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Governmental interference in negatively affected real estate markets: A comprehensive analysis of the "Koopinstrument" in the earthquake-affected area of Groningen

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Colofon

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Abstract

The discovery of gas fields in Groningen led to extraction activities supported by the Dutch government, triggering earthquakes that damaged the housing stock. In response, the government has implemented various aid measures to assist affected residents, one of them being the Koopinstrument. This is a buy up instrument designed to help homeowners who are "stuck" in their house. This form of governmental interference can help regain wealth quickly after big disasters. Nonetheless, there are concerns about potential overreach by the government. This research explores the history of governmental interference in the earthquake-affected area by analysing the transaction data of the Koopinstrument. The results of the research reveal that in 67.9% of the researched transactions, acquisition prices exceed sales prices. Key factors such as sales price, square meter living area, and time in the portfolio influence the differences between acquisition and sales prices of transactions, examined through price reduction rates. Lower-valued properties cause high volatility in these rates, larger homes tend to increase the rates, and difficult-to-sell properties also see increases in reduction rates. Higher rates indicate that sales prices decrease more relative to acquisition prices. Overall, the study suggests that the negative externalities of the earthquakes are reflected in discounts on properties, as evidenced by acquisition prices often exceeding sales prices, emphasizing the important role of the government in the region.

Keywords: housing prices, externalities, earthquakes, governmental interference, and safety net

Abbreviations: NCG – Nationaal Coördinator Groningen

SWAG – Stichting Woonbedrijf Aardbevingsgebied Groningen

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1 Introduction

1.1 Motivation

The discovery of one of the world's largest gas fields in the province of Groningen led to government support for gas extraction activities. As a result, the Dutch government acquired a stake in the Nederlandse Aardolie Maatschappij, the company responsible for initiating gas drilling in 1959 (Nederlandse Aardolie Maatschappij, n.d.). Nonetheless, in 1986, an earthquake occurred near Assen in the province of Drenthe, marking the first of a long series of seismic events caused by gas extraction. Over the years, the frequency of earthquakes has increased, surpassing a total of 1,100 earthquakes (KNMI, n.d.). Between 1986 and 2012, several initiatives were undertaken to study the correlation between gas extraction and earthquakes. However, there was a long period without alterations in gas extraction practices. It was not until the substantial earthquake in Huizinge in 2012 that perceptions shifted, with this event serving as a wake-up call. The earthquakes profoundly impacted the daily lives of citizens, with negative effects on social, environmental, health, and economic factors (Slomp, 2022).

The interplay between these negative impacts has influenced the housing market, causing increased property damage and decreased housing values in the region. This has led to a reduction in value of around 2,500 euros per property for each earthquake (Koster & Van Ommeren, 2015). Beyond the financial impact and housing market conditions, those affected by the earthquakes experience, as mentioned before, additional negative effects. The earthquakes have caused fear and mental health issues, reducing the quality of life in the region. Some affected residents wish to move to safer areas; however, this is often impossible due to heavily damaged properties and declining housing prices (Sociaal planbureau Groningen, 2014). In contrast, real estate brokers observe that the housing market in Groningen is performing relatively well in 2017, even with the issues arising from earthquakes. This is mainly because of ongoing demographic changes, such as birth, deaths, divorces, and the need to live in larger housing (Nagtzaam, 2018)

To help affected households in the area, the government founded the foundation Stichting Woonbedrijf Aardbevingsgebied Groningen (hereafter SWAG). The organization carries out valuation and acquisition processes on behalf of the Nationaal Coordinator Groningen (hereafter NCG). SWAG operates on a non-profit basis and is funded by the Dutch Ministry of Economic Affairs and Climate. To buy the designated assets an instrument was

created, called the Koopinstrument. This instrument helps households in the affected earthquake area to sell their house, so people will not get “stuck” in their current residence. This instrument will be further explored in Chapter 2.1 (SWAG, n.d.). The performance improvement of the region is evident in the declining number of households applying for the Koopinstrument. A significant factor affecting Koopinstrument applications was the backlog of housing initially awaiting this instrument. The NCG speculates that the decline in applications over recent years may be attributed to a more appealing housing market. This makes the applications to the Koopinstrument correlated to the fluctuating market tendency of the housing market (NOS, 2020).

In general, there is ongoing debate about the best approach to managing the disturbed housing market and addressing the resulting mental health problems. However, governmental support through initiatives such as the Koopinstrument not only provides this economic assistance to those affected, but also contributes against mental health issues as well as other problems.

1.2 Academic relevance

This research holds academic relevance as it investigates the gap in the literature regarding the necessity of governmental interference in affected real estate markets. Natural disasters affect both society and economy. The externalities of such events can lead to severe consequences for individuals and communities. Economically vulnerable people are likely to suffer more. The disruption caused by natural disasters can increase existing inequalities, leaving those without a buffer at greater risk of long-term economic hardship and social instability (Tasri et al., 2022). In addition, natural disasters can severely affect the economy. The economic repercussions include substantial losses, both physical damage and indirect damage by disturbed infrastructure. The damage to homes, businesses, and public utilities disrupts economic activities in regions that are affected (Abbas Khan, K. et al., 2019).

Real estate markets are also specifically impacted by the externalities of natural disasters, often resulting in decreased property values. Geological disasters tend to have the most severe negative effects on house prices. The decline in property values can diminish homeowners' wealth and equity, leading to reduced consumer spending and lower levels of investment. These reductions in consumption and investment can create negative spillovers that further weaken the broader economy. The effects of lower house prices due to natural disasters can thus contribute to prolonged economic downturns, increased financial instability, and

greater challenges in economic recovery (Apergis, 2020). However, it is challenging to accurately quantify the exact costs of natural disasters on real estate markets. While direct costs can be estimated with some degree of accuracy, indirect costs are much harder to measure. These indirect costs include long-term economic impacts, such as reduced property values, loss of rental income, and decreased investment in affected areas (Hallegatte & Przyluski, 2010).

Even without knowledge of the total costs, the government's response to help stabilize real estate markets involves intervention in various ways. Policymakers have implemented public-private partnerships, which include government subsidies tied to consumer choices. This approach leverages market competition, recognizes the diverse needs and preferences of consumers across different geographies, and seeks to optimize subsidy rates (Miller et al., 2019). Overall, compensations can take the form of regulations, taxes, subsidies, or by providing alternative goods and services. However, governmental involvement in the economy increases the complexity of the real estate market since the compensations are stated on political decisions and therefore can change when there is a new political view (Harvey & Jowsey, 2004, p. 152-154). Within the compensation form of providing goods, there are three main systems: compensation if the damage occurs, compensation at the front, and buy up arrangements (Groetelaers & de Wolff, 2016).

Research on the real estate market in the earthquake-affected area of Groningen reveals a range of impacts. Bosker et al. (2018) found that transaction prices, between 2012-2018, in the affected zone were about 2.6-3% lower than in unaffected areas. The research identifies another notable factor causing decreases in the region, namely that the area is classified as a shrinkage zone. Overall, the decrease in value is mostly affecting detached, luxury, and larger homes. Additionally, other research reported an average property value decline of 8.9%, exacerbated by extensive damage claims (Elhorst, 2019). Besides the value decreases, the quality of life and housing market dynamics have deteriorated, with government policies and media coverage exacerbating uncertainty and complicating sales processes (Boelhouwer & Van der Heijden, 2018; De Kam & Mey, 2017). In the region, worsened sales procedures led to decreased property values and financial strain, correlating with mental health and societal issues (De Kam et al., 2018). Despite substantial material damage and safety concerns reported by affected residents, particularly those in higher-value detached homes, research on the recovery and rebuilding of these areas remains scarce.

This study aims to fill this gap by analysing property transaction data and price reduction rates, focusing on the Koopinstrument managed by SWAG.

1.3 Research problem statement

This research focuses on the limited scientific knowledge about governmental interference in real estate markets within disturbed regions. The research tries to fill that gap, focusing on real estate markets in earthquake-affected areas in Groningen. The governmental interference is used in the form of subsidies operating the Koopinstrument, with money being the primary parameter considered. Understanding the history of this interference contributes to a wider comprehensive analysis of the government's role in stabilizing disturbed housing markets. This study focuses on historical transaction data from SWAG, established by the Dutch Ministry of Economic Affairs and Climate, which has operated the Koopinstrument for almost a decade. While previous studies have explored the broader implications of governmental interference and the implications of the value of housing prices in affected areas, this research seeks to fill the gap in understanding the differences between the acquisition and sales prices within these affected areas. Using a practical approach with real historical transaction data. This leads to the following research question:

To what extent do the acquisition and sales prices of transactions within the Koopinstrument fund differ?

The research aims to assess the need for governmental interference and analyse the market dynamics of the region. It uses quantitative methods to align historical acquisition and sales prices in order to achieve these objectives. Additionally, it investigates whether specific characteristics influence the differences between the acquisition and sales prices, either increasing or decreasing them. For this research, the focus will be on visual distributions due to the complexity of the dataset. Relying solely on statistical models may obscure certain patterns and important outliers. These patterns and outliers are important since the dataset is limited by only 53 historical transactions. With the visual examination, the cases can be analysed on a more individual level. The statistical models will later be used to support the initial findings. In addition, it is important to identify specific characteristics for lower or negative price reduction rates. Creating a deeper insight into the need for governmental interference in the form of the Koopinstrument. The findings will contribute to scholarly understanding but also offer practical insights for policymakers with the need for decision-making regarding market dynamics and governmental interference in real estate markets.

2 Compensation instruments in the Netherlands

There are various compensation instruments in the Netherlands. This chapter will explain the main researched instrument, followed by a section focusing on other instruments with similar characteristics. By aligning these benchmarks, common mechanisms can be identified through their similarities.

2.1 Koopinstrument

In 2016 Stichting Proef Koopinstrument started with a mechanism to buy up housing in the earthquake-effected area in Groningen, called Koopinstrument. The foundation was founded by the Ministry of Economic Affairs and Climate. In 2019 the organization was transformed into Stichting Woonbedrijf Aardbevingsgebied Groningen. Initially, the foundation is established to help affected households in the area. The main tasks are carrying out valuation and acquisition processes on behalf of the NCG. Funding is through 30 million in total for the Koopinstrument and 10 million for the managing costs during the period of the existence of the Koopinstrument (Tweede Kamer der Staten-Generaal, 2018). These payments are paid by the Nederlandse Aardolie Maatschappij and the Ministry of Economic Affairs and Climate. Conditions to apply for the Koopinstrument are:

- The house must be located within the designated area. A zip code file contains all the applicable zip codes;
- The house must be publicly listed by a real estate broker for a minimum of 8 months;
- The house must be owned and serve as the primary residence, or inherited;
- In every scenario, the plot of land must be designated for residential use;
- The house must be free of any lease contracts (NCG, 2023)

When people apply and meet the criteria outlined in the conditions, the application is forwarded to SWAG. They start with a taxation of the property, by two independent appraisers. These appraisers agree on the market value of the current property based on comparable transactions. In practice, this assessed taxation value can differ from the sales price. Currently, in most regions of the Netherlands, sales prices are higher than taxation value due to the high housing demand. However, in the earthquake-affected regions, there is a higher chance that the sales price will be lower due to reduced housing demand in these areas. SWAG makes an offer of 95% of the taxation value. This 95% instead of 100% serves as an incentive to encourage individuals to sell their homes themselves. At the time of the offer, people are still able to sell

their house on the public market; however, they have up to 3 weeks to decide on the offer. If the offer is not accepted the house is not applicable for the Koopinstrument for 2 years, this happens rarely (NCG, 2023). Once SWAG acquires the asset into its portfolio, small preparations are made to make the asset suitable for resale. Before listing the property on the market, a real estate broker conducts inspections to identify any small issues, such as leaks, rot, and other practical concerns. SWAG's objective is to get the house back into the market for a marketable price as promptly as possible, without improving the quality of the housing but maintaining its condition at the time of the purchase. This instrument establishes a safety net, ensuring that other households in the market understand that there is an organization to assist in times of need. Consequently, aside from financial aid, it also provides mental support by alleviating the stress associated with being unable to sell your house, according to Ernst van der Leij, Partner at Brink, the company that set up different buy up mechanisms such as Koopinstrument, Moerdijkregeling, Vughtse Regeling, and Wijkverbetering Rotterdam-Zuid.

2.2 Other buy up compensation instruments

In recent years other compensation instruments such as the Koopinstrument have been implemented for several problems. Buy up instruments can serve as safety nets for the market, ensuring that homeowners have the assurance of selling their houses when in need. This safety net characteristic benefits not only those directly utilizing the instrument but also other properties in the affected area. As a result, stability returns in the market, as observed with previously used buy up instruments, according to Ernst van der Leij. The following paragraph elaborates on various practices within the Netherlands.

The first compensation instrument is the Moerdijkregeling. In 2014 Havenstrategie Moerdijk 2030 was created, a plan to make use of the economic, strategic location of Moerdijk between the harbour of Rotterdam and Antwerp. The plan disrupted Moerdijk, as residents feared a decline in property value or overall unsellable properties. Therefore, the government began with the Moerdijkregeling. It was guaranteed that housing in Moerdijk could be sold for 95% of the taxation value. The taxation value is done from the point in 2013 when the Havenstrategie Moerdijk 2030 was not published yet. Starting from the value of 2013 maintenance status, renovations, and value developments can affect the price. The municipality, with the funding help of Havenbedrijf Moerdijk, buys up the housing for 95% and plans to sell the property afterward (Moerdijk, n.d.). However, because of the decreased interest in the area, the properties do not sell for sustainable prices. Therefore, most of the housing is being rented

out. Hereby, the municipality keeps the area amusing and liveable (Groetelaers & de Wolff, 2016).

De Vughtse Regeling is another relevant buy up compensation instrument. Vught is a village located near important infrastructural junctions in the south of the Netherlands. The highways N65 and A2, and big railroads surround the village. A substantial part of the infrastructure required renovation, and plans were made for some roads to be constructed underground. This would result in a reduction in future pollution and hinder. However, these plans take 10 years causing problems for the current residents. Some need to abandon their property because of the renovation, while others have experienced decreases in house values, as the area was perceived as a major construction site (Overheid, 2018). To help those affected De Vughtse Regeling was created. Households located within the designated area can sell their house to the municipality for 95% of the taxation value. The municipality will keep the housing and sell it back to the market when the building activities are finished. In the meantime, the municipality is renting out the bought properties, ensuring that the area is still liveable and appealing for the future (Brink, n.d.). In practice, the area of Vught is a very favourable region, which is why there are not many applications other than extreme cases.

The third compensation instrument is called Wijkverbetering Rotterdam-Zuid. This mechanism is designed to acquire low-quality, unsustainable housing. The foundation purchases homes in the area that are available on the public market and renovates them above market standards. These homes are then rented out as mid-range housing to target the demographic they seek in the area. The funding is from the Dutch bank Rabobank and SOFIE. SOFIE is a foundation in Rotterdam that finances loans for better building climate focusing on sustainability and liveability. SOFIE is funded by the municipality of Rotterdam and Havenbedrijf Rotterdam (SOFIE, n.d.). The idea behind this is that improving one home in a block impacts all units within that block. By spreading this approach throughout the area, an impact is made. If the right tenant eventually wants to buy the property, the foundation will sell. In conclusion, this instrument is created to improve the whole neighbourhood by transforming a part of the housing stock (Brink, n.d.).

The last relevant buy up mechanism is Ruimte voor de Rivier. The instrument has been available since 2007 and is designed to address river-related fooling issues. The vulnerability of the Netherlands to both sea and river floods is increasing due to the impacts of climate change. Incidental big floods of rain and glacial water are filling up the rivers unevenly. Households situated near the rivers Ijssel, Rijn, Lek, and Waal are exposed to risks from these occurrences. Dutch governmental organs have emphasized the importance of ensuring safety

for households while also allocating adequate space to rivers to mitigate the risk of flooding in other regions (Rijkswaterstaat, n.d.). Therefore, within the Ruimte voor de Rivier method, the government now has four stances where it can buy up assets: the moment prevention measurement needs to be placed on the location of the house, that all economic activity is gone, an unsafe and unliveable situation is at hand, and when the current use does not fit in the zoning plan anymore. These properties are bought off for 100% of the taxation value of the same houses but then without the threats of the waterways. When households can be bought off for 100% there is a possibility of ghost towns; however, this is not the problem for this instrument. Ruimte voor de Rivier is only applicable for households that are very close to the river so no so-called ghost towns will be created. In addition, these properties will be demolished to create more space for the river. Ruimte voor de Rivier is seen as a successful and necessary instrument to compensate individuals who are affected by governmental decisions (Groetelaers & de Wolff, 2016).

In summary, table 1 gives a schematic overview of the different characteristics of the buy up instruments. The Koopinstrument is designed to assist affected homeowners, acting as a safety net for those who are stuck or have no way out. This is similar to the Moerdijkregeling, Vughtse regeling, and Ruimte voor de rivier. Unlike most other instruments, the Koopinstrument demonstrates national interest through its funding by NAM and the Ministry of Economic Affairs and Climate. This stands in contrast to the Moerdijkregeling and Vughtse regeling, which also aim to help homeowners who are stuck in their houses, but funded by local entities. These local instruments focus on getting properties back on the market in better times and renting them out in the meantime, adding layers of governmental interference in the form of property management. Both are responses to area improvements directed by governmental bodies that impact current residents. The Koopinstrument addresses the ongoing uncertainty of when earthquakes will stop and the reinforcement of the region stops while the Moerdijkregeling and Vughtse regeling have a hard expiration date, presenting a unique continuing challenge for the Koopinstrument. Additionally, the Wijkverbetering Rotterdam-Zuid and Ruimte voor de rivier address broader issues of housing market sustainability and high-risk living situations with different funding structures and objectives. The Koopinstrument is a unique governmental method that sells the properties immediately without any holding period; however, the characteristics as a safety net and 95% rule are in line with the Moerdijkregeling and Vughtse regeling.

Table 1: Schematic overview of the buy up instruments

Instruments	Goal	Funded by	Buy up	Sell of
Koopinstrument	Help people that are “stuck” in their house	NAM and Ministry of Economic Affairs and Climate	95% of current taxation value	Get back on the market
Moerdijkregeling	Help people that are “stuck” in their house	Havenbedrijf Moerdijk	95% of taxation value in condition without Havenstrategie 2030	Get back on the market in better times, rent out now
Vughtse regeling	Help people that are “stuck” in their house	Municipality Vught	95% of current taxation value	Get back on the market in better times, rent out now
Wijkverbetering Rotterdam-Zuid	Directing the housing market to a more sustainable stock	Municipality Rotterdam and Havenbedrijf Moerdijk	100% market value	Rent out, when the right buyer comes in the picture the house will be sold
Ruimte voor de rivier	Help people who are living in a high-risk location	Central Government	100% taxation value of similar properties without risks	Not applicable, because of demolition

3 Theoretical framework

The benchmark from the previous chapter provides insight into governmental interference in practice. Combined with the theories about governmental interference and disasters, described in this chapter, they form the comprehensive framework for the research, resulting in the applicable hypothesis.

3.1 Market failures that affect the housing market in Groningen

The housing market in Groningen has been impacted by earthquakes resulting from gas extraction activities. These earthquakes generate negative production externalities, including direct damage to properties and indirect economic consequences. The direct impact is seen through high repair costs by homeowners, while the indirect impact is shown by discounts on sales prices due to decreased demand (Duran, 2022). As the perception of risk increases, the demand for housing in the affected areas declines, leading to a downward shift of the demand curve. In the case of Groningen, the risk is not confined to the region but is recognized nationwide, and prominently featured in the news and political agendas. This widespread publicity decreases demand both within and beyond the affected area (De Kam & Mey, 2017). Consequently, this drop in demand drives property prices down. Different studies argue for correct discount percentages, the most recent one states an average decrease of 8.9% of the

value in the affected areas (Elhorst, 2019). The decline in property prices results in a reduction of both consumer and producer surplus, culminating in welfare loss and deadweight loss. This scenario exemplifies a market failure, thereby providing a compelling rationale for governmental interference to mitigate the adverse effect on the housing market and restore market equilibrium.

3.2 Governmental interference

Governmental initiatives have the potential to stimulate economic activity in regions. Intervention can enhance well-being in various ways, as it has been shown to raise social cohesion and create environments conducive to new developments. In the long term, this support can lead to innovative advancements, transforming threats into opportunities for further growth (Siyongwana & Shabalala, 2018). Targeted governmental growth efforts can increase land prices in affected areas without necessarily reducing prices in neighbouring regions. This appreciation of property values highlights the crucial role governments play in revitalizing local economies (Brueckner et al., 2022). Theoretically, governmental compensation instruments, such as the Koopinstrument, can act as a safety net in the market. This is because not only the properties that apply for the instruments receive benefits, but also the surrounding properties, due to the assurance that all properties can be bought out. Thus, every new homebuyer has the assurance they can sell their house if needed, for the taxation value (Van der Heijden & Boelhouwer, 2017). The safety net function of the Koopinstrument can be viewed as an abstract form of a price floor, a government-imposed minimum price for a good. Normally in a disturbed market, this price floor is above the current market value (The Economic Times, 2024). However, for the Koopinstrument, it is 5% lower than the taxation value, which is the theoretical market value. The taxation value can differ from the market value because real estate markets are dynamic systems influenced by factors such as supply, demand, and price. Most valuations are conducted at a specific moment in time and for a particular purpose, such as funding or selling, which can affect the price (Kuryj-Wysocka et al., 2015). To conclude, the safety net function might restore prices to their original levels, thereby mitigating negative externalities.

However, governmental interference can also have negative outcomes. Pessimistic views suggest that every market failure reflects a failure of government intervention. When governments interfere, the market is disturbed and may not be able to recognize important market signals, a disadvantage of price floors. For instance, governmental subsidies on

agricultural land in the United States were later capitalized in land prices, distorting the land market into a government-dependent one. This aspect must be considered when designing compensation instruments. The market should not become overly reliant on government intervention but rather be supported to provide a boost (Brueckner et al., 2001). This argues that more governmental interference may only worsen the market.

Nonetheless, government intervention is particularly warranted in Groningen since the government itself caused the earthquakes in the region. According to the 'L'égalité devant les charges publiques' principle, compensation is applicable for individuals who suffer damage due to rightful actions by the government, which result in unequal harm to some individuals. The rationale for this approach is that while individuals may struggle after such events, a larger collective effort from a municipality, province, or state can be mobilized to address the problem with minimal individual burden (Van Herwijnen & Blok, 2007)

3.3 Challenges in the aftermath of natural disasters

There are multiple difficulties regarding the housing market after natural disasters. One key difficulty is that housing affordability often takes longer to recover in low-income neighbourhoods. Additionally, the distribution of disaster relief funds is typically based on the magnitude of the financial loss, which can disproportionally benefit wealthier individuals with more expensive homes, even though poorer individuals face greater financial challenges after severe disasters (Bernstein et al., 2006).

The aftermath of earthquakes demonstrated that restoring the economic stability of a region requires substantial time and effort. Important for this recovery is a joint effort for the rebuild between government, industry, and community (Wang et al. 2020). However, various complex challenges are inevitable along the way to economic stability. Bernstein et al. (2006) emphasize the importance of the involvement of communities for a successful rebuilding process. Efforts with good community communication will mostly be more successful, even if there are insufficient funds for rebuilding. For governmental organizations, it has been proven that allocating recovery funds can provide stronger support for housing by accounting for the demographic and financial diversity among the population. Hereby, the more heavily affected are helped. A strategy to make this happen is by using local non-profit housing corporations that help to get the money in the right places (Bernstein et al., 2006).

However, disturbances in the recovery process can arise. For example, in Christchurch, New Zealand, during the recovery from an earthquake, damage claims issued by the community

were misused, with funds diverted to purposes other than repairing residential properties. This misuse led to a lack of security for housing buyers, who could not be assured that the damage would be repaired. This uncertainty complicates the restoration of economic activity and highlights the need for more effective collaboration among recovery actors in the affected area (Nguyen et al., 2023). Additionally, when free aid is available, individuals may be less inclined to invest their own funds in recovery efforts (Andor et al., 2020). This paragraph underscores the complexity of governmental interference in disturbed real estate markets. It is clear that governmental interference can help to get to a stable state but factors such as low-income societies and coherence of government with the affected make the good allocation of funds difficult.

3.4 Hypothesis

1 The acquisition price of housing transacted via the Koopinstrument is higher than the sales price of those houses.

The assumption of the hypothesis is grounded in the theoretical framework highlighting the impact of earthquakes on the Groningen housing market. Earthquakes, caused by gas extraction activities, have inflicted negative externalities, directly through repair costs and indirectly through decreased demand and reduced property values (Duran, 2022; Elhorst, 2019).

4 Empirical materials

This chapter explains the data used to examine the theory and describes how the data is utilized to make statements on the hypothesis. Unlike the previous chapter's framework, this chapter concentrates on the new research concerning the Koopinstrument.

4.1 Data collection

The dataset used in this research contains unique data on the 53 transactions of SWAG facilitated through the Koopinstrument. It is a non-public dataset that covers all the historical activities of SWAG. The first transaction was made in 2017 and the last one in 2024, thus this being the timeframe of the data. Within this dataset, details are provided regarding the

acquisition and selling of designated properties, with transaction prices and corresponding dates. With this information, the analytical assessment of governmental interference can be started. Additionally, there are property characteristics included, square meters of living area, square meters of extra indoor area, square meters of parcel, energy label, and the type of dwelling. These housing characteristics, incorporated into the analysis, serve as the main control variables essential for the analytical framework. A total of 53 observations are included, comprising all objects that have been bought and sold. Currently, more objects are bought but not sold, these unsold objects lack the total information needed for this research. Properties that have been demolished have also been excluded due to different circumstances.

Table 2 presents descriptive statistics for the dataset, offering a comprehensive overview of properties involved in transactions via the Koopinstrument. The first variable examined is the acquisition price, denoting the amount paid by SWAG for each property, measured in euros. Acquisition prices range from €76,000 to €850,250 with an average of €272,318.40. In contrast, the average sales price experiences a slight decrease to a mean of €266,446.51, ranging from €83,000 to €625,000. Additionally, the dataset includes variables about property size, calculated in square meters of living area. Sizes range from 76 to 635 square meters, with an average of 196 square meters. Extra indoor areas, such as sheds, barns, and warehouses are sometimes not present; however, the largest extra indoor area spanning 1,700 square meters. Parcel sizes vary widely, ranging from 40 to 23,342 square meters, with an average of 1,717 square meters. At last, there is a variable for the time an asset is in the portfolio in days, with a minimum of 78 days and the longest time in the portfolio was 1,407 days. However, the average is a bit above a year, 438 days.

Table 2: Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Acquisition price (€)	53	272,318.40	172,949.2	76,000	850,250
Sales price (€)	53	266,446.51	148,011.9	83,000	625,000
Living area (sq m)	53	196.32	107.35	76	635
Extra indoor area (sq m)	53	131.79	278.93	0	1,700
Parcel (sq m)	53	1,717.25	3,689.17	40	23,342
Time in the portfolio (d)	53	438.26	347.95	78	1,407

To mitigate the impact of price changes, a dataset sourced from CBS is employed, with insights into the sales price of housing per region. These general price changes need to be used due to the sparsity of the dataset. The prices reflect the trends in home sale prices, with properties required to be located within the province of Groningen and sold to private individuals. The dataset figures for existing homes and is based on comprehensive registration of property sales transactions by the Land Registry and the WOZ values of all homes in the Netherlands (CBS, 2024). To get an index for the first quarter of 2024, another document of CBS is used. Wherein CBS stated the changes in the prices in the province of Groningen (CBS, 2024). For the other observations, the yearly index is used over monthly and quarterly. This is because yearly has more stability and the ability to capture long-term trends, simplifying strategic decisions. This approach ensures a clearer understanding of broader economic conditions and enhances the interpretability of results.

The primary focus of this study lies in the visual examination of the acquisition and sales prices for each object within the context of the price reduction rates. This difference is defined by the discrepancy observed between these two prices. The data consists of nuanced details but a notable level of complexity, the dataset necessitates a structured analytical framework for meaningful interpretation. The main reasons for the complexity are the heterogeneous characteristics of each of the transactions and the number of observations. The variables acquisition price, sales price, square meters of living area, and time in the portfolio are used in the analysis to compare with the price reduction rates. The visual view shows relationships between these variables. Afterward, statistical regressions are made to see if the first analytical observations are aligned with the regressions. For the statistics, the price reduction rate, in percentages, is used to achieve a normally distributed outcome. To see the price reduction instead of the growth the whole equation is calculated times -1, with the reduction rate the real discount in percentages in shown. Resulting in the following equation:

$$Price\ reduction\ rate = \frac{indexed\ sales\ price - indexed\ acquistion\ price}{indexed\ acquisition\ price} * 100\% * -1 \quad (1)$$

4.2 Ethics

In the examination of the price reduction rate of the Koopinstrument in the earthquake-affected area in Groningen, attention is devoted to the ethical dimension, taking the emotional and complicated issues of this problem into account. Central to the ethical framework is the treatment of sensitive data sourced from SWAG. Upholding strict confidential standards, the privacy of individuals impacted by the earthquakes is protected. Principles of consent and data anonymization are made to shield the identities and personal information. To ensure

the validity of the dataset, personnel from the foundation conducted a thorough double-checking process. This involves comparing the information within the derived dataset with various taxation reports, purchase agreements, and sales contracts. Through this verification procedure, the integrity of the dataset is upheld, confirming its validity.

5 Results

To assess the price reduction rates of the transactions handled through the Koopinstrument, an investigation into the distribution and correlation of the reduction rate is needed. Beyond the scope of statistical models, the utilization of descriptive statistics, histograms, and scatterplots provides a nuanced understanding of price reduction rates. The descriptive statistics, in Table 2, give valuable insights. It is seen that the acquisition price exhibits variability, ranging from €76,000 to €850,250. This wide range indicates that some purchased properties had tax valuations with values more than 10 times higher than others, suggesting both lower and higher-income individuals are affected. Conversely, when examining the maximum sales price, a notable decrease is observed, with no property selling for more than €625,000, representing a difference of €200,000 compared to the acquisition price. Interestingly, the minimum sales price remains nearly the same. This narrower range and downward shift contribute to a lower mean and standard deviation for sales prices. This is also seen in Figure 1, where the correlation between acquisition and sales prices is visualised. A glance at the scatterplot reveals a pattern wherein acquisition prices tend to exceed sales prices, revealing 67.9% of the transactions. This observation suggests a prevailing discount across the objects that have been transacted with the use of the Koopinstrument.

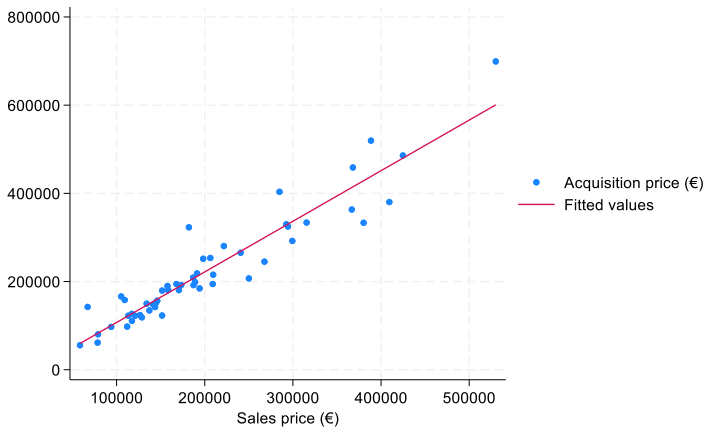

Figure 1: Relationship between acquisition and sales price

The difference between the acquisition and sales price is quantified as the, in Figure 1, indexed sales price minus the indexed acquisition price, examined per property in euros. Figure 2a reflects the distribution of the absolute difference between the acquisition and sales price, with an average positive amount of €22,185.82 per property. The distribution shows a spectrum ranging from the highest positive difference of €169,045.20 to a negative value amounting to €44,275.19. The negative values and reduction rates indicate instances where the Koopinstrument sold properties better off than the acquisition price. Notably, 17 of the 53 instances exhibit those negative outcomes, 32.1% of all the transactions. These anomalies can be attributed to market fluctuations. SWAG mitigates the risk for sellers who are eager to sell after not being able to sell their house for 8 months. For the foundation, it is possible to hold the asset as long as needed. Eventually, SWAG can sell for a sustainable price when the time is right, without material damage and the fear of being unsafe in your own house, what affected individuals perceive, as stated in chapter 1.2. Additionally, when analysing the distribution as a percentage of the acquisition price, depicted in Figure 2b, the mean price reduction per property stands at 6.9%, with fluctuations ranging from -27.6% to 52.9%. Notably, the distribution across both Figure 2a and Figure 2b exhibits considerable dispersion just above the zero point, indicating a lot of observations where there is a minimum difference.

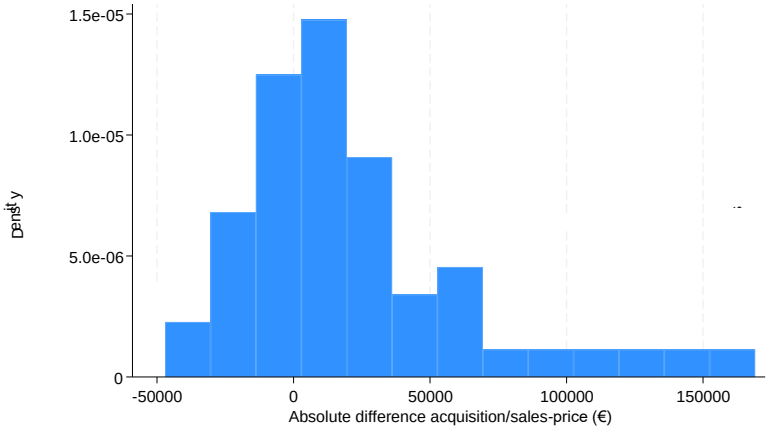

Figure 2a: Absolute difference between the acquisition and sales price in euros

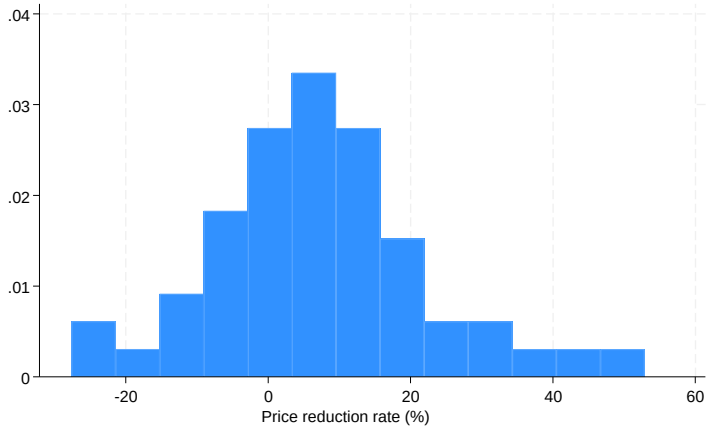

Figure 2b: Overview of all the price reduction rates in percentages

Further insights are seen in Figures 3a and 3b, where the price reduction rates and absolute differences are aligned against the acquisition price. The correlation, as seen in Figure 3a, between the reduction rates and acquisition price is set with a high number of residuals, caused by the high number of fluctuations going up and down. Looking after the €400,000 threshold

an upward shift is seen towards higher price reduction rates. Similarly, the distribution of percentages in Figure 3b highlights variability, particularly in the lower acquisition price range, while stabilizing between 10% and 25% beyond the €400,000 threshold. This indicates heterogeneous differences in the lower and more homogenous outcomes in the higher-valued properties, with high differentiations within the lower-valued properties.

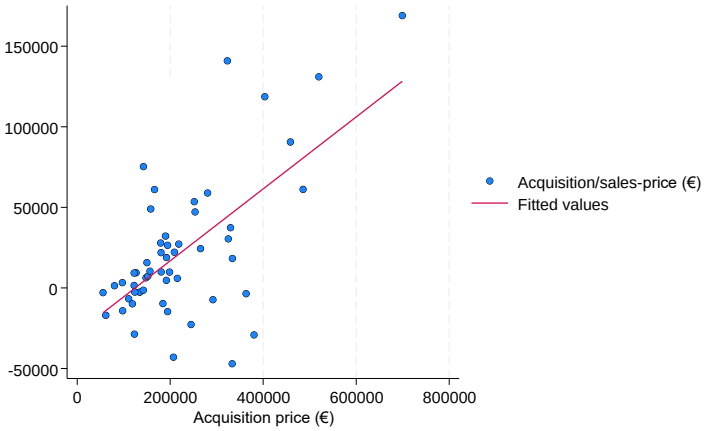

Figure 3a: Relationship of the acquisition price and the absolute difference between the acquisition and sales price in euros

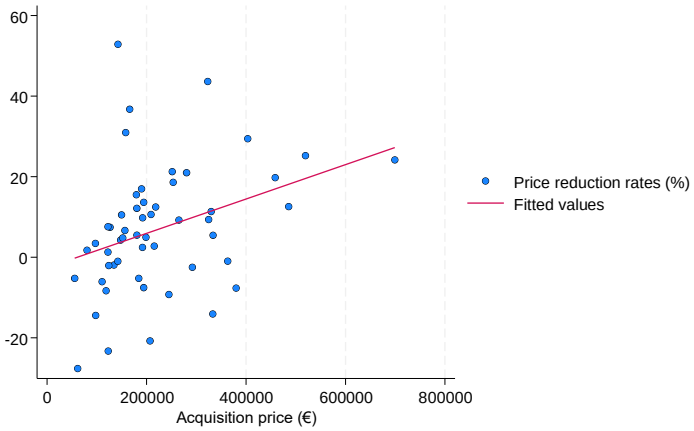

Figure 3b: Relationship of the acquisition price and the price reduction rates in percentages

Figure 4a and Figure 4b show the same correlation of the price reduction rates and absolute differences but concerning the sales price. It can be observed that the distribution in the figures shows more variance and is less consistent compared to the graphs for acquisition price. However, in line with the acquisition price, the price reduction rates aligned with the sales price show high volatility in the rates in the lower part of the sales price, with smaller percentages in the higher sold cases. Noteworthy is the emergence of an equilibrium point around the €200,000 threshold, approximately €65,000 below the average acquisition and sales price, where the reduction rates are minor and zero. Overall, it can be seen that there is not a particular percentage for the differences between the acquisition and sales price. Regarding the sales price, the price reduction rates are heterogeneous for each observation seen by the high fluctuations. In contrast, the regression line shows a slightly increasing line of around 6%.

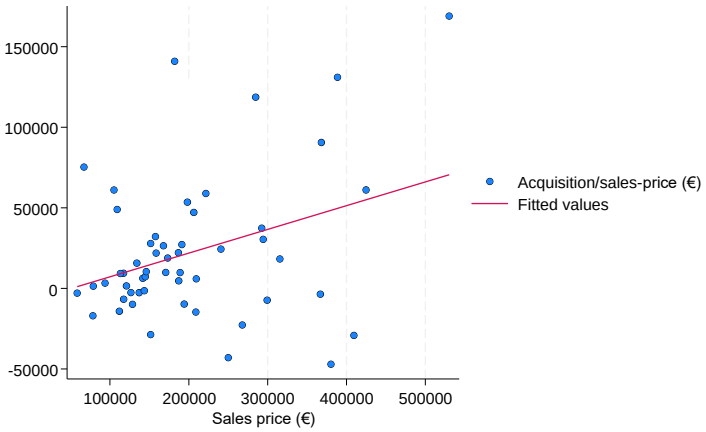

Figure 4a: Relationship of the sales price and the absolute difference between the acquisition and sales price in euros

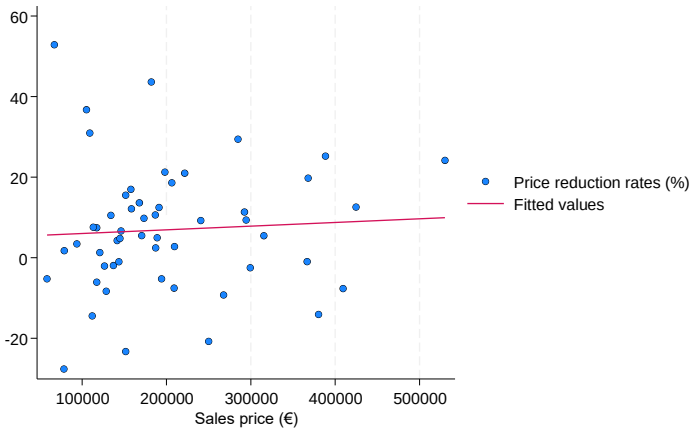

Figure 4b: Relationship of the sales price and the price reduction rates in percentages

The following two figures illustrate the correlation between the price reduction rates and square meters of living area. Upon visual inspection of the graphs, similar patterns to those observed in the relationship with acquisition prices emerge. Namely, in Figure 5a, the same fluctuations are noticeable until the 300-meter threshold, followed by an upward trend in the absolute differences. For the acquisition price, the turning punt was the €400,000 threshold. However, these fluctuations appear to be more pronounced compared to those observed in the acquisition price. This suggests a stronger correlation. Figure 5b provides arguments indicating that smaller houses are the only ones where the price reduction rate is more likely to be negative, so a price growth. One possible explanation for this phenomenon is the living square area, which needs less reinforcement work to get to an earthquake-proof building. Additionally, there are higher and lower fluctuating percentages in the lower square meters than in the higher square meters.

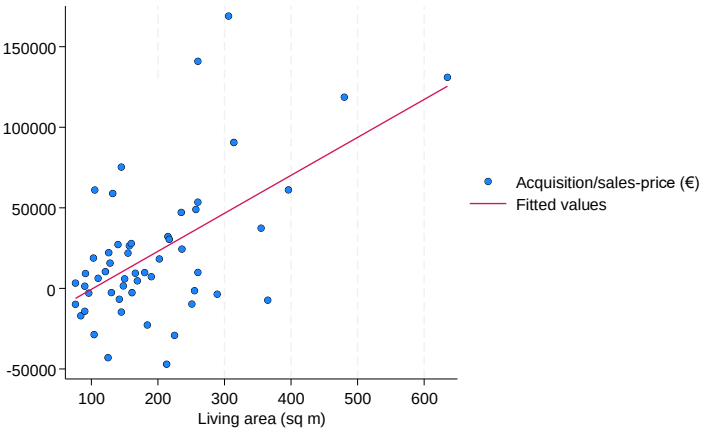

Figure 5a: Relationship of the square meters living area and the absolute difference between the acquisition and sales price in euros

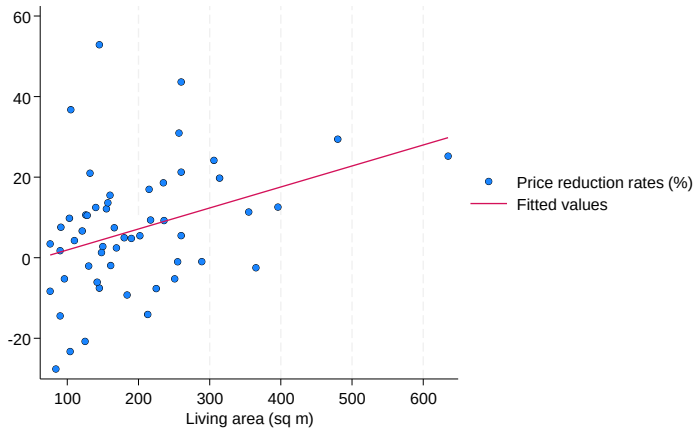

Figure 5b: Relationship of the square meters living area and the price reduction rates in percentages

The final two graphs depict the relationship between the duration a property remains in the portfolio, measured in days, and the price reduction rates and absolute differences. In Figure 6a, there is an upward trend indicating that the absolute differences tend to increase as the property remains in the portfolio for a longer period. Particularly noteworthy is the trend where properties sold within approximately a year receive a minimal or even negative rate, indicating cases with a higher sales price in comparison with the acquisition price. After this point, there are more fluctuations, with even properties lingering in the portfolio for an extended duration exhibiting negative differences. Figure 6b demonstrates an even stronger correlation with a more consistent distribution, suggesting a proportional increase in the price reduction rates as the property's time in the portfolio extends, especially until the 1,000-day mark. However, in the later phase, the negative percentages are seen again, visualizing the pattern as a reversed U-curve. Additionally, there are also high rates, indicating the risk of both high negative and high positive rates. This could be attributed to SWAG unconsciously waiting for market conditions to improve and seeking the right buyer. Conversely, those urgently needing to sell, because of problems within the earthquake problems, may lack this option. In cases falling into that category, all actors are satisfied. Affected are not stuck in their homes, and governmental aid in financial terms is not needed only by taking the risks associated with property ownership.

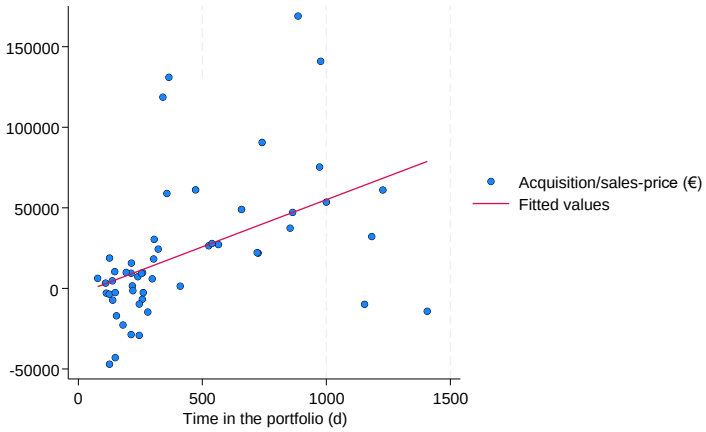

Figure 6a: Relationship of the time in the portfolio and the absolute difference between the acquisition and sales price in euros

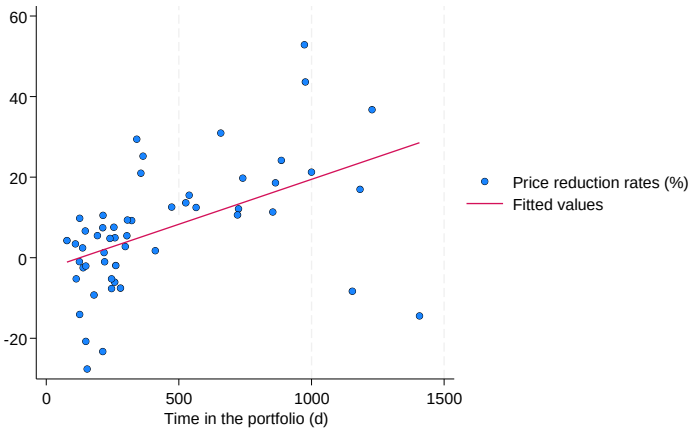

Figure 6b: Relationship of the time in the portfolio and the price reduction rates in percentages

To assess whether the relationships from the observed figures hold significant outcomes, various statistical models are used. The primary focus lies in estimating the impact of the sales price, the main independent variable. In the previous section, the results indicate that there is no correlation between the sales price and the absolute or price reduction rates. To test this, a simple regression model is formulated:

$$\mathrm{Pr}_i = \beta_0 + \beta_1 \ln\_\mathrm{Ps}_i + \varepsilon_i \quad (2)$$

where Pr represents the price reduction rate. Using the price reduction rates in percentages results in a more normally distributed value, as demonstrated in the distribution of both the absolute differences and the price reduction rates shown in Appendix A. In this model, i stands for the individual transaction, first the constant is stated, ln_Ps includes the natural logarithm of the sales price, and ε is the error term. An overview of the normal and natural logarithm of the sales price is included in Appendix B, a better distribution is seen in the natural logarithm.

A total of 4 models will be tested, model 2, equation 3, includes the sales price with property characteristics. The resulting statistical model is as follows:

$$\mathrm{Pr}_i = \beta_0 + \beta_1 \ln\_\mathrm{Ps}_i + \beta_2 \mathrm{Ml}_i + \beta_3 \mathrm{Mx}_i + \beta_4 \mathrm{Mp}_i + \beta_5 \mathrm{E}_i + \beta_6 \mathrm{Di}_i + \varepsilon_i \quad (3)$$

Model 3, equation 4, will test the influence of only property characteristics on the price reduction rates. The statistical model is:

$$Pr_i = \beta_0 + \beta_2 Ml_i + \beta_3 Mx_i + \beta_4 Mp_i + \beta_5 E_i + \beta_6 Di_i + \varepsilon_i \quad (4)$$

Model 4, equation 5, focuses on the time in the portfolio variable. With the aligning statistical model:

$$Pr_i = \beta_0 + \beta_7 T_i + \varepsilon_i \quad (5)$$

where Pr remains to represent the price reduction rate in percentages, i stands for the individual transaction, than the constant is stated in the model, other variables include ln_Ps the natural logarithm of the sales price, Ml the square meters of living area, Mx the square meters of the extra indoor areas, Mp the square meters of the total parcel, E a dummy variable for the energy label, D a dummy variable for the type of dwelling, T is a variable for time in the portfolio of SWAG in days. Finally, ε is the error term. The models will be tested on the 95% confidence interval, with a smaller sample size, it is more reliable to use a wider confidence interval to recognize estimation uncertainty. The regression is checked with the use of regcheck in Stata to ensure OLS assumptions. However, the use of linear regressions for percentages can lead to unrealistic expectations. Therefore, a Beta regression is performed on the same models to check if the outcomes are similar to those of the linear regression, as a robustness check. To address the appearance of negative fractions, a constant of 0.277 is added.

Table 3 presents the outcomes of the four distinct linear models. The first, most straightforward, model tests the relationship between the price reduction rate and the sales price, the regression shows a similar result as the observed results of the scatterplots. Because there is no significant result implying that the sales price correlates with the price reduction rate. In addition, the model only consists of an R-squared of 0.16%, indicating that the variation of the price reduction rate is not well explained by the sales price.

In Model 2, various property characteristics are introduced, including square meters of living area, extra indoor area, parcel size, energy label, and type of dwelling. The addition of these variables yields significant outcomes, with a higher R-squared of 42.53%. The model suggests that for every percentage increase in sales price, the price reduction rate decreases by 0.17 percentage points, indicating higher rates for lower sales prices. This is partly visible in the scatterplot of the sales price, with the more excessive fluctuations. However, this is not in line with the slightly increasing regression line in the histogram of Figure 4b. Additionally, the square meters of living area increase the price reduction rate, per square meter living area the

percentual rate increases by 0.09 percentage points. This is aligned with the visual analysis in Figure 5. Extra indoor square meters and square meters of parcel do not find significant effects in this model.

With the inclusion of only the property characteristics, there is no change in which characteristics show significant impacts. The difference is that the coefficient for square meters of living area decreases to 0.06 percentage points. Notably, the R-squared has decreased to 32.85%.

Finally, Model 4 presents the results, incorporating the time in the portfolio of SWAG. The model suggests that this variable increases the price reduction rates by 0.02 percentage points per day. However, looking at the visual distribution of Figure 6b, there is an upside-down U seen, indicating that there is a non-linear relationship. The main trend is seen in the first part of the scatterplot. In the end, the statistical and visual analyses indicate, by the increasing reduction rates in the first years, that the buy up instrument is needed to help people not get stuck in their current house, described as one of the goals of the Koopinstrument. If the affected people did not have this instrument the value of their property would probably decrease way more, especially in the first 1,000 days, Figure 7 shows this problem in a theoretical figure. Otherwise, a governmental organization would be needed be help affected with larger sums of money, as seen as the red triangle. Notably, this final model consists of a low R-squared, 24.44%. Across all 4 models, the R-squared values are relatively low, emphasizing the importance of the visual analysis.

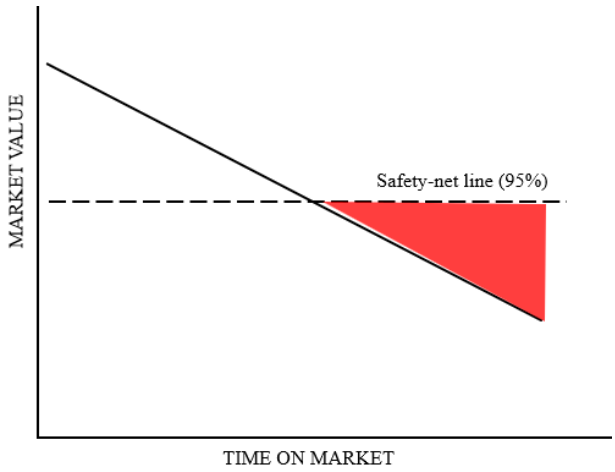

Figure 7: Market value problem if there was no Koopinstrument regarding time on the market, by author

To check the robustness of Table 3, a Beta regression is performed on the four models. The trends observed in the linear regressions are consistent with those in the Beta regressions. Both the negative and positive coefficients as well as their significance levels are the same for each variable, as shown in Appendix C. Therefore, the Beta regression confirms that the linear model is sufficiently robust.

Table 3: Results of statistical models

Variable	Model 1	Model 2	Model 3	Model 4
Log Sales price	1.2799 (4.438405)	-17.09617 ** (6.757678)	-	-
Sq meter living area	-	.093434 *** (.0272872)	.0572994 ** (.0248081)	-
Sq meter extra indoor area	-	.0429586 (.0317433)	.0509803 (.0337004)	-
Sq meter parcel	-	-.0021541 (.0024865)	-.0032741 (.0026107)	-
Fixed effects for energy label	No	Yes	Yes	No
Fixed effects for type of dwelling	No	Yes	Yes	No
Time in portfolio	-	-	-	.0222937 *** (.0054887)
Constant	-8.539301 (53.72619)	210.2796 ** (82.3378)	6.244987 *** (17.69879)	-2.829544 (3.060223)
Observations	53	53	53	53
R-squared	0.0016	0.4253	0.3285	0.2444

*Note: the dependent variable is the price reduction rate. *** p<0.01 ** p<0.05 *p<0.1*

6 Discussion

6.1 The broad need for governmental interference

In this research the data shows that most of the price reduction rates hover between 0-15%, indicating numerous instances where there was a minimal difference. This suggests that for many properties, a small discount is enough to increase the amount of transactions, helping people to not get stuck in their houses. Interestingly, larger homes exhibit higher differences between the acquisition and sales price, with increasing rates indicating that the larger the asset, the more the sales price falls below the acquisition price. A reason for this could be that more square meters require more repair costs when a property is affected by earthquake damage. With the buy up of SWAG, the foundation bears the role of supporting affected individuals while potentially profiting from market changes. This action can ultimately benefit the whole

society, as SWAG passively waits for improved market or normal conditions and suitable buyers, unlike those needing to sell urgently who lack such flexibility. Overall, the Koopinstrument increases transactions in the affected region at minimal costs to the government, highlighting the policy's effectiveness in supporting all homeowners who have been impacted by earthquakes.

6.2 Limitations of the research

The research focuses on a relatively understudied and infrequent topic, which restricts the literature on broader governmental interference in negatively affected areas. The goal of this particular study was to get more insights into the market dynamics and governmental interference in the earthquake-affected area in Groningen. The sample size of 53 observations could be seen as limited, especially for a specialized research topic. While these observations are representative of the available data, the small sample size hinders the ability to fully generalize the findings to other regions. The unique dataset and the visual method of analysis make the research results primarily applicable to the Groningen case. However, insights gained from this study could potentially motivate actors to set up new government buy up initiatives when needed, like the Vangnetregeling Oostpolder.

Other limitations warrant consideration. The analysis aggregates price changes over the entire year and region, which potentially oversimplifies the dynamics of individual property transactions of the studied region. Variations in pricing throughout the year and across different areas within the region could skew the results. For instance, the Groningen City Center may not be affected by earthquake-related issues, the price trends could differ from those of the affected areas. This approach may hide important fluctuations and trends that occur on a smaller scale, leading to an incomplete understanding of the price reduction rate. Therefore, an analysis on a smaller scale consistent with seasonal variations and differences within the region would provide a clearer picture of the real price reduction rate.

The last notable limitation that influences the acquisition and sales price is the absence of consideration for managing and repair costs incurred during the period of property management by SWAG. Repairs undertaken during this period may impact property prices, potentially influencing the relationship between acquisition and sales prices. Failure to account for these costs introduces a source of potential bias and limits the completeness of the analysis.

6.3 Policy implications

Even with the limitations within the research, the outcomes help policymakers with plans for governmental interference in disrupted markets. Currently, the government employs various measures to assist residents, including the Koopinstrument. This instrument provides an affordable and effective solution to support disrupted housing markets. Other measures mostly consist of subsidies which cost a lot of money without any guidance after they have been applicable for those who are affected. Policymakers in the Netherlands should continue using the Koopinstrument until the market stabilizes, either through the cessation of earthquakes or the construction of earthquake-resistant housing. While this instrument could be applied to multiple regions, it is crucial to consider the diverse nature of regional markets and specific problems. Therefore, tailored approaches must be developed for each instrument, as evidenced by the variations among different buy up instruments examined in this research. Vulnerable other regions where a buy up instrument could be useful are the surrounding areas of Schiphol and Tata Steel.

6.4 Future research recommendations

Future research could focus on all the transactions in the region, this opens avenues for a broader exploration of the market dynamics. Expanding the analysis to all transactions in the earthquake area, including the non-Koopinstrument properties, can shed light on the presence of the Koopinstrument within the market. Stabilizing market conditions might be seen from the foundation of SWAG, with particular emphasis on its safety net features.

While this research predominantly views governmental interference through a financial lens, there is notable importance in considering the risk associated with property ownership and its impact of the duration on the market. Further investigation into strategies that mitigate holding risks and market turnover warrants attention.

Additionally, collaborating with other buy up instruments or conducting comparative analyses of each instrument individually could provide insights into their respective strengths and weaknesses. By scrutinizing differences among these instruments, opportunities for optimization can be identified, potentially enhancing a better way to address these market challenges.

Besides the program to buy up via the Koopinstrument, SWAG has more arrangements to buy up property. Further analyses of the whole practice of the organization can get more insight into the market. These practices are the Koop-sloop, koop-zonder-sloop, and CBS

agreements. However, an analysis of these agreements with the influence of the instruments, will be complex because of the different processes and rules to acquire the property. In the end, the instruments can give a deeper insight into the needs of the market in the affected area.

7 Conclusion

This research assessed the difference between the acquisition and sales prices of the Koopinstrument in the earthquake-affected area in Groningen. Which creates an insight into the governmental interference in the region. The differences were researched by the use of historical acquisition and sales prices from the Koopinstrument. The data showed that governmental interference could be essential due to the discrepancy where acquisition prices often exceed sales prices, 67.9% of the transactions, supporting the hypothesis. Further visualization of the governmental interference, in the form of price reduction rates, highlighted the complex interplay between property value, characteristics, and market dynamics in determining the differences. The research revealed heterogeneity in the acquisition and sales prices, particularly noting that price reduction rates for lower-valued properties exhibit significant fluctuations, ranging from high negative to high positive values. This risk could have severe consequences if it were individual, but governmental interference through the Koopinstrument spreads this risk across the population. The variable square meters of living area had a linear effect on the price reduction rate, living areas with higher values resulted in higher reduction rates. This is in contrast to the correlation of the reduction rates with the individual acquisition and sales prices, which showed lowered rates for the higher prices. Additionally, the time spent in the portfolio showed an interesting pattern, forming a reversed U shape. The rates started low, gradually increased, then stabilized at a certain point, and eventually decreased again. Notably, some high rates were also observed during the longest periods. This indicates that SWAG can take the risk of holding the property for a longer period without the risk of being stuck in the home as a resident or experiencing financial problems because of value decreases. In the statistical model, the increase of the price reduction rates for a longer time in the portfolio showed that the longer a house is in the portfolio the higher the rates, without the analysis of the visual distribution there the finding of the reversed U was never seen. However, both views show that the people would be stuck in their houses if there was not a buy up instrument looking at the increasing price reduction rates in the first years, showing the need for the buy up instrument. SWAG bears the burden of owing the disrupted

housing, aiding affected individuals while also potentially profiting from market changes. Conversely, those needing to sell urgently lack such flexibility. Overall, this research indicates that the negative externalities of the earthquakes are reflected in discounts on properties, as evidenced by sales prices often exceeding acquisition prices, emphasizing the characteristics of a disturbed housing market where the need for governmental interference could be essential.

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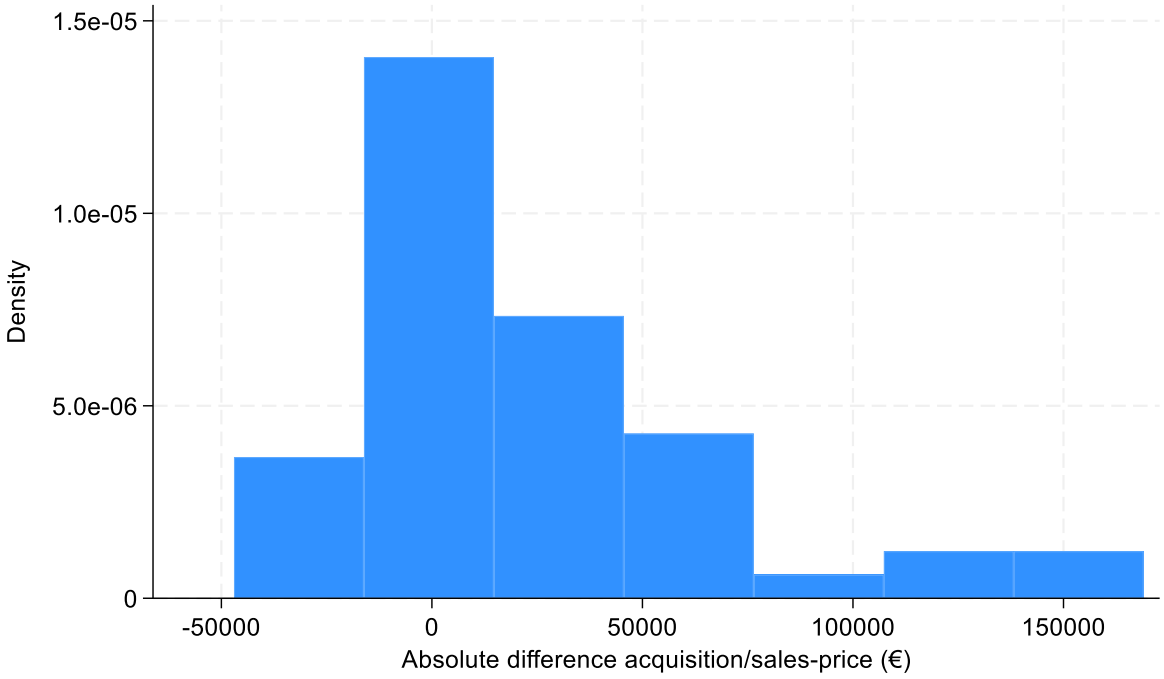
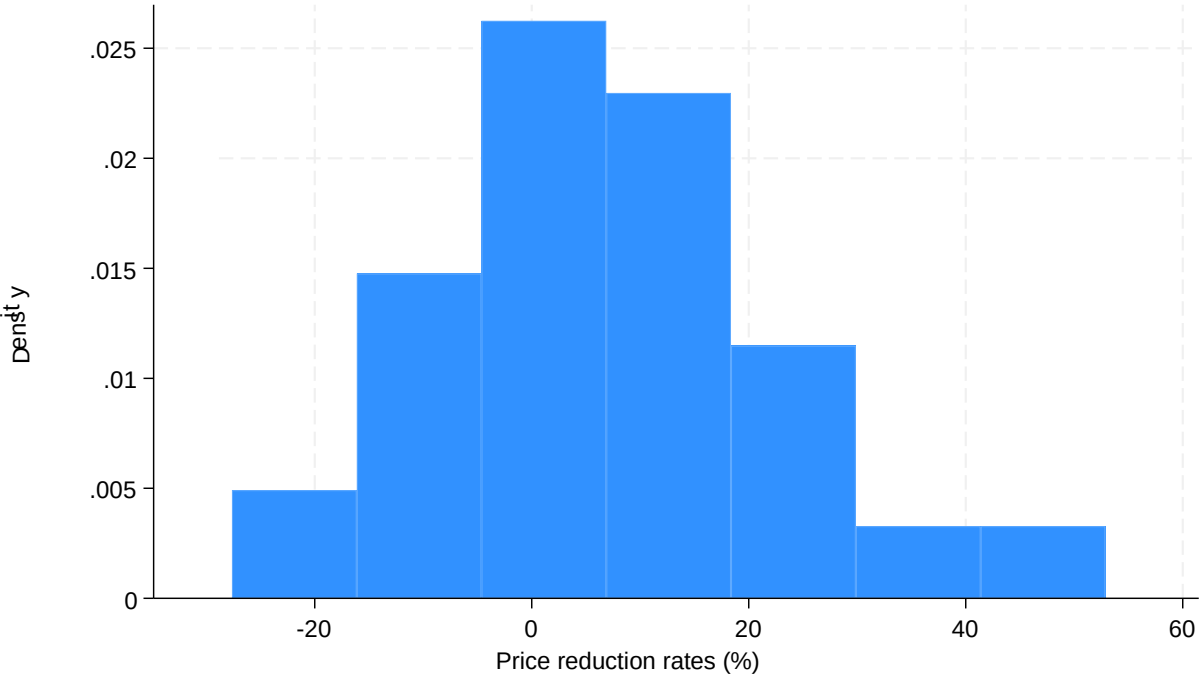
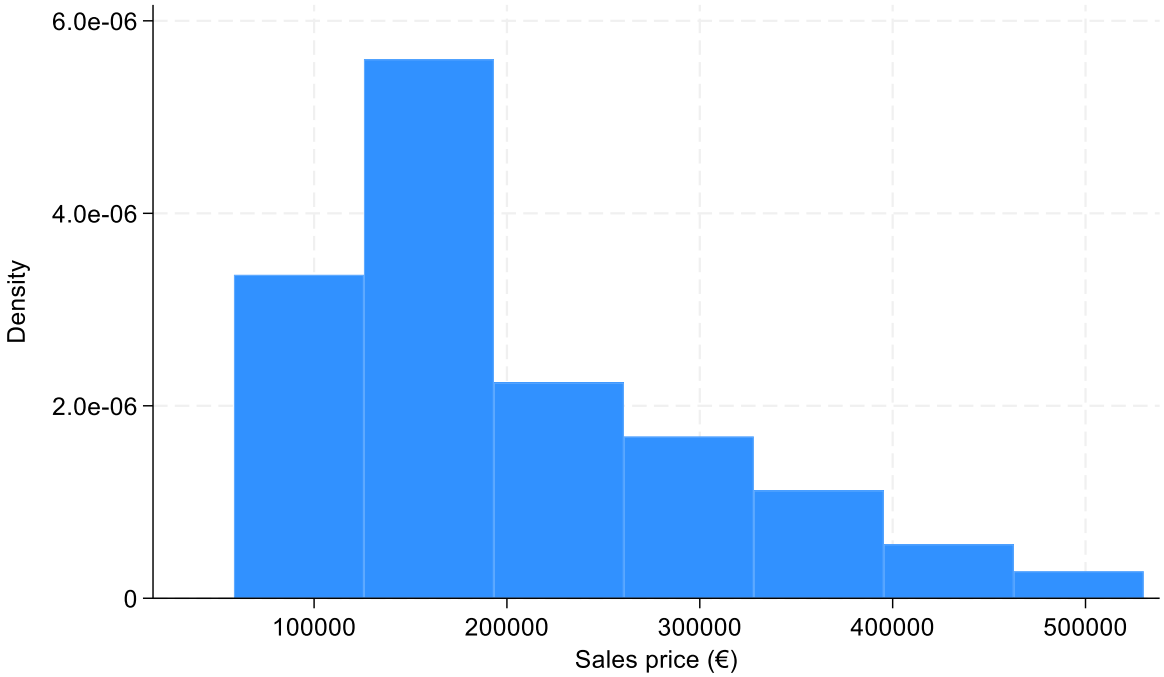
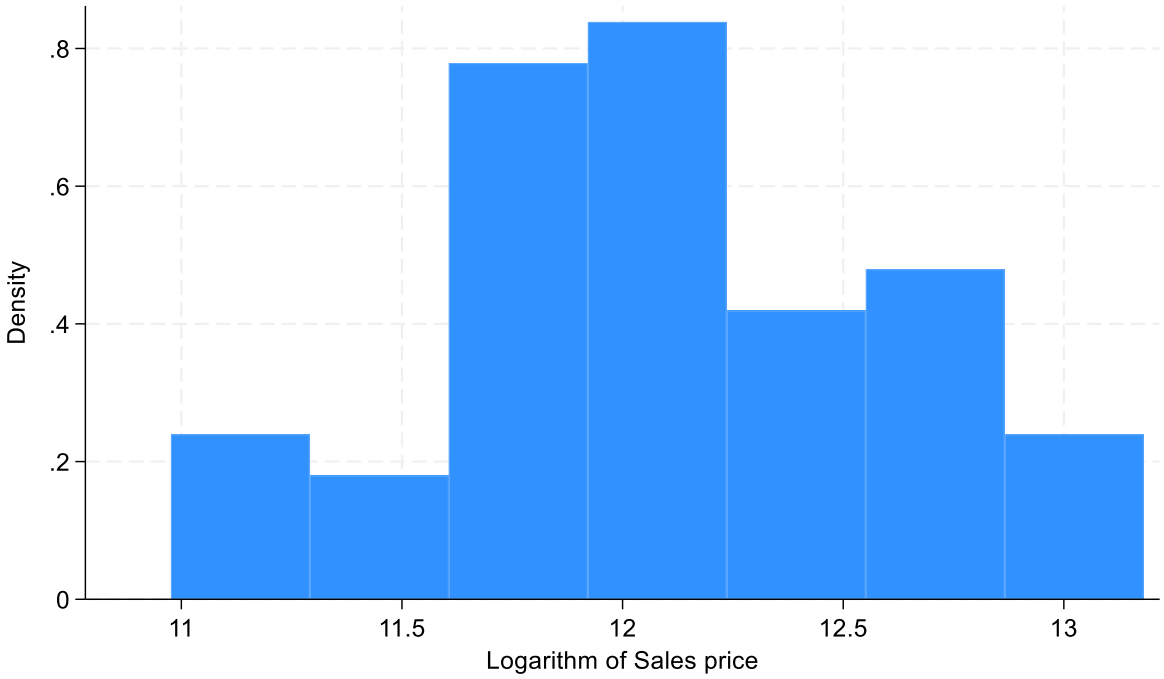
Appendix A: Histograms of absolute difference and the price reduction rates





Appendix B: Histograms of sales price





Appendix C: Beta regressio

Variable	Model 1	Model 2	Model 3	Model 4
Log Sales price	.2892537 (.2137722)	-.5903825 (.309191)	-	-
Sq meter living area	-	.0039526*** (.0012702)	.0027267 ** (.0011085)	-
Sq meter extra indoor area	-	.0020779 (.0014829)	.002378 (.0014655)	-
Sq meter parcel	-	-.0001211 (.0001152)	-.0001616 (.0001132)	-
Fixed effects for energy label	No	Yes	Yes	No
Fixed effects for type of dwelling	No	Yes	Yes	No
Time in portfolio	-	-	-	.0010185 *** (.000288)
Constant (location parameter)	-4.168992 (2.59113)	5.711999 (3.613833)	- 1.193177 *** (.2758554)	-1.124117 *** (.1632191)
Constant (scale)	1.806548 *** (.1824155)	2.281706 *** (2.281706)	2.208205 *** (.1861676)	1.990409 *** (.1843426)
Observations	53	53	53	53
Log likelihood	19.392108	31.832485	30.118358	24.240669

*Note: the dependent variable is the price reduction rate + 0.277. *** p<0.01 ** p<0.05 *p<0.1*

Appendix D: Syntax file

```
*Real Estate Studies Master Thesis: "
*Luuk van Dijk*
cd "X:\My Documents\Master Real Estate Studies\Data"
import excel "Kadasterdata Koopinstrument", firstrow

scatter taxatiewaarde Verkoopprijs
xi: summarize taxatiewaarde Verkoopprijs M2woonoppervlakte m2overigoverigeinpandigerui perceeloppvervlakt TijdopdemarktinSWAGportefe
asdoc summarize taxatiewaarde Verkoopprijs TijdopdemarktinSWAGportefe M2woonoppervlakte perceeloppvervlakt
ssc install asdoc

gen AankoopJaar = year(Aankoop)
gen indexAJ = AankoopJaar if 2017 == 100
replace indexAJ = 100 if AankoopJaar == 2017
replace indexAJ = 105.0975 if AankoopJaar == 2018
replace indexAJ = 112.42 if AankoopJaar == 2019
replace indexAJ = 123.5946 if AankoopJaar == 2020
replace indexAJ = 145.3821 if AankoopJaar == 2021
replace indexAJ = 163.6363 if AankoopJaar == 2022
replace indexAJ = 160.841 if AankoopJaar == 2023
replace indexAJ = 169.8196 if AankoopJaar == 2024

gen VerkoopJaar = year(Verkoop)
gen indexVJ = VerkoopJaar if 2017 == 100
replace indexVJ = 100 if VerkoopJaar == 2017
replace indexVJ = 105.0975 if VerkoopJaar == 2018
replace indexVJ = 112.42 if VerkoopJaar == 2019
replace indexVJ = 123.5946 if VerkoopJaar == 2020
replace indexVJ = 145.3821 if VerkoopJaar == 2021
replace indexVJ = 163.6363 if VerkoopJaar == 2022
replace indexVJ = 160.841 if VerkoopJaar == 2023
replace indexVJ = 169.8196 if VerkoopJaar == 2024

tabulate energielabel, gen (energielabel_)
tabulate Soortwoning, gen (Soortwoning_)
gen M2living = M2woonoppervlakte
gen TimeMarket = TijdopdemarktinSWAGportef

*95% taxatie*
gen RealAq = taxatiewaarde/indexAJ*100
gen RealSel = Verkoopprijs/indexVJ*100
gen RealAid = RealAq - RealSel
gen PRealAid = ((RealSel - RealAq)/RealAq *100)*-1

*Analyse*
twoway (scatter RealAq RealSel) (lfit RealAq RealSel)

histogram RealAid, bin(13)
histogram PRealAid, bin(13)
summarize RealAid
count if RealAid < 0
summarize PRealAid

twoway (scatter RealAid RealAq) (lfit RealAid RealAq)
twoway (scatter PRealAid RealAq) (lfit PRealAid RealAq)
twoway (scatter RealAid RealSel) (lfit RealAid RealSel)
twoway (scatter PRealAid RealSel) (lfit PRealAid RealSel)
twoway (scatter RealAid TimeMarket) (lfit RealAid TimeMarket)
twoway (scatter PRealAid TimeMarket) (lfit PRealAid TimeMarket)
twoway (scatter RealAid M2living) (lfit RealAid M2living)S
twoway (scatter PRealAid M2living) (lfit PRealAid M2living)

*Model with log Real aid*
gen ln_RealSel = log(RealSel)
summarize RealAid

*Histograms for Appendix*
histogram RealAid
histogram PRealAid

histogram RealSel
histogram ln_RealSel

*Regression with percentages*
histogram PRealAid

regress PRealAid ln_RealSel

regress PRealAid ln_RealSel M2living m2overigoverigeinpandigerui perceeloppvervlakt  energielabel_* Soortwoning_*

regress PRealAid M2living m2overigoverigeinpandigerui perceeloppvervlakt energielabel_* Soortwoning_*

regress PRealAid TimeMarket

*Betaregression with fraction + constant*
gen FrRealAidC = (((RealSel - RealAq)/RealAq)*-1)+0.277
betareg FrRealAidC ln_RealSel
betareg FrRealAidC ln_RealSel M2living m2overigoverigeinpandigerui perceeloppvervlakt  energielabel_* Soortwoning_*
betareg FrRealAidC M2living m2overigoverigeinpandigerui perceeloppvervlakt energielabel_* Soortwoning_*
betareg FrRealAidC TimeMarket

ssc instal regcheck
regcheck
```