0,9262	0,9719

Table 6. the median assessment to sale price ratio per decile in 2021.

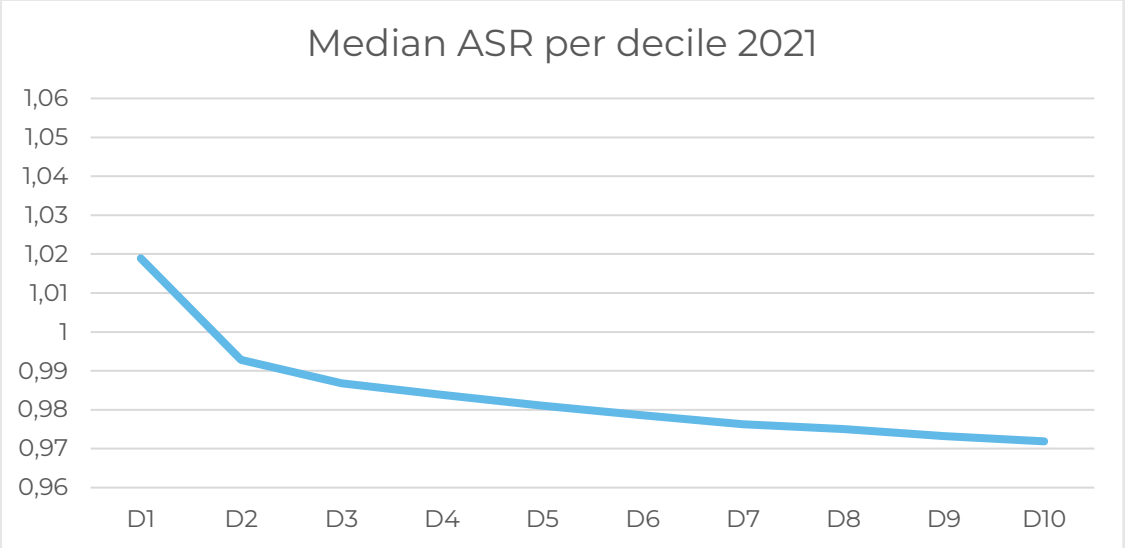

Image 13. The mean median assessment to sale price ratios per decile for 2021

The visualization shows also for this value reference date comparable conclusions.

The results for 2021 are presented in table 6. Below:

2022	ASR(t-1)	ASR(t+1)	Mean median ASR
D1	1,1479	0,9700	1,0589
D2	1,0925	0,9462	1,0193
D3	1,0792	0,9433	1,0113
D4	1,0754	0,9382	1,0068
D5	1,0677	0,9372	1,0025
D6	1,0623	0,9375	0,9999
D7	1,0578	0,9362	0,9970
D8	1,0551	0,9345	0,9948
D9	1,0499	0,9319	0,9909
D10	1,0377	0,9303	0,9840

Table 7. the median assessment to sale price ratio per decile in 2022.

The visualization of the mean median assessment to sale price ratios per decile for 2022 is presented below in image 14.

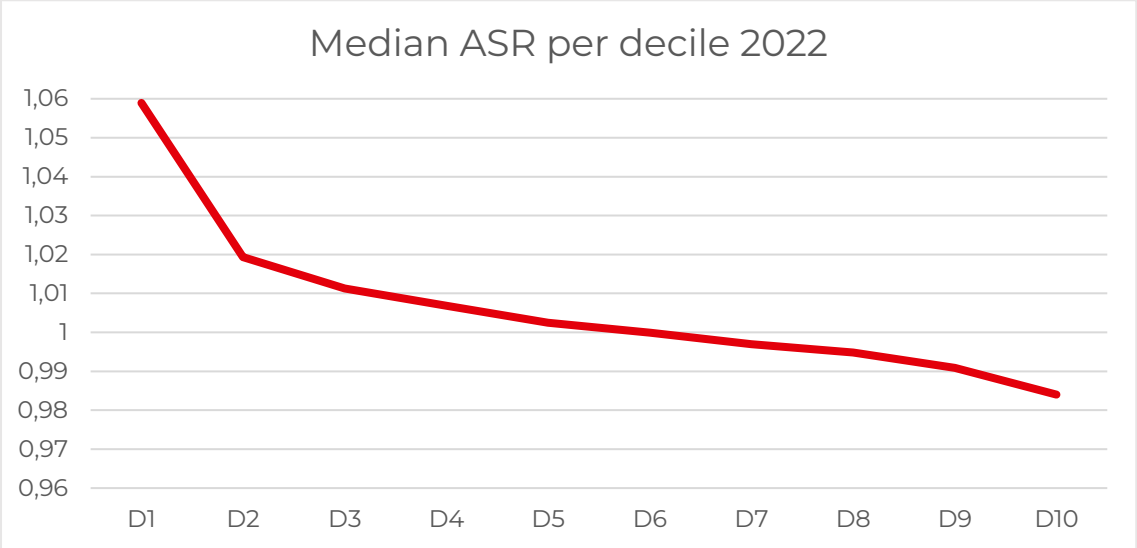

Image 13. The mean median assessment to sale price ratios per decile for 2022

The visualization shows also for this value reference date that the lower side of the market has an indication of overassessment.. It is noteworthy that the mean median ASR in the first decile violates the IAAO threshold. The preliminary findings therefore indicate the presence of vertical inequity in the 2022 data that require further investigation.

To visualize how the years compare to each other the lines are plotted together on the same scale below in image 15.

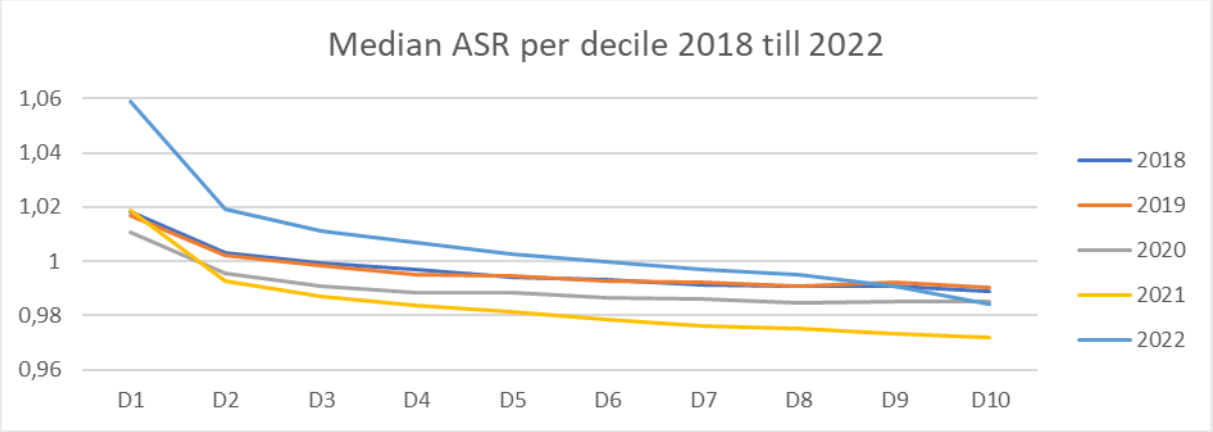

Image 15. The mean median assessment to sale price ratios per decile for each year in the study

The lines in image 15 show a similar trend for each year. The first decile seems to have a slight overvaluation whereas the last decile has a slight tendency for undervaluation. Some of this might be explained by the “regression to the mean” effect within real estate assessment. The line for the year 2022 seems to indicate more problematic vertical inequity in a regressive form. A complete answer to this sub-question can only be formulated when the analysis is also done for the unsold homes.

6. Discussion and conclusion

The research presented in this paper is prone to some points of discussion. Firstly, we have explored the alignment of the assessed values vs the sales prices for properties sold on the market. The next step exploring the assessment of unsold properties is not completed at this stage. This means that the sub-questions and thereby the main research question concerning the alignment of the assessed value vs the market value for all properties (sold and unsold) cannot be answered completely at this point.

Furthermore, the second part of the research project is severely limited by the data availability for calibrating one model for all residential properties in the Netherlands to be used for the AMR. Configuring an automated valuation model of high enough quality for this analysis is challenging, because most of the data used by municipalities for the appraisal is not available on central level. However, the researchers do believe an adequate model should be possible to configure using geo weighted regression or an AI-based model.

Furthermore, to identify true vertical inequity academic literature suggest the use of multiple measures. This research limits itself in only using the comparison of the deciles for investigating vertical inequity.

When we look at the preliminary results in general, the assessed values for sold residential properties in the Netherlands are on the level indicated by sales prices. Whether this is also true for the unsold properties is still under investigation.

The conclusion on vertical inequity is for most value reference date within this project that the lever of vertical inequity is on an expected level in any system of mass valuation. However further research is suggested to investigate the possible presence of vertical inequity for the value reference date 1 January 2022.

References

Allen, M., & Dare, W. (2009). Changes in Property Tax Progressivity for Florida Homeowners after the “Save Our Homes Amendment”. Journal of Real Estate Research, 31(1), 81-92.

Beimer, Jeroen and Marc Francke. (2019). "Out-of-Sample House Price Prediction by Hedonic Price Models and Machine Learning Algorithms." Real Estate Research Quarterly: 13-20.

Bervoets, B., Gieskes, J., Leijenhorst, G., Monsma, E., Witkam, M. (2016). Wet waardering onroerende zaken en daarmee samenhangende gemeentelijke belastingen. Deventer: Wolters Kluwer

Bidanset, P. E., & Rakow, R. (2022). Survey on the use of automated valuation models (AVMs) in government assessment offices: An analysis of AVM use, acceptance, and barriers to more widespread implementation. Journal of Property Tax Assessment & Administration, 19(2), 3.

Borst R. A. (2014) *Improving Mass Appraisal Valuation Models Using Spatio-temporal Methods*. International Property Tax Institute

Davis, P., McCluskey, W., Grissom, T. V., & McCord, M. (2012). An empirical analysis of simplified valuation approaches for residential property tax purposes. Property Management, 30(3), 232-254.

Field, A. (2018). Discovering statistics using IBM SPSS Statistics. SAGE Publications Limited.

Fotheringham, A. S., Brunsdon, C., & Charlton, M. (2002). Geographically weighted regression: The Analysis of Spatially Varying Relationships. Wiley.

Gieskes, J., Kathmann, R. (2010). WOZ: Naar waarde belast. Deventer: Wolters Kluwer

Hermans, L. D., Bidanset, P. E., Davis, P. T., & McCord, M. J. (2022). Using property-level ratio studies for the incorporation of validation models in single-family residential real estate assessment. Journal of Property Tax Assessment & Administration, 19(1), 3.

IAAO. (2013). Standard on Ratio Studies. Kansas City, MO: IAAO

IPTI. (2021). The Potential of Artificial Intelligence in Property Assessment. Toronto: International Property Tax Institute.

Rakow, R. (2023). Comparative measures of property tax equity in Suffolk County, Massachusetts. Journal of Property Tax Assessment & Administration, 20(1), 2.