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Master Thesis [International Economics]

Quantitative Easing: Present-Day Robin Hood? Evaluating its effect on wealth dispersion in the Netherlands.

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Abstract

In the wake of the Eurozone crisis and the GFC, central banks have declined their short-term interest rates to remarkably low levels, with the aim of lifting up the economic system. At some point, these rates kept stuck at the effective lower bound and economic growth slacked, pushing central banks into other, more unconventional measures, with Quantitative Easing (QE) being one of them. As QE is an effective tool in lowering the yield curve and boosting asset prices, this has spiked the debate on whether QE has (partially) contributed to increased wealth dispersion, thus presenting itself as a "reversed Robin Hood". To evaluate whether these concerns are legitimate, this thesis tries to assess the impact of QE on wealth dispersion in the Netherlands over the period 2015-2023. First of all, the effect on two major drivers of wealth dispersion is estimated, namely housing wealth and financial assets, before evaluating the impact on total wealth inequality, thereby using the P90/P50 ratio and the Gini Index of wealth. The former two are estimated for both the richest decile and bottom 50% of the Dutch wealth allocation, to assess whether changes in inequality are attributable to changes in these specific components of wealth. Exploiting a SVAR model framework with zero- and sign restrictions introduced by Arias et al. (2018) and confirmed by the robustness checks in this paper, I find that wealth inequality significantly decreases in the Netherlands in response to a positive QE shock: the larger increase in housing wealth for the bottom 50% more than offsets the larger increase in financial wealth for the top 10%. However, as the results are only applicable to the P90/P50 ratio and the Gini Index of wealth, they should not be projected onto other wealth inequality measures. Due to the limited availability of data at this point, this will thus be left for future research.

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1. Introduction

From the outset of the Great Financial Crisis (GFC), federal banks have dropped their short-term interest rates to significantly low levels (see Appendix Figure 1), intending to boost the economy after a period of severe crisis and uncertainty. However, these low levels were maintained for almost a decade, especially in the Euro Area, until Russia invaded Ukraine and inflation started to rise. One would expect rising economic growth in a prolonged period of low interest rates, however, there is a possibility that economic activity dwindles at some point. In that case, central banks have to unlock their toolboxes and use other monetary measures to stir up the economy. Quantitative Easing (QE) is one of these unconventional tools. The purpose of QE is to decrease the long-term interest rate, and central banks try to pursue this by purchasing long-term government bonds and other assets in significant quantities, with newly created money, resulting in an expansion of their balance sheets. The extent to which QE was implemented in the Eurozone, is depicted in Appendix Figure 2, which presents the total assets of the European Central Bank (ECB). It clearly shows a large rise in January 2015, when the ECB revealed its own Asset Purchase Program (APP). The purchases lasted until June 2022, with a short pause in 2019 (ECB, n.d.). On top of this, a new wave of QE was launched in March 2020 with the start of the COVID-19 Pandemic, also known as the Pandemic Emergency Purchase Program (PEPP) (ECB, 2021). Consequently, the ECB's balance sheet has grown substantially since its establishment in 1998, prompting questions about the potential effects of these levels of QE, especially amidst the COVID-19 Pandemic. One of QE's potential side effects will be the primary focus of this thesis, namely the impact of QE on distributional wealth. To elaborate on this, there is potential for significant increases in housing- and stock prices, as consumers and firms search for higher yields. This situation of increased asset prices is shown in Appendix Figure 3 and 4 for the Netherlands; the average price of housing and the Amsterdam Exchange Index (AEX) has been increasing steadily for almost more than a decade, mostly during this expansionary monetary policy period. However, since both stocks and property are assets and thus components of net wealth, this has raised the question of whether some income groups have profited more than others, and whether these distributional differences in wealth might be partly attributable to monetary policy, specifically to unconventional monetary policy. This debate already started in 2014, when a news article by Giles was published in the Financial Times. Policymakers began to fear that QE would benefit the rich and harm the poor, as the top part of the wealth quintile held most of the (risky) assets. Petrou (2021) published a similar article, in which he shed light on increasing inequality in the United States and the part attributable to (un)conventional monetary instruments. Does QE really direct "money to the rich", and if so, is there some form of heterogeneity between nations, or are the results comparable? In particular, the amount of literature on the impact of QE on wealth disparity in the Netherlands is limited. Again, if there is heterogeneity between the Netherlands and other Euro Area countries, this could be relevant for (Dutch) policymakers. Moreover, most of the existing literature on this topic has focused on periods before the COVID-19 pandemic, although, as discussed before, central banks' balance sheet levels have reached significant highs during the past four years. This will make the COVID-19 Pandemic an interesting timeframe to examine, as the effects could be more prominent compared to previous times, and thus to prior research.

In an effort to provide a solution to the above discussions, this paper tries to answer the following research question:

What effects does QE - executed by De Nederlandsche Bank (DNB) - have on wealth inequality in the Netherlands, and can this effect be explained by distributional differences in housing wealth and financial assets?

To provide an answer to this inquiry, this paper will use data from 2015 to 2023 onwards on distributional differences in total net wealth and its components - like net housing wealth and financial assets - between the richest 10% and the lower 50% of the wealth distribution in the Netherlands. Furthermore, data on the balance sheet of *De Nederlandsche Bank* (DNB) is used (English: the Dutch federal bank). To explain this, each nation in the Euro Area has to follow the policies implemented by the ECB, including the Netherlands, and the majority of the asset buying programs performed by the ECB in the Netherlands – so the APP and PEPP – are executed by DNB (De Nederlandsche Bank, n.d.). Besides, the trendline in Appendix Figure 5 shows the balance sheet of DNB and, as one can note, the shape is almost identical to the one of the ECB (De Nederlandsche Bank, n.d.). Therefore, this paper will use data on the level of total assets of DNB as a proxy for the amount of QE implemented in the Netherlands.

The methodology used will be a Structural Vector Autoregressive (SVAR) model, in which macroeconomic shocks are allowed to be interdependent. The SVAR model will contain as well zero- as sign restrictions, and in order to implement this method, an algorithm created by Arias et al. (2018) will be utilized.

Concerning the variables in the SVAR model, most of them are available on a monthly basis, except for the outcome variables (the variables related to wealth). These variables are only available on a quarterly basis, from 2015 to 2023, which could result in so-called *small sample bias*: in that case, the mean squared error – estimated by Ordinary Least Squares (OLS) - becomes too large, resulting in biased impulse response functions, especially over a longer horizon. In the Vector Autoregressive methodology, OLS has a tendency to to downgrade persistence in case of a short sample size. (Jarocinski & Marcet, 2010). Therefore, for the main results of the thesis, all of the outcome variables are transformed from quarterly into monthly frequencies. However, as this might result in some form of measurement error, the findings of the models using the quarterly data are added as a sensitivity analysis, thereby using both standard Cholesky decomposition and the SVAR model algorithm of Arias et al. (2018). In the results, it becomes clear that both the mean of the ratio of total (net) wealth of the top 10% to the bottom 50% - from now on *the P90/P50 ratio* - and the mean of *the Gini Index of wealth* decrease in response to a positive APP shock. For the P90/P50, the decrease is barely significant in the first few periods, while the significance for the Gini Index of wealth is more visible and lasts for a longer period. The robustness check with quarterly observations and standard Cholesky decomposition show that the mean of the two measures of wealth inequality remain negative, thus in line with the main results. However, now the significance level of both the response of P90/P50 ratio and the Gini Index is higher and lasts for a longer period of time. These results hold when estimating both models with quarterly observations and the algorithm by Arias et al. (2018). Thus, as the means of the P90/P50 ratio and the Gini Index show a negative response in all cases – and as the results are statistically significant in the robustness checks with quarterly observations – it can be concluded that QE has a lowering impact on wealth inequality in the Netherlands. Now the question remains; where does the response of the P90/P50 ratio originate from? To answer this inquiry, four other models will be estimated, in which the main outcome variables are *(net) housing wealth* and *financial wealth,* both for the richest decile and lower half of the wealth distribution. The results in the main part of the thesis indicate that the response of housing wealth is larger for the bottom 50%, while the response of financial wealth is more pronounced for the top 10%, in line with the relevant literature. However, the results are statistically insignificant for the bottom 50%, and as the algorithm by Arias et al. (2018) does not allow for a standard Wald test for the equality of means, the aggregated response of the P90/P50 ratio is leading in concluding how and whether wealth inequality has changed in response to a positive QE shock.

Now, I will briefly shed light on the framework of this thesis. In Section 2, the literature related to this topic will be addressed, and Section 3 explains the relevant hypotheses. Section 4 gives a comprehensive analysis of the data, Section 5 clarifies the empirical method used, and Section 6 presents the main findings. In Section 7, specific robustness checks will be performed, and finally, Section 8 presents the main conclusion and potential limitations.

2. Literature Review

2.1 Conventional Monetary Policy

During normal times – when policy rates are not within close range of zero – central banks use conventional monetary policy tools to either stimulate or slow down the economy. For example, the

ECB tries to pursue its duty of ensuring stable prices, by keeping an inflation target of 2% in the Eurozone (ECB, n.d.). In an effort to reach this goal, three benchmark short-run policy rates are set by the ECB, and belong to the ECB's "conventional" toolbox: the Deposit Facility Rate (DFR), the Marginal Lending Facility Rate (MLFR), and the Main Refinancing Operations Rate (MROR). First, the DFR determines the amount of interest banks obtain by storing their overnight deposits at the central bank. Secondly, the MLFR denotes the rate at which banks are able to get funds from the federal bank. The DFR and the MLFR provide a floor and a ceiling, respectively, for interbank lending. Lastly, the MROR determines the weekly interbank borrowing rate in exchange for collateral. (ECB, n.d.).

The DFR is a clear indicator of the ECB's stance on monetary policy. When the ECB increases the DFR - indicating contractionary monetary policy - borrowing becomes relatively more expensive and saving relatively less, resulting in a decline in loan demand and consumption, and a surge in savings. Besides, firms' investment levels will go down, and as consumers and firms are spending less, this will result in a decrease in real output, employment, and prices. This mechanism also works the opposite way. A decrease in the DFR – or expansionary monetary policy - leads to decreased savings and increased loan demand. As a result, consumption and investments increase, leading to a rise in real output, employment, and prices. As long as the DFR is not close to zero, the ECB can use these short-term rates to perform accommodative monetary policy. However, following the GFC, when the effective lower bound came into play, the ECB had to use unconventional policy instruments to stimulate the economy. One of these unconventional instruments is called Quantitative Easing (QE), and will be discussed in the following paragraph.

2.2 Quantitative Easing

2.2.1 What is QE?

QE consists of extensive buying of long-term sovereign bonds and other financial assets, performed by major central banks like the ECB, thereby aiming to influence the long-term interest rate. To elaborate on this, if central banks buy long-term government bonds in large quantities, demand for those bonds will increase, and thereby the price. As the yield on those bonds is inversely related to the price, consequently, the long-term yield will drop. The main idea of QE is that a decrease in the long-term sovereign yield will lead to a surge in loan demand, consumption, and investments, which in turn boosts real output, employment, and price levels.

2.2.2 QE in the Eurozone

As the Netherlands belongs to the Eurozone, DNB has to follow and execute policies that are implemented by the ECB, for the Netherlands. These include conventional monetary policy tools, as well as unconventional monetary policy instruments, like QE. In January 2015, the ECB published one of these QE policies: the Expanded Asset Purchase Program (APP) (ECB, n.d.). The initial APP was already decided on in October 2014, including the Asset-Backed Securities Purchase Programme (ABSPP) and the Third Covered Bond Purchase Programme (CBPP3). The ECB extended the APP in January 2015, by adding the Public Sector Purchase Programme (PSPP). Finally, on the 10th of March 2016, the Corporate Sector Purchase Programme (CSPP) was incorporated into the APP. (Deutsche Bundesbank, n.d.).

The goal of the APP was to strengthen the economy, as the Eurozone was still recovering from a period of severe crisis. The first round of asset purchases was performed in March 2015, and ended in December 2018. From January to October 2019, no purchases were made, but from November 2019 to June 2022, the ECB started additional purchases under the APP. (ECB, n.d.). On top of this, with the emergence of the COVID-19 Pandemic, the ECB announced the Pandemic Emergency Purchase Programme (PEPP), and initiated the first round of purchases in March 2020 (ECB, 2021). The ECB's total holdings under the APP in May 2018 were estimated to be around 2.4 trillion euros (Dell'Ariccia et al., 2018), and reached a peak of around 3.4 trillion euros in June 2022 (ECB, n.d.). Initially, under the PEPP, 750 million euros were made available by the Governing Council. However, by December 2020, this amount was adjusted to a total of 1.85 billion euros (ECB, 2021).

Both the APP and PEPP consisted of the Asset-Backed Securities Purchase Programme (ABSPP), the Corporate Sector Purchase Programme (CSPP), the Third Covered Bond Purchase Programme (CBPP3), and the Public Sector Purchase Programme (PSPP) (ECB, n.d.). The goals and details of these programs will be discussed in more detail below.

First of all, the ABSPP consisted of purchases of asset-backed securities (ABS), which is a specific type of bond that is backed by a financial asset. It generates cash flow from certain types of debt, like loans, receivables, and leases. The ECB bought these types of securities from November 2014 to December 2018. In November 2019, the ECB made additional purchases, lasting until June 2022 (ECB, n.d.). Secondly, the CBPP3 contained so-called covered bonds: these are bonds supported by a group of securities which are rated with the highest level of creditworthiness (Packer et al., 2007). Covered bonds thus offer more protection to investors compared to corporate bonds, as only the best securities are included. The timeframe during which CBPP3 was implemented, was similar to the one of the ABSPP. Thirdly, the PSPP consisted mostly – around 90% - of government bonds and bonds issued by recognized agencies. The PSPP was implemented first in March 2015, and lasted until June 2022, with a short break between January and October 2019. Lastly, the CSPP only consisted of purchases of corporate bonds, and was first implemented in June 2016. The CSPP lasted for 6 years, with again a short break in the period from January 2019 to October 2019. (ECB, n.d).

2.2.3 Transmission Channels of QE

According to the ECB, there are three main channels through which the APP operates: *the Signalling Channel, the Portfolio Rebalancing Channel*, and *the Direct Pass-Through Effect* (ECB, 2016). These will be discussed in the following paragraphs.

2.2.3.1 The Signalling Channel

As discussed in Section 1, the ECB launched its own QE programs – APP and PEPP -, as part of the ECB's "unconventional" toolbox. The total amount and timing of these asset purchases are pre-determined, and by buying these assets, the ECB "signals" to economic agents its aspiration to preserve low interest rates for a certain duration. This commitment leads to increased certainty about the future course of interest rates (ECB, 2016). This "signalling" works as long as the commitment is credible (Eggertson & Woodford, 2003). As a result of this increased certainty, banks expect interest rates to be lowered for a longer period of time, resulting in reduced rates on longer-maturity loans. This channel is known as *the Signalling Channel*. (ECB, 2016).

2.2.3.2 The Portfolio Rebalancing Channel

With APP and PEPP, both private- and public investors sell their assets to the ECB, and the prices of these assets – the assets that are targeted by the APP and PEPP – will most likely increase as a result of this increase in demand, eventually leading to a lower yield on those assets. As a result, investors will have an incentive to invest in other - more risky - assets in their search for yield. It is less likely that investors would keep the funds obtained from the ECB as money or cash, since they do not consider money as a perfect substitute for government bonds. So, as these sellers will invest in other assets, this will eventually lead to higher prices and decreased yields for those particular assets, even though they have not been directly targeted by the ECB's asset purchase programs. This mechanism is called *the Portfolio Rebalancing Channel*. (Benford et al., 2009; Joyce et al., 2010).

The Portfolio Rebalancing Channel has several effects on borrowing costs. First of all, banks lend more to households and firms, and more lending leads to reduced costs of borrowing. Secondly, the rate on the capital market – the market for long-term money demand – decreases, resulting in more financing for firms. Besides the effect on borrowing costs, these asset purchase programs could also lead to a devaluation of the exchange rate. This could occur in case investors purchase assets outside of the Eurozone, thereby utilizing their extra funds. (ECB, 2016).

2.2.3.3 The Direct Pass-Through Effect

Besides public assets, the ECB can purchase private assets that are connected to loans which are issued by banks, like mortgage-backed securities and covered bonds. As demand for those securities increases, the prices of those assets increase as well, encouraging banks to create more of these assets by lending more to households and consumers. As banks lend out more money, borrowing costs for households and firms tend to decrease, resulting in improved financing conditions. (ECB, 2016).

According to the ECB (2016), both *the Direct Pass-Through Effect* and *the Portfolio Rebalancing Channel* reduce borrowing costs for firms and households, resulting in improved circumstances for financing. This will eventually increase consumer spending and investments, leading to a boost in aggregate demand.

2.3 QE & Asset Prices

Now that QE has been discussed in more detail, this section will start evaluating the impact of QE on asset prices. As assets are a component of wealth, it will be helpful to gather relevant literature on this topic.

2.3.1 Theory

According to Joyce et al. (2010), there are a few mechanisms through which QE can affect asset prices. First of all, QE can affect asset prices through *the Portfolio Rebalancing Channel*, as discussed in Section 2.2.3.2. Because of the decreased yield on government bonds, investors who sell to the central bank will use these funds to invest in other, more risky assets, thereby putting upward pressure on the prices of those assets. Secondly, QE may signal information on the current and future economic outlook, which could result in changes in the *expectation* of future cash flows. Lastly, a decrease in the long-term yield could also change the *discounted value* of future cash flows. All of these mechanisms could lead to changing asset prices, and will now be discussed in greater detail below.

2.3.1.1 Housing Prices

QE could influence housing prices through several channels. First of all, *the Direct Pass-Through Effect,* discussed in Section 2.2.3.3, could play a role. In large-scale asset purchase programs, central banks could target private assets that are backed by some form of debt, usually being issued by banks. An example of such types of assets are mortgage-backed securities. When central banks buy these types of assets in large quantities, the price of those assets increases, resulting in lower yields. As yields decline, borrowing costs for households and firms decline too, potentially leading to more demand for housing. This could put upward pressure on housing prices.

Secondly, QE could potentially affect housing prices through *the Portfolio Rebalancing Channel*. In their search for yield, investors turn away from government bonds towards assets with higher returns, like real estate. As a result, this increased demand for real estate investments could lead to rising housing prices.

Lastly, by committing to keeping interest rates low for a certain period, central banks intend to lower uncertainty about the future economic outlook. As a result of this increased certainty, banks will keep interest rates lower on long-term loans, including mortgages. This could lead to increased demand for housing, putting upward pressure on prices. In this way, QE affects property prices through *the Signalling Channel,* as discussed in section 2.2.3.1.

2.3.1.2 Stock Prices

The effect of QE on stock prices also works through several mechanisms. First of all, the long-term yield on government bonds decreases, which should increase the discounted value of future business profits, as the latter is dependent on the former. As share prices represent the discounted cash flows of future profits, it can be concluded that the former will rise in response to an increase in the latter. Secondly, if investors reinvest the funds - from selling to the central bank - into more risky assets, the equity risk premium will drop, leading to a surge in equity prices (Joyce et al., 2010). In this case, QE works through *the Portfolio Rebalancing Channel*.

Thirdly, if central banks make a credible promise to preserve low policy rates for a certain period, this could lead to more certainty concerning the projected course of interest rates and the prospective economic outlook. This improved sentiment about the future could also result in increased equity prices. However, expectations could also lead to the opposite outcome. To elaborate on this, Joyce et al. (2010) state that the equity risk premium and expected future cash flows could drop significantly, in case the economic outlook is less fortunate than predicted. This will result initially in declining stock prices. *The Signalling Channel* – or "*the Macro/News Policy Channel*" (Joyce et al., 2010, p.117) – encompasses both of these outcomes, thus as well the positive as negative ones

To conclude, even though the theory claims that the effect of QE on stock prices could be ambiguous in the short run, it is predicted that a well-developed asset purchase program will eventually result in stock price increases (Joyce et al., 2010).

2.3.1.3 Corporate Bonds

Now, what effect would QE have on the prices and yields of corporate bonds? First, the most obvious reason will be discussed: central banks target corporate bonds within their QE programs, and consequently, demand for corporate bonds will rise, and thereby the price. However, there are also other mechanisms through which QE affects the valuation of corporate bonds. These will be discussed in more detail below.

Firstly, as corporate bonds are riskier than government bonds, there will be a difference in yields, the so-called risk premium. If the yield on long-term government bonds declines due to QE, this will automatically result in a decline in the yield on corporate bonds, as the variance in yield between corporate bonds and government bonds – the risk premium - has to remain stable. As yields and prices are inversely related, the price of corporate bonds will thus increase. (Joyce et al., 2010).

Secondly, *the Portfolio Rebalancing Channel* could also affect corporate bond valuations. If investors reinvest their received funds from selling government bonds into corporate bonds, this will put upward pressure on the price of corporate bonds, leading to a decline in the yield.

Lastly, QE could signal that the future economic outlook is less fortunate than predicted. This could change expectations about corporations repaying their future debts, resulting in increased corporate yields (Joyce et al., 2010). However, it could also work the opposite way. As central banks want to signal to economic agents that they intend to maintain low interest rates, this could result in more certainty about firms repaying their future debts. This will lead to declining corporate yields, and thus to an upward surge in the prices of corporate bonds. Again, both of these mechanisms are incorporated by *the Signalling Channel*.

To conclude, although the theory claims that the effect of QE on corporate bonds could be ambiguous in the short term - just as with stock prices - it is predicted that a well-developed asset purchase program will eventually result in higher prices. (Joyce et al., 2010).

2.3.2 Empirical Results

Now that most of the theory regarding QE and its effect on several asset prices has been discussed, this section will turn to the results found in empirical research.

First of all, Rahal (2016) examined the effect of QE on housing prices in Japan, Canada, Switzerland, Sweden, Norway, the United Kingdom (UK), the Euro Area, and the United States (US). By exploiting a Panel VAR framework, this paper concluded that for all countries, housing prices increased in reaction to a positive QE shock. Besides, the Impulse Response Functions (IRFs) show great similarity – except for the Euro Area - and reach a peak between 1 and 3 years. To be more specific, in the Euro Area and Japan, housing prices are the least responsive to QE. By contrast, the UK and the US show the biggest increase in housing prices.

Another paper by Lenza & Slacalek (2018) researched the impact of large-scale purchases of assets on housing- and share prices in France, Spain, Italy, and Germany, using a Bayesian VAR model. For all those countries combined, QE caused stock prices to increase by around 4%. Additionally, in Germany, housing prices increased only by 0.7% in response to a QE shock, although, this effect was much higher in Spain, France, and Italy. One explanation for this difference could be that housing prices in countries with higher adjustability in mortgage markets and with a changeable mortgage rate composition are more sensitive to a QE shock, like Spain (Calza et al., 2013; Lenza & Slacalek, 2018). Similar results for Spain and Germany are found by Nocera & Roma (2018). They evaluated the effect of contractionary monetary policy on real estate valuations in Belgium, Germany, Spain, Ireland, France, Italy, and our country of interest, the Netherlands, by exploiting a structural VAR model framework. The authors conclude that a the short-term policy rate increase of 0.25 percentage points causes housing prices to drop by around 1.5% in Belgium, Ireland, France, Italy, and the Netherlands. In Germany, this drop is smaller – around 0.4% - compared to the largest drop in Spain, of around 3%.

The number of papers on the impact of QE on housing prices is thus rather scarce. However, when evaluating the effects of QE on other asset prices, more research is available. Joyce et al. (2010) researched the effect of QE1 implemented by the Bank of England on asset prices by using an event study methodology, thereby distinguishing between changes around the announcement dates and changes during the actual implementation of QE. The authors concluded that the long-term gilt[1] yield dropped by around 100 basis points due to the announcement made by the Bank of England. Furthermore, corporate bond yields also declined sharply and stock prices, however, did not change much due to the announcements made. By contrast, equity prices increased significantly during the implementation period of QE - throughout 2009 – and during the same period, the gilt yield increased by around 30 basis points. In addition, corporate bond yields declined even more. Thus, for corporate bonds and equities, the effect of QE is more prominent during the actual implementation, in contrast to gilts. This could be explained by the fact that it takes time for investors to rebalance their portfolios (*Portfolio Rebalancing Channel*).

Christensen & Rudebusch (2012) also examined the effect of asset purchases by the Bank of England, namely QE1 & QE2. Using an event-study methodology, they found a decrease of around 45 basis points in the long-term gilt yield – with 5 to 10 years of maturity - on the announcement dates. Just like in the paper by Joyce et al. (2010), the authors found that QE mainly operated through the *Portfolio Rebalancing Channel*.

Andrade et al. (2016) evaluated the effect of QE in the Eurozone on several asset prices, like equities and bonds. They found results of similar magnitude for the effect of QE on 10-year maturity bonds as Christensen & Rudebusch (2012); The APP of the ECB caused the 10-year sovereign yield to be reduced by a total of 45 basis points. When evaluating the macroeconomic effects of the APP, the authors find that corporate bond yields declined by around 20 basis points. Besides, the overall stock index in the Eurozone - the EURO STOXX - increased by 3.2% on the announcement date of the APP, and the STOXX Europe 600 by 3.4%. These results are similar to the 4% rise in equity prices found by Lenza & Slacalek (2018).

Next, Altavilla et al. (2015) estimate the impact of QE on valuations of assets for Spain, France, Italy, Germany, and the Eurozone. By exploiting an event study methodology, in which they control for macroeconomic news, they find that 10-year sovereign yields in the Eurozone declined by 30 to 50 basis points, depending on the specific time window[2] used. These findings again correspond with both

[1] UK government bonds

[2] Altavilla et al. (2015) use a 1-day and a 2-day time window around the announcement days of QE.

Andrade et al. (2016) and Christensen & Rudebusch (2012). For Spain and France, the one-day drops were estimated to be 80 and 30 basis points, respectively, and for Germany and Italy, 17 and 75 basis points. Using a 2-day time window, they remained largely unchanged. On top of this, the authors find that corporate bond yield spreads – evaluated at a 1-day timeframe - decline by around 20 basis points in response to QE, for financial- as well as non-financial corporations. However, when evaluating the effect at a 2-day time window, the result seems more prominent for financial corporations, as the yield spread drops by another 10 basis points compared to the 1-day time window. The magnitude of the decrease is similar to the result found by Andrade et al. (2016). Lastly, equity prices also increased in response to QE (Lenza & Slacalek, 2018; Joyce et al., 2010). The EURO STOXX increased by 1% to 2% depending on the specific time window used. The positive response is in line with the result found by Lenza & Slacalek (2018) and the response of the EURO STOXX found by Andrade et al. (2016), although this finding is smaller in magnitude.

In addition, Rogers et al. (2014) found that during the GFC, equity prices increased by around 0.92 to 1.55 percentage points – again depending on the specific time window - in response to the ECB's announcements concerning unconventional monetary policy. This finding conforms to the 1 to 2% increase found by Altavilla et al. (2015). By contrast, the authors found that corporate bond yields *increased* significantly in the Eurozone, just as the German 10-year government bond yield. One explanation provided by the author is that financial conditions improved in the Eurozone, as fewer people invest in safe-haven funds and there is more trust regarding the financial stability of the Monetary Union.

To conclude, most of previously discussed the literature finds that QE lowers (increases) long-term government bond yields (prices), corporate bond yields (prices), and has a positive effect on housing- and equity prices, as expected. In the following section, this paper will turn to the theory and empirical results concerning the effect of QE on wealth inequality.

2.4 QE & Wealth Inequality

Now that the effect of QE on asset prices has been discussed more thoroughly, this section will shed light on the relevant literature concerning the effect of QE on wealth inequality. But first; what is wealth, and how is it defined in this paper? This will be elaborated on in the following paragraph.

2.4.1 Defining Wealth & Wealth Inequality

There are numerous definitions of wealth, however, as QE intends to affect wealth inequality through changes in asset prices, net wealth is referred to as the total amount of financial- and non-financial assets, after deducting any outstanding debt. Examples of financial assets are equities, bonds, deposits, asset-backed securities, and covered bonds. Non-financial assets include both real estate and land. To measure wealth inequality, first, the population within a specific country is ranked based on net wealth. Thereafter, the population is partitioned into equal segments, quintiles or deciles, representing respectively 20% and 10% of the total population. The lowest decile or quintile represents the poorest of the population, while the upper subsets represent the richest. (ESCB, n.d.). In this way, differences in net wealth among different subsets can be compared.

Moreover, key groups are the most widely used inequality measures, according to the World Inequality Database, like P90/P50, P90/P10, or P99/P10. These inequality measures compare net wealth of respectively the top 10% compared to the bottom 50%, the top 10% relative to the bottom 10%, and the top 1% relative to the bottom 10%. These key measures can be expressed in averages, shares, or thresholds. Averages refer to the average wealth of each person in the relevant subset, and shares refer to the amount of wealth of the group relative to the amount of wealth of the total population. Thresholds refer to the minimum level of wealth that is necessary to be in a certain subset. (WID, n.d.).

Lastly, the Gini Index of wealth can also be used as an inequality measure. This index measures the actual level of dispersion within a country, relative to no dispersion at all. If the coefficient is equal to 1, this represents maximum wealth dispersion, as only one person holds all the wealth, while 0 indicates no wealth dispersion at all. In the latter case, every person has an equal amount of wealth. (ESCB, n.d.). According to the De Luigi et al. (2023), the Gini Index lays more emphasis on changes in the centre of the distribution. So, what happens around the tails is more easily captured by, for example, the P99/P10, or the P90/P10 (De Luigi et al., 2023).

2.4.2 Empirical Results

Now that the definition of wealth (inequality) is known to the reader, this paper turns to the empirical results concerning the effect of QE on wealth dispersion. To start off, Lenza & Slacalek (2018) researched the impact of a the ECB's APP on housing- and stock prices in several European countries, to eventually assess the effect of QE on wealth inequality. As discussed in Section 2.3.2, by conducting a Bayesian VAR, the authors found that stock- and housing prices have increased significantly in all of the countries. This is relevant, as the response of net wealth to QE is a combined response of asset prices and the distribution of wealth among the different wealth quintiles. The authors find that in Spain, Italy, and France – except for Germany - wealth increases by 1.5% in the top 80% of the wealth distribution. There is little proof indicating that the results are more prominent for the top 20%, although, this assumption does not have to hold for the top 10%, as this decile holds relatively more equity. In addition, the authors identified QE shocks by employing the algorithm designed by Arias et al. (2018), and assessed the effect of QE on wealth inequality by using the Gini Coefficient. However, the reduction found was of unimportant magnitude. Lenza & Slacalek (2018) note how crucial it is to include housing wealth in the assessment, as many households across the whole distribution own some form of real estate - like their residence - while more risky financial assets - like shares or equities – are held mostly by the top deciles. All in all, the authors find negligible effects of QE on wealth inequality in all countries.

Furthermore, Domanski et al. (2016) examine the impact of monetary policies on the dispersion of wealth in six advanced economies, namely Germany, France, Spain, Italy, the US, and the UK. According to the results of the microsimulation, wealth dispersion has increased since the banking crisis of 2007. Additionally, they find that unconventional instruments have affected wealth inequality to a larger extent than traditional monetary instruments, as the former aim to directly affect asset prices and portfolio composition. In the simulation results, it becomes clear that not bond prices, but housing- and stock prices are the driving forces behind respectively decreasing and increasing wealth dispersion. To elaborate on this, there is little difference in the holdings of bonds across the distribution, in contrast to the holdings of real estate and stocks: lower deciles hold relatively more real estate, and the top decile owns more equity. Rising equity prices have only been counterbalanced to a certain degree by rising real estate prices, and as a consequence, wealth inequality has increased. This finding is not in line with the results found by Lenza & Slacalek (2018), even though both papers conclude that *the Portfolio Rebalancing Channel* is the main mechanism behind the results.

O'Farrell et al. (2016) provide similar reasoning as Domanski et al. (2016), as they note that increasing housing prices reduce inequality, while rising equity- and bond prices result in the opposite effect. As a result, if both asset classes increase, it is not very likely that rising asset prices lead to significant changes in wealth inequality. To assess this, they evaluated the effect of declining asset prices during the GFC – and reviving asset prices in the period after, due to QE – and come to the following estimations. Due to declining real estate- and stock prices in the period 2007-2010, the authors expect a rise in wealth inequality in the Netherlands and the US, and a drop in France, Italy, and the UK. In the Netherlands and the US, wealth inequality is expected to have risen as the lowest deciles are relatively high-leveraged compared to the richest. Additionally, in Belgium, Canada, and France, bond- and real estate prices have increased, and even though stock prices have declined, this has resulted in a higher level of total assets. Therefore, the authors expect a drop in net wealth dispersion in Belgium and Canada. However, in Germany, the opposite result is anticipated, as housing wealth is more skewed towards richer deciles. After the GFC, the effects are anticipated to be reversed for all countries; however, in the Netherlands – considering the continuous increase in total assets - wealth inequality is expected to have risen further. In the UK and Canada, households in the middle deciles benefit the most from rising asset prices, resulting in a continued decrease in wealth dispersion. Thus, when evaluating the total effect between 2007 and 2012, net wealth dispersion is expected to have risen in the Netherlands and the US and to have fallen in Canada, Belgium, the UK, and Germany.

In Italy and France, wealth dispersion is expected to have remained the same. The authors conclude that the question of whether wealth inequality increases within a specific country is rather difficult to determine beforehand, as this depends on country differences in portfolio composition, distribution of assets, and comparative price deviations. Moreover, to answer this inquiry, empirical research is needed.

In another study, Adam & Tzamourani (2016) evaluate the effect of increasing asset prices on distributional wealth in the Euro Area. This paper is relevant for this research, as QE rather than conventional monetary policy targets asset prices directly (Domanski et al., 2016). This has also been discussed thoroughly in Section 2.3.2. Adam & Tzamourani (2016) find that only the richest top 5% benefits from bond- and stock price increases. To elaborate on this, an increase of 10% in stock- and bond valuations, results in a 3-4% (net) wealth increase for the top 5%. By contrast, for housing prices, the results are more widespread: the median household experiences an 8% increase in net wealth, while this is more than 10% for the top 5% and 10%. Compared to the Eurozone as a whole, the bottom 20% benefits relatively more[3] from increases in real estate prices in the Netherlands, Finland, Portugal, and Spain, as households in these countries more frequently possess a residence (in contrast to countries like Malta, Austria, Germany, France, and Italy). Furthermore, the authors find that equity price appreciation results in an increase in the Gini Index of net wealth, while housing price increases result in the opposite effect, especially in countries where poorer households benefit more from housing price increases, like the Netherlands, Spain, Finland, and Portugal. Bond price appreciations are found to have a negligible effect on the Gini coefficient. These findings are largely corresponding to Domanski et al. (2016) and O'Farrell et al. (2016). However, to determine whether wealth inequality increases, it is crucial to know the composition of net wealth across the distribution, as this is heterogeneous for each country. For the Netherlands, the decrease in the Gini Index due to rising real estate prices – and due to the high home ownership rate in the poorer part of the wealth distribution - more than offsets the increase in the Gini Index due to equity price rises, thus overall leading to reduction in the Gini Index.

In addition, Casiraghi et al. (2018) examine the impact of non-standard monetary stimulus on wealth disparity in Italy, over the period 2011-2013. They do find that the richest benefit more than the median household due to increasing capital gains, however, households at the bottom also have the opportunity to benefit more because of increased leverage. The authors find that unconventional monetary policy tools benefit the less wealthy for a short amount of time, but still, the effect on the Gini coefficient remains economically and statistically insignificant. This is in line with the result found

[3] Compared to the remaining part of the wealth distribution within each specific country.

by Lenza & Slacelek (2018), and with the prediction of O'Farrell et al. (2016) concerning Italy. To conclude, the authors find a negligible impact on wealth disparity.

Bunn et al. (2018) also estimate the effect of (un)conventional monetary instruments on income- and wealth dispersion in the UK, by exploiting a large-scale econometric model. They find negligible effects on the Gini Index of wealth, just as some of the previously mentioned studies (Casiraghi et al., 2018; Lenza & Slacalek., 2018). Increases in financial wealth – due to expansionary monetary stimulus - are expected to increase the Gini coefficient, as richer households own relatively more financial assets. On the contrary, rising housing wealth leads the Gini coefficient in the opposite direction, as middle and lower deciles hold relatively more real estate (O'Farrell et al., 2016; Adam & Tzamourani, 2016; Domanski et al., 2016). However, when combining both results, monetary policy again has negligible effects on wealth dispersion.

Lastly, De Luigi et al. (2023) estimate the effect of QE on wealth dispersion in France, Belgium, Portugal, Italy, Austria, Finland, Germany, Spain, and the Netherlands, thereby distinguishing between housing wealth and risky financial assets[4] and using a local projections framework. The authors find again that increasing housing prices lead to an overall decrease in wealth inequality, while the reverse holds true for rising share or equity prices (Bunn et al., 2018; Domanski et al., 2016; Adam & Tzamourani, 2016; O'Farrell et al., 2016). They find for the Netherlands that the P90/P50 ratio – so the ratio of (net) wealth of the richest decile relative to the bottom 50% – slightly increases (even though this effect is negligible) while the Gini index of wealth depicts a decrease. The latter result holds true for most of the countries examined, especially since the Gini puts more focus on the centre of distribution. Most of the other measures – the ones that focus more on the outer ends of the wealth distribution – indicate an increase in wealth dispersion, which is the result of rising financial asset prices.

To conclude, the findings concerning the effect of QE on wealth inequality are rather ambiguous. Equity price rises lead to increased wealth inequality, while the opposite is true for rising housing prices (O'Farrell et al., 2016; Bunn et al., 2018; Adam & Tzamourani, 2016; Domanski et al., 2016; De Luigi et al., 2023). Some studies find a negligible effect of asset purchases on wealth dispersion (Lenza & Slacalek., 2018; Bunn et al., 2018; Casiraghi et al., 2018), while others expect changes (O'Farrell et al., 2016; Domanski et al., 2016). However, the results depend heavily on the distribution of assets, as this is specific to each country. For the Netherlands, O'Farrell et al. (2016) expected wealth inequality to

[4] We will follow the paper by De Luigi et al. (2023) in making a distinction between the effects of QE on housing wealth and financial wealth, but the results will only be estimated for the top 10% and bottom 50% of the Dutch wealth distribution. Besides, the methodology used in this thesis will be different, and we will focus specifically on the Netherlands. The details will be discussed more thoroughly in the following sections of this thesis.

increase as a result of QE in the period 2007 – 2012, while Adam & Tzamourani (2016) found that rising asset prices resulted in a decline in the Dutch Gini Index of wealth, as a consequence of higher home ownership rates in the poorer segment. De Luigi et al. (2023) also found a decrease in the Gini index for the Netherlands. By contrast, the response of the P90/P50 was found to be positive, but rather small. Thus, as the results are rather indefinite, specific data on the composition of household net wealth is needed, along with empirical research, in order to determine whether wealth inequality has increased, decreased, or has remained the same in the Netherlands. Data on wealth specific to the Netherlands will be delved into further in Section 4.

3. Hypotheses

In this section, several hypotheses will be formulated, based on the main research question of this paper:

What effects does QE - executed by De Nederlandsche Bank (DNB) - have on wealth inequality in the Netherlands, and can this effect be explained by distributional differences in housing wealth and financial assets?

As mentioned in section 2.4.2, rising real estate prices are expected to decrease wealth dispersion, while rising equity – or financial asset – prices are expected to achieve the opposite result, as richer deciles hold relatively more of their wealth in risky assets, while middle deciles hold more of their wealth in real estate (O'Farrell et al., 2016; Bunn et al., 2018; Adam & Tzamourani, 2016; Domanski et al., 2016; De Luigi et al., 2023). Following the results of these papers, this thesis formulates the following two hypotheses for the effect of QE on the Dutch wealth distribution:

$H0$*:* QE has a more positive impact on (net) housing wealth for the lower 50% of the Dutch wealth distribution relative to the richest 10%, thus exercising an *equalizing* effect.

$H1$: QE has a more positive impact on (risky) financial wealth for the richest 10% of the Dutch wealth distribution relative to the lower 50%, thus exercising a *disequalizing* effect.

However, the total effect of QE on wealth inequality in the Netherlands depends on distribution of assets – along with other factors – as this is specific to each country. As mentioned in the previous section, O'Farrell et al. (2016) expect wealth dispersion to have risen in the Netherlands in the period during and right after the GFC. Additionally, De Luigi et al. (2023) found a positive, yet small increase in the P90/P50 ratio in the Netherlands. By contrast, Adam & Tzamourani (2016) estimated a decrease in the Dutch Gini index of wealth, similar to De Luigi et al. (2023). Thus, considering the rather scarce amount of literature on QE's impact on wealth disparity in the Netherlands, the following two hypotheses are developed, depending on the specific inequality measure used:

$H2$: QE is expected to decrease the Gini Index of wealth in the Netherlands, thus exercising an *equalizing* effect.

$H3$: QE is expected to increase the P90/P50 ratio in the Netherlands, thus exercising a dis*equalizing* effect.

4. Data

In this section, the relevant variables and its sources will be presented. First, some background information is provided on the databases and thereafter, the variables will be discussed thoroughly.

4.1 Databases

All of the outcome variables originate from the Distributional Wealth Accounts (DWA) database, created by the European System of Central Banks (ESCB). They gather data on Quarterly Sector Accounts (QSA) for the whole Euro Area and individual countries. Financial and non-financial transactions and positions are included and obtained from country-specific statistical organizations and Eurostat. Secondly, the ESCB also gave rise to the Household Finance and Consumption Survey (HFCS). This study is executed in 2010, 2013, 2017 and 2021, and contains information on how wealth is distributed among households in all European countries. Both the QSA and the HFCS are combined into the DWA, to assess whether distributional household wealth is in tune with macroeconomic aggregates. (ESCB, n.d.). Data on total (net) wealth and its components - like (net) housing wealth and wealth in the form of financial assets - held by the richest decile and the lower 50% of the Dutch wealth distribution, are extracted from the DWA.

Another database that will be used, is the Federal Reserve Economic Data (FRED), established in 1991. This database is assembled by the Federal Reserve Bank of St. Louis and contains 823,000 international and US variables in time series form, like gross domestic product, monetary aggregates, employment, etc. (FRED®, Federal Reserve Bank of St. Louis, n.d.). Data on the Dutch Consumer Price Index (CPI), Industrial Production Index (IPI), and long-term government bond yield are obtained from this database.

The last variables that are used in this thesis, are extracted from the database of De Nederlandsche Bank (DNB), which contains data on the financial sector and the balance of payments in the Netherlands (DNB, n.d.). In specific, the asset side of the balance sheet of DNB will be obtained from this database.

4.2 Variables

In this section, a detailed description of all the variables employed in this thesis will be given. A graph of each of them is presented in the Appendix, starting from Figure 6 up to and including Figure

13. First, the variable of interest will be elaborated on - the level of DNB assets – and thereafter, this paper will shed light on the variables related to wealth (the outcome variables). Lastly, the remaining variables that are used in each of the SVAR models will be presented.

4.2.1 The Variable of Interest

4.2.1.1 DNB Assets

First of all, the variable of interest will be discussed in more detail, namely the level of QE implemented and executed the Netherlands. To elaborate on this, as a member of the European Union, the Netherlands - and thus its national central bank (DNB) - has to follow the policies implemented by the ECB. Besides, the majority of the programs that are implemented by the ECB, are executed by DNB for the Netherlands. For these reasons, and for the fact that *the balance sheet of DNB* represents the amount of assets sold and bought by DNB, this variable will be used as a proxy for the amount of QE implemented in the Netherlands. This variable is obtained from the database of DNB, and measured on a monthly basis, from January 2015 to October 2023, in millions of euros. (De Nederlandsche Bank, n.d.). Thereafter, this variable is transformed into natural log form.

4.2.2 Outcome Variables

In this section, all of the outcome variables will be discussed. The variables are extracted from the DWA database, and are available on a quarterly basis. However, linear interpolation is used in order to transform the variables from quarterly into monthly frequencies. The only concern is that this transformation will introduce some kind of measurement error, however, measurement error in the outcome variable is not expected to introduce any bias, as long as the measurement error is unrelated to the variable of interest. This is assumed to be the case, as the results of the linear interpolation are not dependent on the level of DNB assets. Nevertheless, the results estimated with quarterly observations are included as a sensitivity analysis in Section 7.

In total, there will be four main outcome variables, namely *(net) housing wealth*, *financial wealth, the P90/P50 ratio* – which is the ratio of total (net) wealth of the richest 10% relative to the lower 50% - and *the Gini Index of wealth.* The former two outcome variables are estimated for both the richest decile and lower 50% of the wealth distribution in the Netherlands. This means that – in the main results part of this thesis - a total of *six* SVAR models will be estimated.

4.2.2.1 (Net) Housing Wealth

One of the biggest components of total (net) wealth, is *(net) housing wealth* of the top 10% and the bottom 50%. This will be the outcome variable in the first and second SVAR model, and is calculated by subtracting outstanding housing debt (mortgage debt) from the residence value. This variable is also converted to a monthly frequency, and estimated in millions of euros. Thereafter, (net) housing wealth is transformed into month-on-month percentage changes, running from April 2015 to October 2023.

4.2.2.2 Financial Wealth

Lastly, *Financial wealth* - in the form of 'risky' financial assets - of the top 10% and bottom 50% will be the main outcome variable of the third and fourth SVAR model, and consists of listed shares, unlisted shares, investment fund shares, other forms of equity, and debt securities. All of these components of financial wealth are added up for each group – so the top 10% and the bottom 50% - and then converted from a quarterly to a monthly frequency, measured in millions of euros. Thereafter, the variables are converted into month-on-month percentage changes. The first observation starts in April 2015 and ends in October 2023.

4.2.2.3 P90/P50 Ratio

The outcome variable of the fifth SVAR model that will be estimated, is the ratio of total (net) wealth of the richest decile compared to the lower 50%, or the *P90/P50 ratio* in the Netherlands. This variable is also transformed from a quarterly into a monthly frequency, and is calculated by dividing total (net) wealth of the top 10% by total (net) wealth of the bottom 50%. Total (net) wealth is measured in millions of euros, and calculated by adding financial assets and non-financial assets, and by subtracting any outstanding debt. After computing the ratio, the variable is transformed into natural log form. The first observation starts in April 2015 and ends in October 2023.

4.2.2.4 Gini Index of Wealth

Finally, the sixth SVAR model will contain the *Gini Index of wealth* as the main outcome variable. This variable is available on a quarterly frequency, and is also converted into a monthly frequency. Thereafter, the variable is transformed into natural log form. The first observation starts in April 2015, and ends in October 2023. A more detailed explanation of the Gini Index can be found in Section 2.4.1.

4.2.3 Remaining Variables

Besides the specific components of total (net) wealth, the P90/P50 ratio, the Gini Index, and the variable of interest, the variables *Industrial Production Index (IPI)*, *Consumer Price Index (CPI)* and *long-term government bond yield*[5] will be added to each of the models. All will now be discussed in more detail.

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[5] In the model for (net) housing wealth, *the long-term government bond yield* was initially replaced by *the mortgage rate,* as the latter is more determinative for the value of real estate. However, both the housing wealth model for the top 10% and the bottom 50% showed signs of autocorrelation at the chosen lag lengths. Due to the short sample size and the risk of overfitting the data, the long-term government bond yield is used instead.

4.2.3.1 Industrial Production Index (IPI)

This paper follows the literature (Lenza & Slacalek, 2018; Schenkelberg & Watzka, 2013) by adding the level of output or production within each of the SVAR models. However, as Gross Domestic Product (GDP) for the Netherlands is only available on a quarterly basis, *the Industrial Production Index (IPI)* for the Netherlands is used instead. This variable is measured as an index, with 2015 being equal to 100. This variable is then transformed into quarter-on-quarter percentage changes. Just like the other variables, the first observation starts in April 2015, and ends in October 2023.

4.2.3.2 Consumer Price Index (CPI)

Again following the relevant literature, *the Consumer Price Index (CPI)* for the Netherlands is included in each of the models, on a monthly frequency. This variable is incorporated into the models with the aim of capturing price fluctuations in the Dutch economy. The CPI is measured as an index, with 2015 being equal to 100, and runs from April 2015 to October 2023. Thereafter, also this variable is transformed into quarter-on-quarter percentage changes.

4.2.3.3 Long-Term Government Bond Yield

The last variable that will be added, is *the long-term government bond yield*, or put differently, the Dutch 10-year sovereign bond yield. This variable is included, as the effect of QE on asset prices runs through a flattening of the yield curve, or a lowering of the long-term sovereign yield. As the long-term government bond yield is already measured in percent, quarter-on-quarter differences are taken. The variable is available on a monthly basis, with the first observation starting in April 2015, and ending in October 2023.

5. Methodology

Now that a detailed description of the data has been provided, this paper will turn to the empirical methodology used, namely the algorithm introduced by Arias et al. (2018), containing a SVAR model with both zero- and sign restrictions. Finally, after a thorough explanation of this methodology and the presentation of the main identification scheme in Section 5.1, the main assumptions will be clarified and assessed. The results of this will be discussed in Section 5.2.

5.1 SVAR model with zero- and sign restrictions

Sims (1980) has been the first to initiate the Structural Vector Autoregressive (SVAR) model, which has become one of the most widely used methods to identify causal effects in macroeconomics ever since. In specific, macroeconomic shocks are frequently interdependent, and the SVAR model allows for the variables to be endogenous - in contrast to other econometric methods - which makes it the ideal method to test this paper’s research inquiry. Unlike the normal VAR model, the SVAR model imposes identification restrictions to lower the number of unknown parameters, and thus to recover all of the structural parameters and -shocks (Breitenlechner et al., 2019). Therefore, the SVAR model has the capacity to predict the effects between the endogenous variables in the model. The ordinary VAR model is not able to do this, and is only estimated in reduced form (with no contemporaneous relation between the model variables). Thus, the ordinary VAR model only produces a summary of the data. The first way to impose restrictions is through Cholesky decomposition, a method in which the ordering of the variables implies a series of causality, with the aim to recover the unknown structural parameters. These so-called *zero restrictions* are imposed on the variance-covariance matrix of the errors of the reduced form. To give an example of this method, consider a SVAR model with 3 variables. The variable ordered first reacts only contemporaneously to its own shock, and with a lag to the second and third variable. The variable ordered second reacts contemporaneously to its own shock and the shock of the first variable, and responds with a lag to the third variable. Lastly, the third variable reacts contemporaneously to a shock in the first and second variable, and to its own shock. Thus, the Cholesky ordering must be based on economic theory, however, which order is legitimate? As a specific ordering of the variables is hard to justify, some researchers prefer to use so-called *sign restrictions* instead. With this method, no recursive ordering is needed, and it allows the variables to react contemporaneously to all other variables in the model. Faust (1998) was the first to implement this identification scheme, and later on, Uhlig (2005) and Canova & Nicoló (2002) followed. Faust (1998) states that this method of identification looks at all the different versions of the SVAR model that match the reduced form, but only keeps the Impulse Response Functions (IRFs) that are logical according to economic theory. (Breitenlechner et al., 2019).

Later on, researchers like Mountford & Uhlig (2009) and Beaudry et al. (2011) combined both *zero*- and *sign restrictions*, to allow for a neutral response of the variable of interest (Arias et al., 2018). However, according to Arias et al. (2018), the algorithms used in the previously mentioned studies only leave the variable of interest unrestricted in theory, but in reality, more sign restrictions are produced on top of the ones imposed in the identification scheme, thus violating the assumption of neutral responses and biasing the results. “The heart of the problem is that none of the existing algorithms correctly draws from the posterior distribution of structural parameters conditional on the sign and zero restrictions” (Arias et al., 2018, p.1). Therefore, Arias et al. (2018) have created an algorithm that accounts for this issue, by drawing from the right posterior.

All in all, to analyse the effect of QE on wealth dispersion in the Netherlands, this paper employs a Structural Vector Autoregressive (SVAR) model with sign- and zero restrictions, thereby using the algorithm imposed by Arias et al. (2018). This algorithm has also been used by Lenza & Slacalek (2018), in order to identify QE shocks. The model specification and the main identification scheme will be discussed in more detail in the next paragraphs.

Stepping into the footsteps of Rubio-Ramírez et al. (2010) and Arias et al. (2018), this paper proposes the following SVAR model specification:

$$y_t{}'A_0 = \sum_{l=1}^{k} y'_{t-l}A_l + \beta + e'_t \quad \text{for } 1 \leq t \leq T, \tag{1}$$

y_t refers to a vector of internal variables estimated within each of the SVAR models[6], A_l is a parameter matrix for $0 \leq l \leq k$, e_t is a Gaussian vector of external structural disturbances, and β is a constant. Finally, the matrix A_0 has an inverse, the lag length is referred to as k, and T is the size of the sample.

Table 1 shows the identification restrictions that will be employed in each of the six SVAR models. To indicate a positive APP shock, a positive sign restriction is assigned to the variable of interest, namely DNB assets. Besides, following the relevant literature (Schenkelberg & Watzka, 2013) it is assumed that the IPI and CPI will react to a monetary policy – or QE – shock with a delay, which means that these variables will be restricted to zero. Besides, the effectiveness of QE on the real economy is rather ambiguous, which is why there is no sign restriction assigned to the IPI. On the other hand, the CPI is also restricted to a positive response, as this corresponds with theoretical models that presume that the effective lower bound is in play, which is mostly the case in periods of large asset purchases (Schenkelberg & Watzka, 2013). Furthermore, in line with the research by Lenza & Slacalek (2018), a negative sign is imposed on the long-term government bond yield, as this is one of the main identifying assumptions in their paper. To elaborate on this, (most of) the relevant literature observes a decline in the long-term sovereign yield in response to a positive QE shock (see Section 2.3.2). Lastly, all of the variables related to wealth will be part of the outcome variables, and therefore, they will be left unrestricted, such that these variables can run its natural course.

Table 1

Identification Restrictions

Variables	**Positive APP Shock**
IPI	0
CPI	0, +
DNB Assets	+
Variables Related to Wealth	unrestricted
Long-Term Government Bond Yield	-

Notes: the variables related to wealth include (net) housing wealth of the top 10% and the bottom 50%, financial wealth of the top 10% and bottom 50%, the P90/P50 ratio, and the Gini Index of wealth.

[6] The IPI, CPI, DNB assets, the variables related to wealth, and the long-term sovereign yield are the endogenous variables in the SVAR system.

5.2 Assumptions

The stationarity of the variables is one of the most important assumptions of the VAR methodology. In case the variables are non-stationary, they have to be transformed or differenced. Therefore, an Augmented-Dickey-Fuller (ADF) test is performed; if the absolute value of the critical value is smaller than the test statistic Zt, then there exists a random walk, which means that there is no presence of a unit root and thus, that the variable is stationary. However, most of the variables used in this paper contain a unit root (in levels). Therefore, the IPI and CPI are transformed into quarter-on-quarter percentage changes, and financial wealth and (net) housing wealth into month-on-month percentage changes[7]. As the long-term government bond yield is already measured in percentage points, this variable is transformed by taking a quarter-on-quarter differences. After the transformation, the stationarity of the variables is tested again. Confirmed by the findings of the ADF-test, all of the variables are now $I(0)$ stationary.

Next, the number of lags are selected for each of the models, by using the Akaike Information Criterium (AIC). According to Lütkepohl (2005), when a suboptimal lag length is chosen, this can create several biases. For example, when selecting a lag length below the optimal one, this could create residual autocorrelation. On the other hand, choosing a lag length above the ideal one could lead to rise in the mean squared prediction of the errors. The results of the lag-order selection test for the six main SVAR models are presented in Appendix Table 1 up to and including Table 6.

To examine whether autocorrelation exists in the residuals, a third test will be performed: the Lagrange-Multiplier (LM) Test. The residuals of the SVAR model should not be correlated, as this could result in smaller standard errors, and thus in too narrow confidence bands (Petit-Bois et al., 2016). For a significance level of 10%, at the chosen lag length, the findings of the LM test indicate that there is no autocorrelation present in the errors of the estimated models. The results are presented in Appendix Table 7 up to and including Table 12.

Finally, the SVAR models need to be stable, and in order for this so-called "stability condition" to hold, the absolute value of all of the eigenvalues need to be strictly less than 1, or within the unit circle (Lütkepohl, 2005). The results are presented in Appendix Figure 14 up to and including Figure 19, and as can be noted from the relevant graphs, all of the eigenvalues reside within the unit circle. As a result, all of the estimated SVAR models satisfy the stability condition.

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[7] For some of the variables, quarter-on-quarter percentage changes are not enough to obtain stationarity, which is why month-on-month differences are taken instead. However, according to Sims et al. (1990), first differencing the data may take out important information compared to estimating a VAR model in levels, which is why the stationarity of the variables is first tested after taking quarter-on-quarter differences. In this way, as much information is kept as possible.

6. Results

In this section, the results of the zero- and sign restricted SVAR models will be presented. All of the IRFs are estimated with 68% confidence bands (corresponding to one standard deviation from the mean), as this is the default set by the algorithm of Arias et al. (2018) and often used in research papers exploiting the VAR methodology. Besides, according to Sims & Zha (1999), in specifying the shape of the likelihood, 68% error bands are usually more informative than the 90% or 95% version. On top of this, researchers that use wider confidence bands may wrongly conclude that there is no effect: for example, if the mean of the IRF remains positive over the full horizon, but the confidence bands of 95% cross the zero line, can it then be stated with certainty that there is no effect at all? For these reasons, this paper will present the results with 68% marginal error bands, thereby following the relevant literature.

First of all, the responses of (net) housing wealth for the top 10% and bottom 50% will be discussed, and thereafter, the responses of financial wealth for both groups. Lastly, this paper will present the findings concerning respectively the P90/P50 ratio and the Gini Index of wealth.

6.1 (Net) Housing Wealth

Figure 1 shows the IRF of (net) housing wealth of the top 10% of the wealth distribution in the Netherlands, in reaction to a positive APP shock. It shows that (net) housing wealth of the top 10% increases by 0.10 percentage points on impact, however, as the confidence bands drop well below zero, the initial impact remains somewhat uncertain. Around 4 months after the shock, the increase becomes significant, and is estimated around 0.12 percentage points. The IRF remains its statistical significance up to 8 months, and after 15 months, the shock returns to zero. When comparing this result to the response of (net) housing wealth of the bottom 50% in Figure 2, it can be noted that the result is more pronounced for the poorer part of the population, as the initial increase is estimated around 0.3 percentage points. The larger response of housing wealth for lower deciles of the of the wealth distribution is in line with the arguments provided in the literature. According to Adam & Tzamourani (2016), the bottom two deciles in the Netherlands profit relatively more from increasing real estate prices compared to other countries. Furthermore, Domanski et al. (2016), Adam & Tzamourani (2016) and Bunn et al. (2018) conclude that rising housing prices have an equalizing effect, as housing wealth is held relatively more by middle and lower deciles of the wealth distribution. As the IRF of the bottom 50% represents a larger response compared to the top 10%, it can be concluded that this result holds for changes in the P90/P50 due to QE in the Netherlands. However, even though the response for the bottom 50% is larger, the finding remains insignificant over the full horizon. Normally, through a Wald test for the equality of means, it can be confirmed whether the difference between means of the responses for the top 10% and bottom 50% is statistically significant. However, as this cannot be assessed with the algorithm of Arias et al. (2018), this paper will conclude through the total effect of a positive QE shock on wealth inequality – so on the P90/P50 ratio - whether dispersion between both groups has increased, decreased or has remained the same. The result of this will be presented in Section 6.3.1.

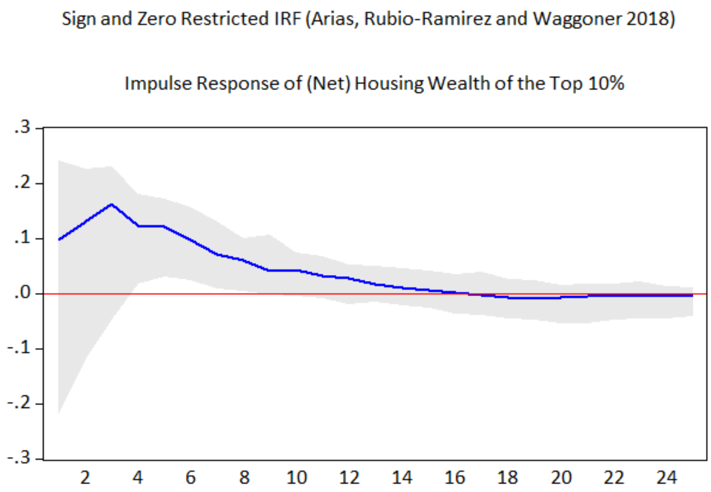


Figure 1

IRF results of the first SVAR model: (net) housing wealth of the top 10%

Notes: The IRFs of the IPI, CPI, (net) housing wealth of the top 10%, and the 10-year sovereign yield are measured in percentage points, and the level of DNB assets in percent. The results are estimated with 68% confidence bands.

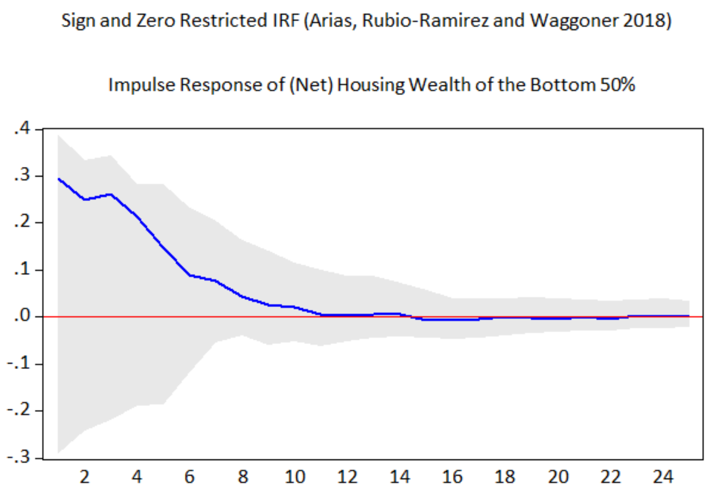


Figure 2

IRF results of the second SVAR model: (net) housing wealth of the bottom 50%

Notes: The IRFs of the IPI, CPI, (net) housing wealth of the bottom 50%, and the 10-year sovereign yield are measured in percentage points, and the level of DNB assets in percent. The results are estimated with 68% confidence bands.

Additionally, *the Forecast Error Variance Decomposition (FEVD)* - or variance decomposition of the forecast error – of the housing wealth SVAR models of respectively the top 10% and bottom 50% are presented in Table 2 and Table 3 below. The middle column indicates how important each of the variables are in explaining the variance of the forecast errors of a positive APP shock. As can be noted from Table 1 and 2, the part of the variance assignable to a positive APP shock is estimated to be around 27% for (net) housing wealth of the richest 10%, and approximately 31% for the lower 50% of the Dutch wealth allocation. Compared to the other variables, the shock has the most explanatory power with respect to the housing wealth forecast error variance. The results apply to a horizon of 24 months and 68% confidence bands.

Table 2

FEVD of the first SVAR model: (net) housing wealth of the top 10%

IPI	0.157762
CPI	0.071696
DNB Assets	0.196292
Housing Wealth Top 10%	0.27219
Long-Term Sovereign Yield	0.21429

Notes: the middle column in Table 2 shows the part of the variance attributed to a positive QE shock, explained by each of the variables in the model. These numbers are measured in percentage points, and apply to a horizon of 24 months and 68% confidence bands.

Table 3

FEVD of the second SVAR model: (net) housing wealth of the bottom 50%

IPI	0.083721
CPI	0.067009
DNB Assets	0.139744
Housing Wealth Bottom 50%	0.310673
Long-Term Sovereign Yield	0.160584

Notes: the middle column in Table 3 shows the part of the variance attributed to a positive QE shock, explained by each of the variables in the model. These numbers are measured in percentage points, and apply to a horizon of 24 months and 68% confidence bands.

6.2 Financial Wealth

Figure 3 and 4 depict the responses of risky financial wealth of the top 10% and the bottom 50%, respectively. Financial wealth for the richest decile responds with an initial increase of around 0.3 percentage points, and is statistically significant between months 3 and 7 of the horizon. Then, the shock dies out, until it almost reaches zero again after 9 months. When comparing this finding to Figure

4, one can note that the response is smaller for the poorer group of the wealth distribution. The latter experiences an initial increase of around 0.24 percentage points on impact. Thereafter, the mean decreases slowly, and reaches zero again after around one year. However, the result for the bottom 50% remains insignificant over the full horizon. The fact that the increase for the top 10% is more pronounced, is consistent with most of the previously discussed papers, which state that risky financial assets – specifically equity - are the main driver of increasing wealth inequality, as these are more prominent in the top decile of the wealth distribution compared to the middle and bottom deciles, and thus compared to the bottom 50% (Bunn et al., 2018; O'Farrell et al., 2016; Domanski et al., 2016; De Luigi et al., 2023). On top of this, Adam & Tzoamourani (2016) found that the richest would benefit most from rising stock- and bond prices. The insignificant and lower response of the bottom 50% could be prove of this result, however, whether the difference between the means of the IRFs for the richest decile and bottom 50% is statistically significant, can again only be examined formally through a standard Wald test for equality of means. Again, as the algorithm of Arias et al. (2018) does not include this option, the response of the P90/P50 ratio will be used to test whether total inequality between both groups has increased, decreased or remained the same (see Section 6.3.1).

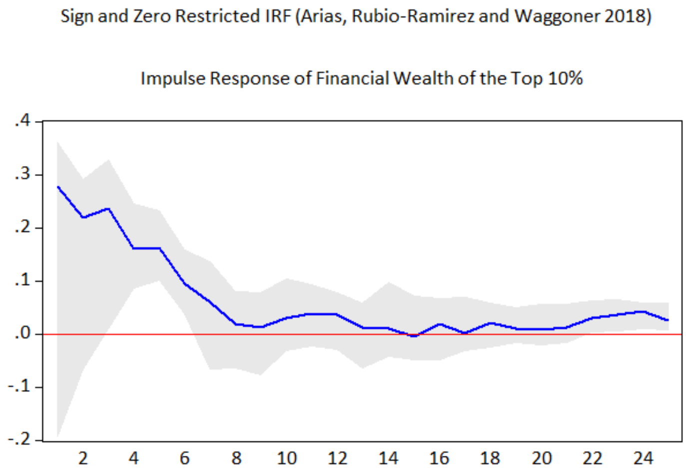


Figure 3

IRF results of the third SVAR model: financial wealth of the top 10%

Notes: The IRFs of the IPI, CPI, financial wealth of the top 10%, and the 10-year sovereign yield are measured in percentage points, and the level of DNB assets in percent. The results are estimated with 68% confidence bands.

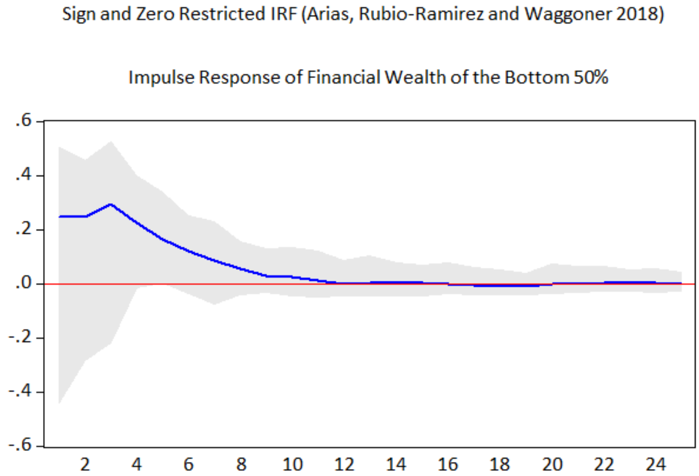


Figure 4

IRF results of the fourth SVAR model: financial wealth of the bottom 50%

Notes: The IRFs of the IPI, CPI, financial wealth of the bottom 50%, and the 10-year sovereign yield are measured in percentage points, and the level of DNB assets in percent. The results are estimated with 68% confidence bands.

Next, the variance decomposition of the forecast error of the top 10% and bottom 50% are presented below in respectively Table 4 and 5, with financial wealth as the main outcome variable in both models. Compared to the FEVD of the housing wealth SVAR models, financial wealth is even more important in explaining the variance of a positive QE shock, as this number is 37% for the top 10% and around 33% for the bottom 50%. Again, when comparing to the other variables, the shock has the most explanatory power with respect to the financial wealth forecast error variance. The results apply to a horizon of 24 months and 68% confidence bands.

Table 4

FEVD of the third SVAR model: financial wealth of the top 10%

IPI	0.115901
CPI	0.11992
DNB Assets	0.20292
Financial Wealth Top 10%	0.373514
Long-Term Sovereign Yield	0.221959

Notes: the middle column in Table 4 shows the part of the variance attributed to a positive QE shock, explained by each of the variables in the model. These numbers are measured in percentage points, and apply to a horizon of 24 months and 68% confidence bands.

Table 5

FEVD of the fourth SVAR model: financial wealth of the bottom 50%

IPI	0.087934
CPI	0.05203
DNB Assets	0.121436
Financial Wealth Bottom 50%	0.32881
Long-Term Sovereign Yield	0.153463

Notes: the middle column in Table 5 shows the part of the variance attributed to a positive QE shock, explained by each of the variables in the model. These numbers are measured in percentage points, and apply to a horizon of 24 months and 68% confidence bands.

6.3 Wealth Inequality

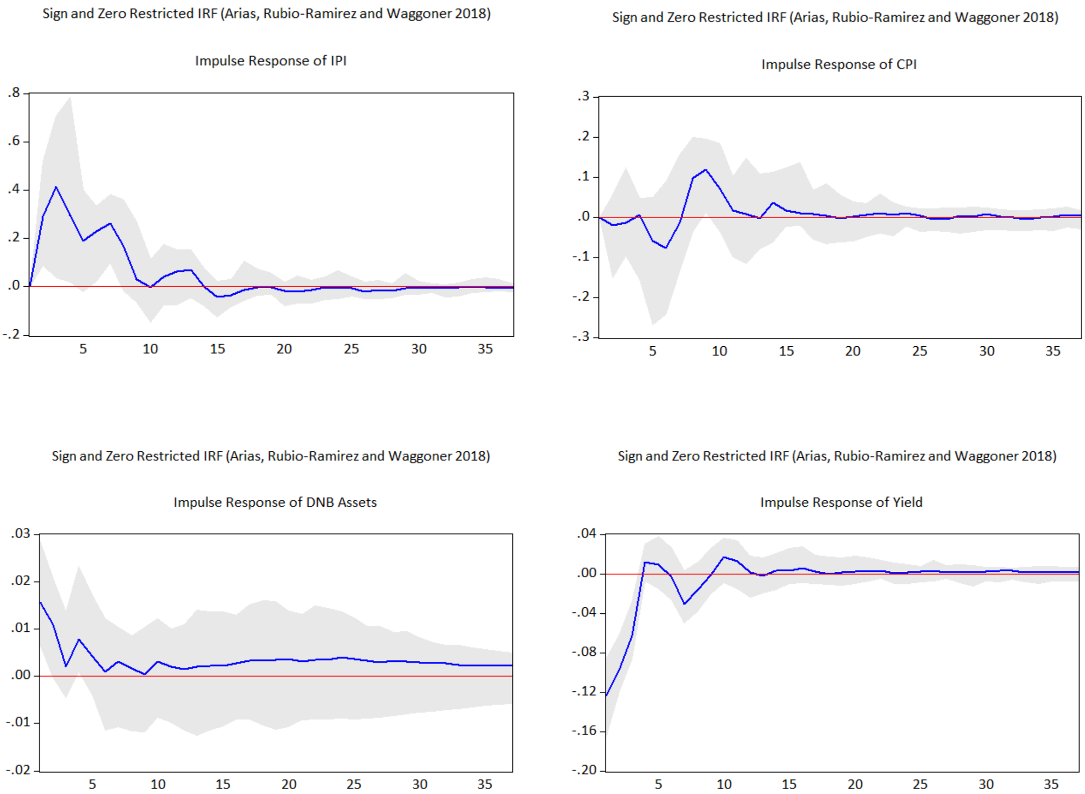
When considering the results in the previous paragraphs, it is hard to draw inference about whether wealth inequality has increased, decreased, or has not changed at all. As the algorithm of Arias et al. (2018) does not allow for the earlier mentioned Wald test, it can only be examined through the response of the P90/P50 ratio whether these results combined lead to a significant change in wealth inequality. Therefore, in this section, the effect of a positive APP shock on the P90/P50 ratio, and the Gini Index of wealth are evaluated.

6.3.1 P90/P50

The IRF results of the fifth SVAR model are presented in Figure 5 below. First of all, the responses of the other endogenous variables – so apart from the inequality measure - will be discussed in more detail. The IPI shows an increase of around 0.4 percentage points in response to a positive QE shock, and remains largely significant in the first 8 months. When evaluating the response of CPI, it can be noted that the IRF only keeps its significance for a short amount of time, with a maximum increase of around 0.12 percentage points. Finally, the long-term government bond yield initially decreases by 0.12 percentage points, and remains significant in the first 5 months after the shock. Now, when evaluating the IRF of the inequality measure in response to a positive APP shock, one can see that the mean of the P90/P50 decreases by a maximum of 0.02 percentage points, and remains negative over the full horizon. It is thus most likely that the higher increase in housing wealth for the bottom 50% relative to the top 10%[8] more than offsets the higher increase in financial wealth for the top 10% relative to the bottom 50%[9], thus overall resulting in a decrease in the P90/P50 ratio. However, the finding is only statistically significant in the first few periods. As this result is specific to the Netherlands, it is hard to compare it with studies that investigate other countries, as the findings are dependent on the

[8] As explained in Section 6.1
[9] As discussed in Section 6.2

composition of wealth within each country. To elaborate on this, the decrease in the P90/P50 ratio is not in line with the prediction made by O'Farrell et al. (2016) for the Netherlands, as the authors expected wealth inequality to increase between 2007 and 2012. However, as these authors were investigating a different period, it is not necessarily the case that the prediction of O'Farrell at al. (2016) has to hold for the period examined in this thesis. Besides, it is not very clear for which inequality measures this prediction is meant, and as the difference in impact on several inequality measures could be substantial, this could be of significant importance. Another study by De Luigi et al. (2023) found an increase in the P90/P50 ratio, and although the response was of negligible magnitude, this result is also not in line with the negative response of the P90/P50 found in this thesis. Overall, the findings of the existing literature – though scarce - concerning this specific inequality measure for the Netherlands, deviate from the finding in this research. Taking this into account, on top of the rather small period of significance, several robustness checks are performed and included in Section 7, to confirm whether the P90/P50 measure has truly decreased. Thus, for a more elaborate and detailed answer to this inquiry, this paper refers to the sensitivity analysis in Section 7 and the definite conclusion in Section 8.



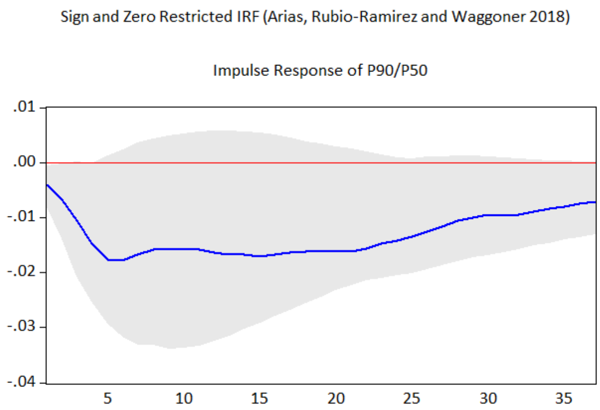


Figure 5

IRF results of the fifth SVAR model: P90/P50 ratio

Notes: The IRFs of the IPI, CPI, and the long-term government bond yield are measured in percentage points, and the IRFs of DNB assets and the P90/P50 ratio in percent. The results are estimated with 68% confidence bands.

In the last paragraph of this section, I refer to the FEVD of the relevant SVAR model, with the findings presented in Table 6. The part of the variance that can be assigned to a positive APP shock, is explained for approximately 14% by the P90/P50 ratio. In this case, this number is 34% for the long-term sovereign yield, and respectively 6%, 5%, and 8% for the IPI, CPI, and the level of DNB assets. In this case, the yield is most important in explaining the variance of the forecast errors, followed by the P90/P50, DNB assets, IPI, and the CPI. Again, the results apply to a horizon of 24 months and 68% confidence bands.

Table 6

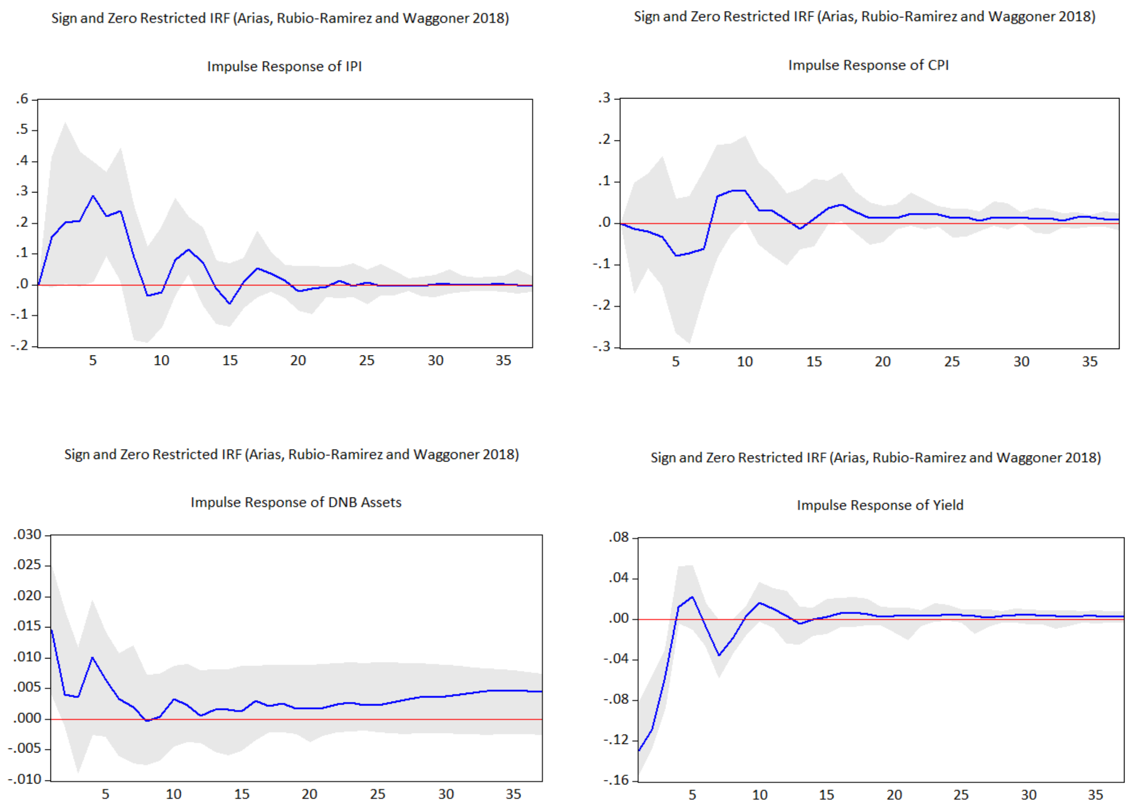
FEVD of the fifth SVAR model: P90/P50 ratio

IPI	0.06264
CPI	0.048958
DNB Assets	0.079753
P90/P50 Ratio	0.140444
Long-Term Sovereign Yield	0.344001

Notes: the middle column in Table 6 shows the part of the variance attributed to a positive QE shock, explained by each of the variables in the model. These numbers are measured in percentage points, and apply to a horizon of 24 months and 68% confidence bands.

6.3.2 Gini Index of Wealth

Next, the impact of QE on another measure of wealth disparity is evaluated, namely the Gini Index of wealth. As this inequality measure is more commonly used in the literature relative to the P90/P50, the findings in this section can be more easily compared to the results found in existing studies on this topic. The IRFs are presented below in Figure 6. First, the response of the IPI, CPI, and the 10-year sovereign yield will be elaborated on. As can be noted from the figure, the IPI responds with an increase of around 0.3 percentage points, and is significant between months 5 to 8 after the shock. The CPI initially decreases, then turns positive approximately 8 months after the shock, and is only shortly significant around 11 months. Lastly, the 10-year sovereign yield responds with an initial decrease of 0.13 percentage points, and is significant until 5 months after the shock. These findings are largely in line with the responses of the IPI, CPI and the long-term government bond yield in the model with the P90/P50 ratio as the main outcome variable. On top of this – similar to the IRF of the P90/P50 ratio - the mean of the Gini Index shows a negative response over the full horizon, and decreases by a maximum of 0.002 percentage points. The result is statistically significant between 15 to 20 months after the shock. This rather small response of the Gini Index is in line with most of the previously discussed literature (Bunn et al. 2018; Lenza & Slacalek, 2018; Casiraghi et al. 2018), as the authors obtained negligible effects of QE on the Gini coefficient. Moreover - for the Netherlands in specific - Adam & Tzamourani (2016) found a decrease of the Gini coefficient in response to increasing asset prices, which could be – as discussed before - a result of QE. On top of this, De Luigi et al. (2023) also found a negative response of the Dutch Gini Index to a positive APP shock. Thus, the findings of these studies are both in line with the decrease of the Gini coefficient found in this research.



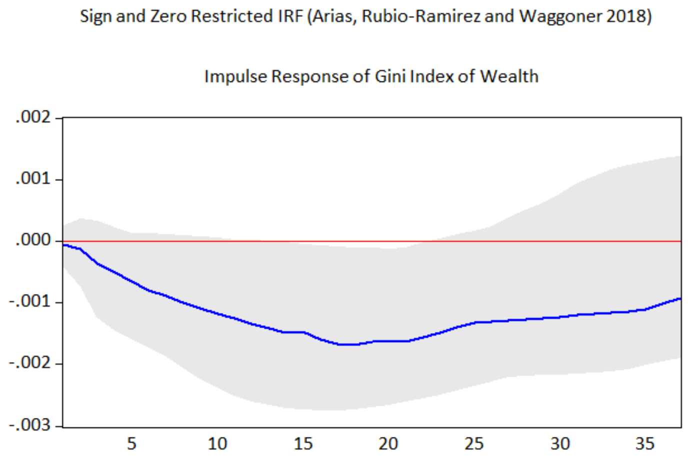


Figure 6

IRF results of the sixth SVAR model: Gini Index of wealth

Notes: The IRFs of the IPI, CPI, and the long-term government bond yield are measured in percentage points, and the IRFs of DNB assets and the Gini Index in percent. The results are estimated with 68% confidence bands.

Again - as with the other models - the specific FEVD is depicted below in Table 7. The part of the variance that can be assigned to a positive APP shock, is explained for approximately 14% by the Gini Index of wealth. This number is of comparable magnitude to the outcome of the P90/P50 in the previous section. The long-term sovereign yield is responsible for explaining 35% of the variance, and the IPI, CPI, and the level of DNB assets for respectively 7%, 6%, and 10%. Just as with the model containing the P90/P50 ratio, the yield is most important in explaining the variance of the forecast errors, followed by the Gini Index, the level of DNB assets, the IPI, and the CPI. The results apply to a horizon of 24 months and 68% confidence bands.

Table 7

FEVD of the sixth SVAR model: Gini Index of wealth

IPI	0.07139
CPI	0.061386
DNB Assets	0.09949
Gini Index	0.140866
long-term sovereign yield	0.349428

Notes: the middle column in Table 7 shows the part of the variance attributed to a positive QE shock, explained by each of the variables in the model. These numbers are measured in percentage points, and apply to a horizon of 24 months and 68% confidence bands.

All in all, it can be concluded that the means of both inequality measures – so the Gini Index of wealth and the P90/P50 ratio – respond negatively to a positive shock in the level of QE implemented in the Netherlands. However, to be more certain of the results, several robustness checks are included – as explained in Section 6.3.1 - and will be discussed in more detail in the following part of the thesis.

7. Robustness Checks

Finally, as elaborated in Section 4.2.2., all of the outcome variables – so the variables related to wealth – have been transformed from quarterly into monthly observations with the use of linear interpolation. As this might result in some form of measurement error – even though measurement error in the outcome variable is not expected to be a problem as long as it is unrelated to the variable of interest – the results of the models with quarterly data have been included as a robustness check. On top of this, as it might be difficult to isolate the APP shock in the algorithm of Arias et al. (2018), all of the SVAR models with quarterly observations are estimated with standard Cholesky decomposition, and thus without any sign restrictions. The variables ordered first and second in the Cholesky Decomposition, are the IPI and CPI, respectively, as these variables are more rigid. Thus, to give an example, the IPI responds with a lag to all the other variables – and only contemporaneously to its own shock - and the CPI responds contemporaneously to a shock in the IPI and to its own shock, and responds with a lag to the other variables. The level of DNB assets is ordered third, after the IPI and CPI. This assumption is sensible, as the central bank changes its policy in response to changes in inflation and output growth (Saiki & Frost, 2014). The variables related to wealth (so the P90/P50 ratio, Gini Index, etc.) are ordered after the level of QE, and the long-term sovereign yield is included last. To elaborate on this, financial variables (like shares and interest rates) contain market information and respond rather quickly – or contemporaneously – to changes in the other variables.

Next, the main assumptions of the VAR methodology will be tested. All of the variables are stationary after transforming them into quarter-on-quarter growth rates. Furthermore, there is no residual correlation present and the stability condition holds too in each of the models. The results of the orthogonalized IRFs are presented in Figure 7[10], with 68% confidence bands. These are the IRFs that correspond to a one standard deviation shock in the level of DNB assets. Referring to Jensen (2022) and the work of Hamilton (2020), the orthogonalized IRFs should be interpreted as a one standard deviation shock in the *root mean squared error* of the impulse variable. Thus, to obtain the number of the response variable in reaction to a *one unit* percentage change in the level of DNB assets – as this variable is in log form – the number of the response variable should be divided by the shock in the variable of interest at the same horizon. Taking this into consideration, one first thing to note from the results is that the responses of the different components of wealth are larger relative to the main part of the thesis. This could be due to the shock in the variable of interest, DNB assets, being approximately

[10] The relevant FEVDs are included in Appendix Table 13 up to and including Table 18.

2 to 3 times larger compared to the main results, depending on the model used. Furthermore, when evaluating the response of (net) housing wealth, one can observe that the response for the lower 50% is more pronounced than for the top 10%, which is similar to the findings of the relevant literature and to the results in the main part of this thesis. Additionally, the response of financial wealth for the bottom 50% remains insignificant over the full horizon, and when comparing the latter result to the response of financial wealth of the top 10%, it can be confirmed that QE is more effective in increasing equity prices (and prices of other financial variables, like debt securities and investment fund shares) for the richest. This is also largely in line with the main results and the previously discussed research.

Similar to the findings in the main results, the means of the P90/P50 ratio and the Gini Index initially depict a decrease. Additionally, the responses are to some extent comparable in magnitude with the results in the main part using the algorithm by Arias et al. (2018). This could be explained by the fact that the shock in the level of DNB assets is somewhat smaller, but not as different in size as with the models discussed in the previous paragraph. One thing that should be noted though, is that the response of the P90/P50 ratio is now more significant (compared to the main result in Figure 5). Due to this difference and to determine whether measurement error is present, another robustness check is included. To elaborate on this, the P90/P50 ratio and the Gini Index of wealth are again estimated with the quarterly data, but now with the use of the algorithm of Arias et al. (2018)[11] instead of the Cholesky decomposition method. The results are depicted in Figure 8[12]. The responses of the P90/P50 ratio and the Gini Index both show a decrease, just as in the robustness SVAR models with standard Cholesky decomposition and the main results with monthly observations. However, the responses are greater in magnitude – as the size of the APP shock is also larger – leading in this case to a more negative response. Another similarity with the SVAR model that uses Cholesky decomposition, is that the decrease in the mean of the P90/P50 ratio and the Gini Index is statistically significant. Thus, it can now be concluded with more certainty that QE has a negative effect on the disparity of wealth within the Netherlands, and that the broader confidence intervals of the P90/P50 in the main part of the thesis is most likely due to some form of measurement error.

Overall, the results in the SVAR model that uses the Cholesky decomposition method are to a large extent in line with the significance and shape of the main results from the zero-and sign restricted VAR add-in by Arias et al. (2018).

[11] The same identification scheme is used as in Table 1.
[12] Again, the relevant FEVDs are presented in the Appendix (Table 19 and 20).

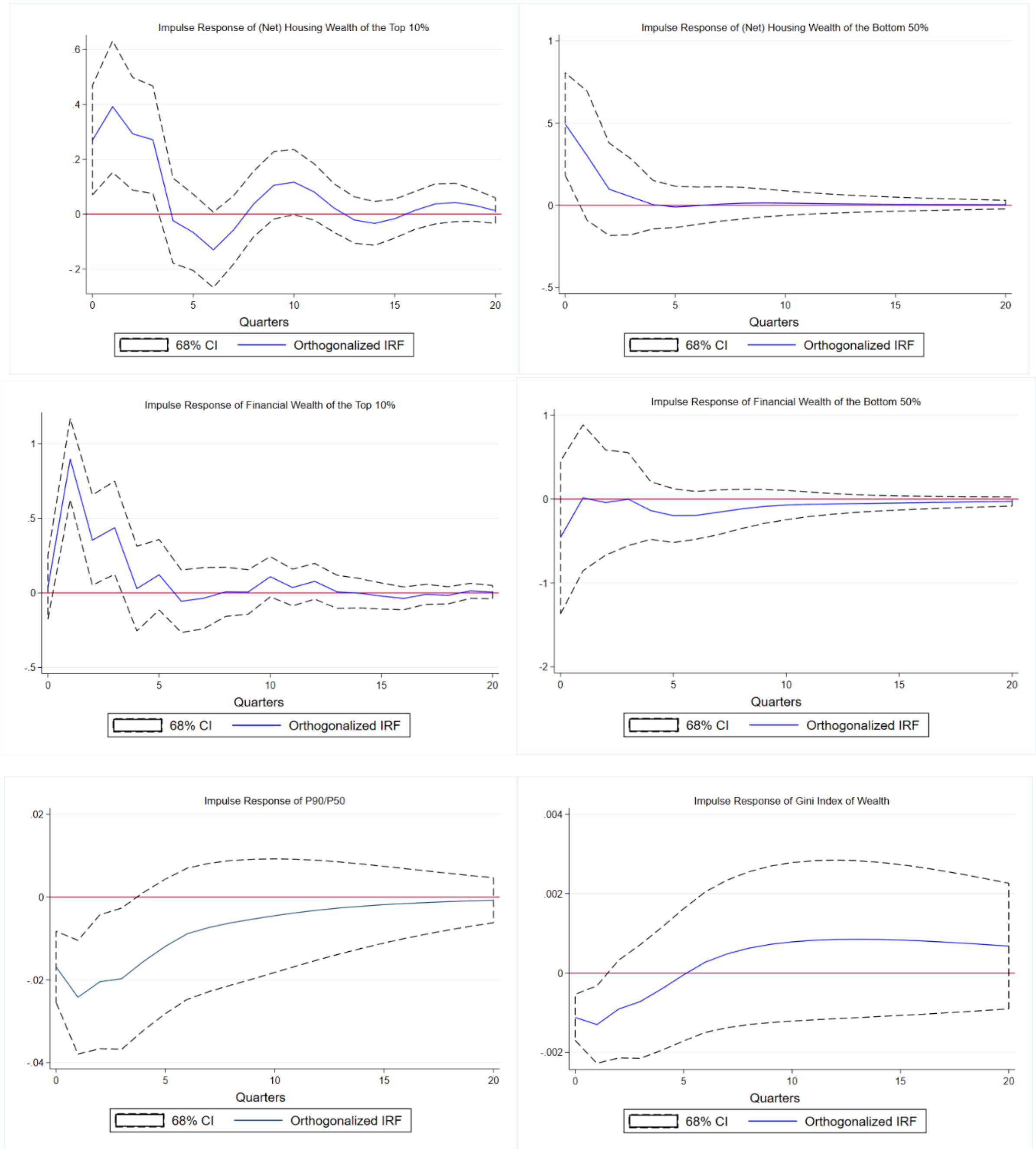


Figure 7

Orthogonalized IRFs of all six SVAR models, estimated with standard Cholesky decomposition

Notes: the models are estimated with quarterly observations, and measured with 68% level confidence bands.

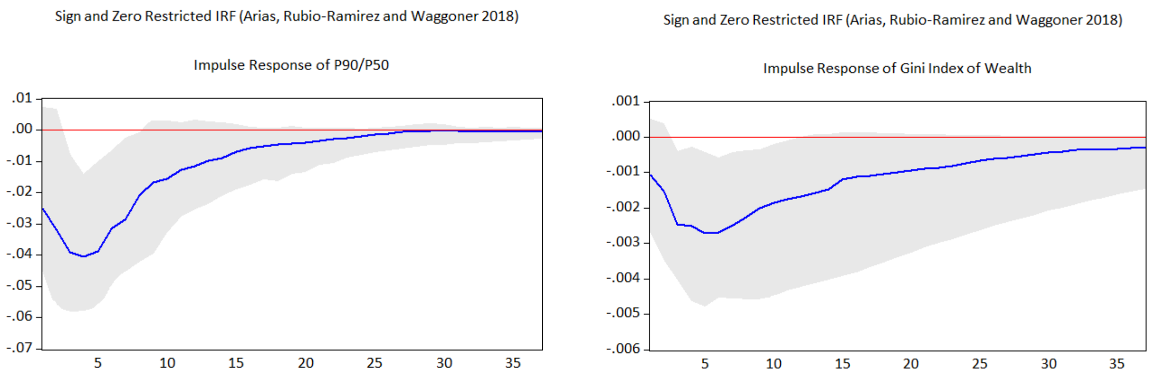


Figure 8

Results of the fifth and sixth SVAR model, estimated with zero- and sign restrictions

Notes: the models are estimated with quarterly observations, and measured with 68% level confidence bands. The zero- and sign restrictions are similar to the identification scheme in Table 1.

8. Conclusion & Discussion

Thus, does QE indeed present itself as a "reversed Robin Hood"? This study proves otherwise: when considering both the P90/P50 ratio and the Gini Index of wealth, it can be concluded that QE in the Netherlands has an equalizing effect on wealth disparity in the Netherlands, over the period 2015-2023. The decrease in the Gini Index of wealth is similar to the prediction by Adam & Tzamourani (2016) and the study by De Luigi et al. (2023), and confirms the hypothesis $H2$ in Section 3. On top of this, since the P90/P50 ratio has not been as frequently researched as the Gini coefficient, it was harder to compare the results with other findings, let alone draw conclusions about inference. For example, the decrease obtained in this paper contradicts the positive but small increase found by De Luigi et al. (2023), but also the prediction made by O'Farrell et al. (2016), even though the latter is based on a different time period and does not necessarily has to hold for this specific inequality measure. Nevertheless, the robustness checks in Section 7 confirmed the negative response of the P90/P50 ratio found in the main part of the thesis, further reinforcing the conclusion that QE has an equalizing effect on wealth dispersion in the Netherlands. The Hypothesis $H3$ is thus the only hypothesis that will be rejected, as the results prove otherwise. Zooming in on (net) housing wealth, it can be concluded that the response is larger for the lower 50% - thus exercising an *equalizing* effect - and in line with the relevant literature (Domanski et al. 2016; Adam & Tzamourani, 2016; Bunn et al. 2018). Furthermore, as prognosed by Adam & Tzamourani (2016), the effect of QE on financial wealth is more prominent for the richest decile, thus resulting in a *disequalizing* effect. So, to conclude, rising prices of financial assets (investment fund shares, equities) lead to increased wealth inequality, while the opposite is true for rising housing prices (Bunn et al., 2018; O'Farrell et al., 2016; Adam & Tzamourani, 2016; Domanski et al., 2016; De Luigi et al., 2023). These results confirm the hypotheses $H0$ and $H1$ made in Section 3.

All in all, given the limited availability of the data, this paper has attempted to answer the main research question. Concerning the Gini Index and the P90/P50, the conclusion that QE has lowered wealth inequality in the Netherlands holds. However, since the findings for each country depend largely on the distribution of assets, they are difficult to compare to studies of other countries on this topic. The contradicting outcomes in the literature – the differing results between countries - thus call for further examination, as this could be very relevant for national policy makers. Besides, as the outcomes with the quarterly data contain few observations, the risk of overfitting exists with the currently used methodology, in which case another method[13] might be more appropriate. Finally, other wealth inequality measures – like the P99/P10, the P99/P50, or the P80/P20 – have not been researched in this paper. Since no inequality measure definitively right or wrong, it cannot be stated that the *disequalizing* effect of QE in the Netherlands holds for all inequality measures. These questions will thus be left for future research.

[13] Like a Bayesian VAR model, for example.

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10. Appendix

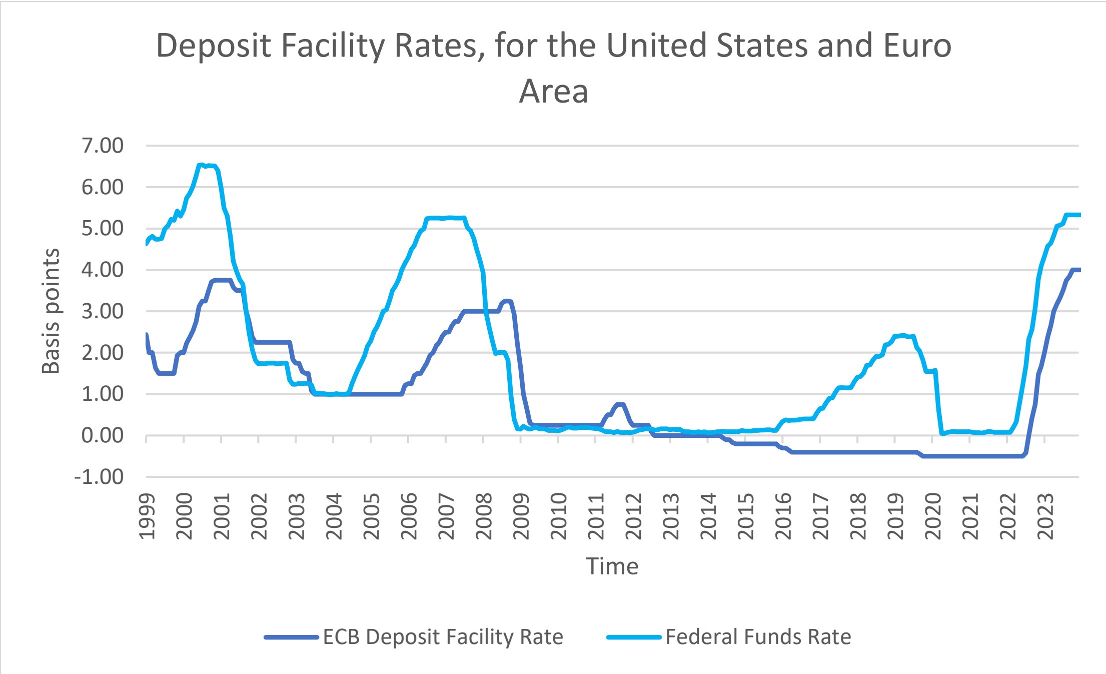

Figure 1

Deposit Facility Rate of the European Central Bank and the Federal Reserve

Note: source: European Central Bank & Board of Governors of the Federal Reserve System

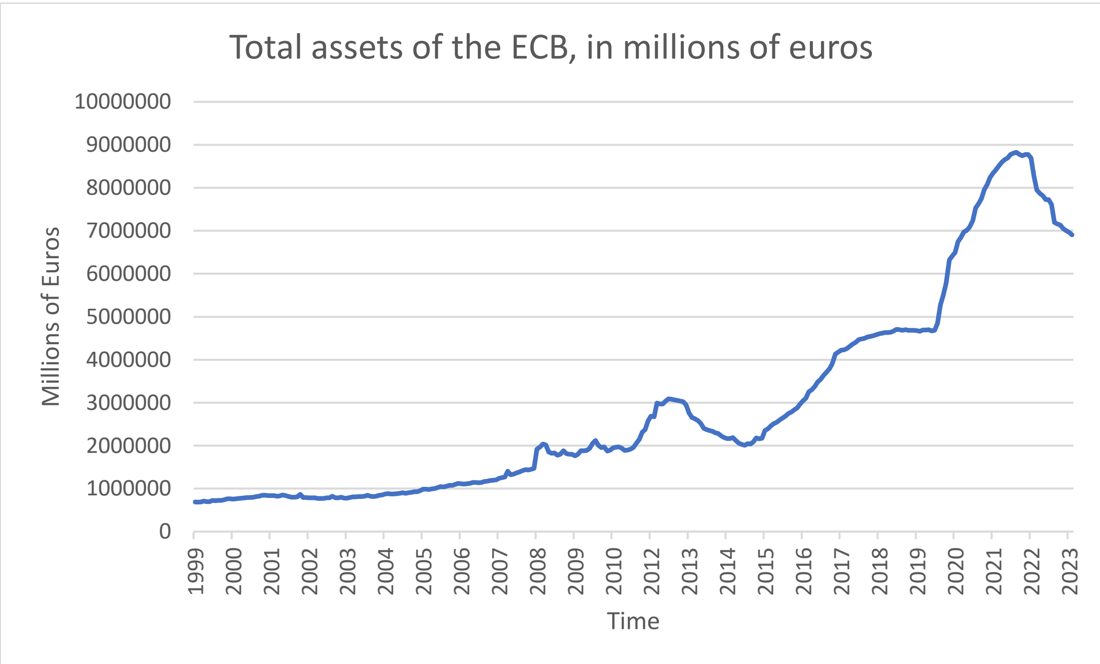

Figure 2

Balance sheet of the European Central Bank, in millions of euros

Note: source: European Central Bank

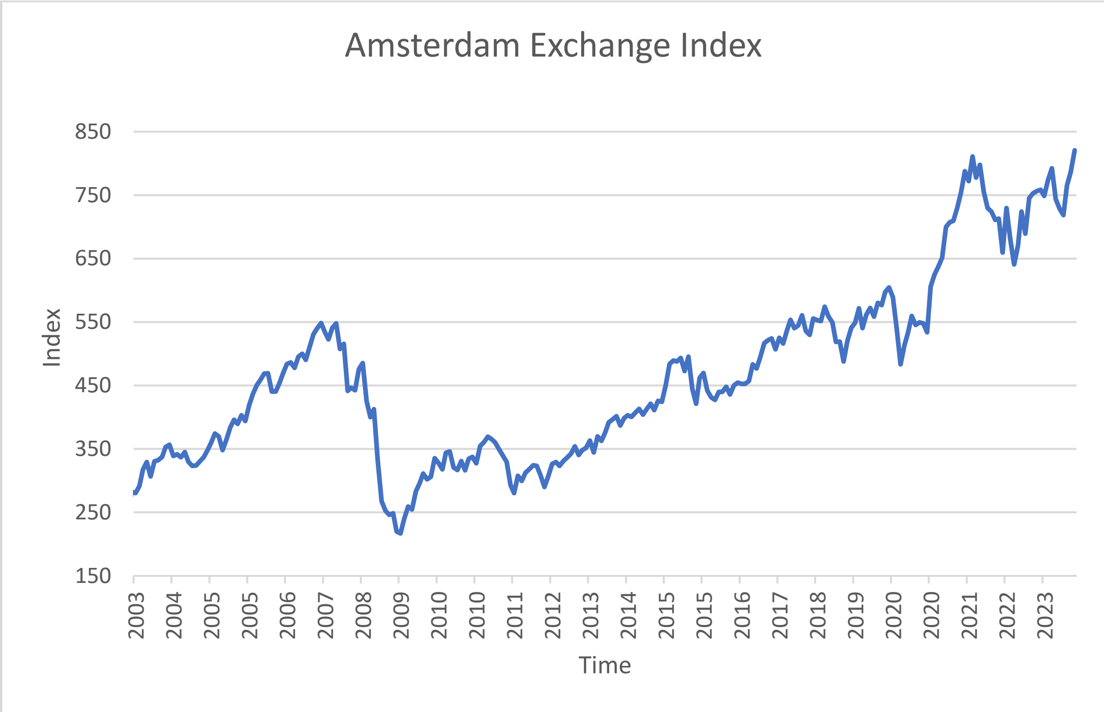

Figure 3

The main stock exchange index of the Netherlands, the AEX

Note: source: yahoo!finance

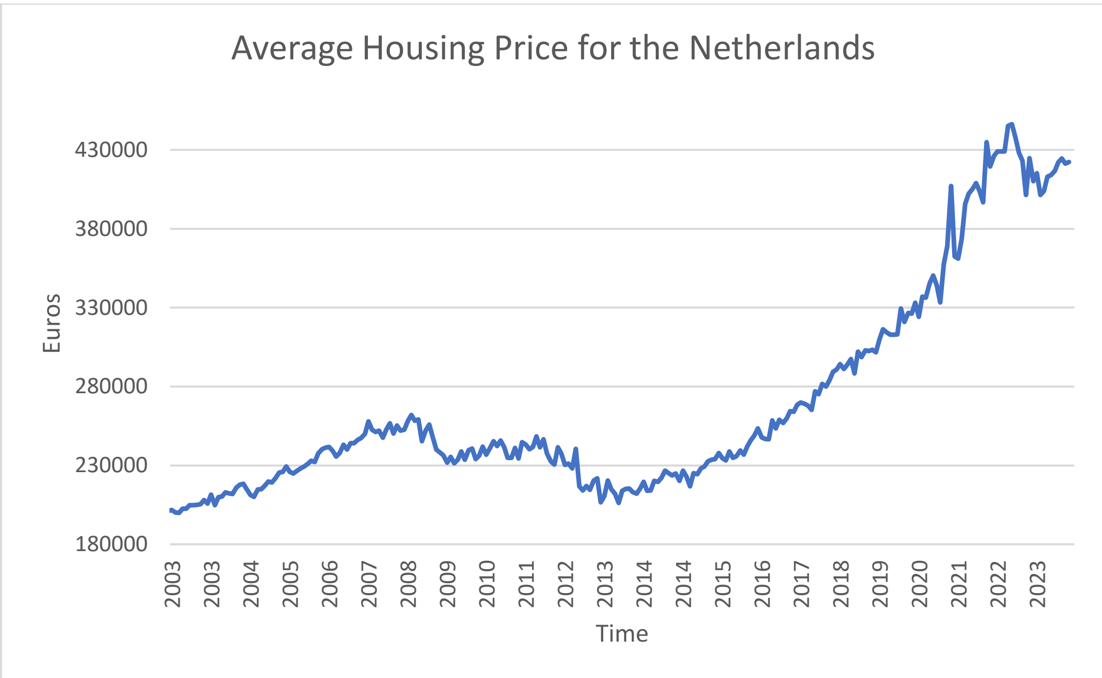

Figure 4

Average housing prices in the Netherlands, in euros

Note: source: CBS StatLine

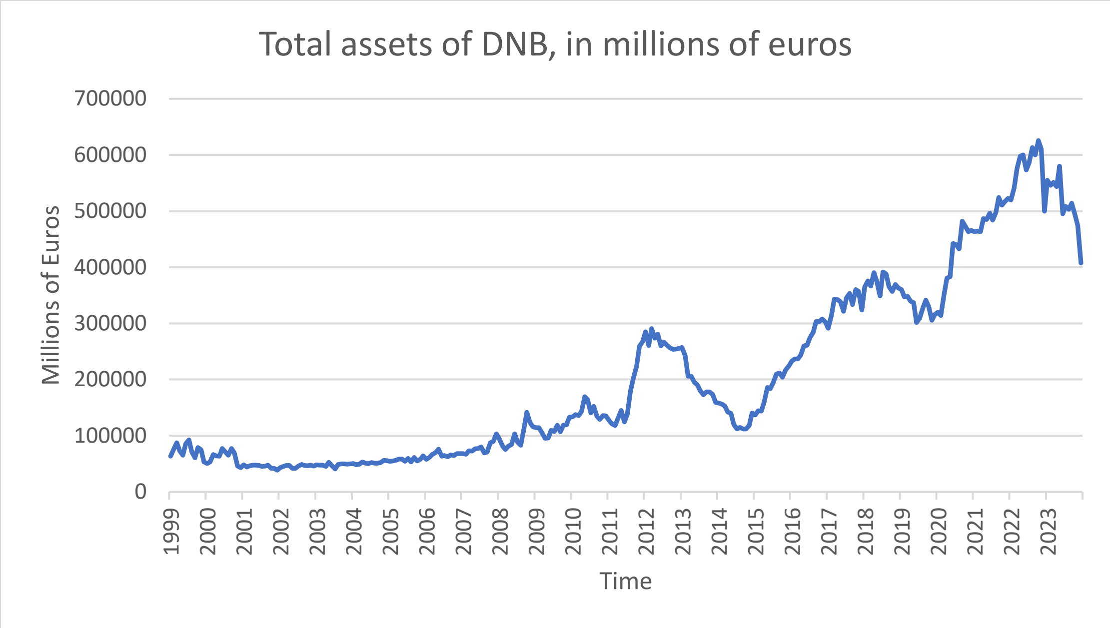

Figure 5

Total assets of De Nederlandsche Bank, in millions of euros

Source: De Nederlandsche Bank

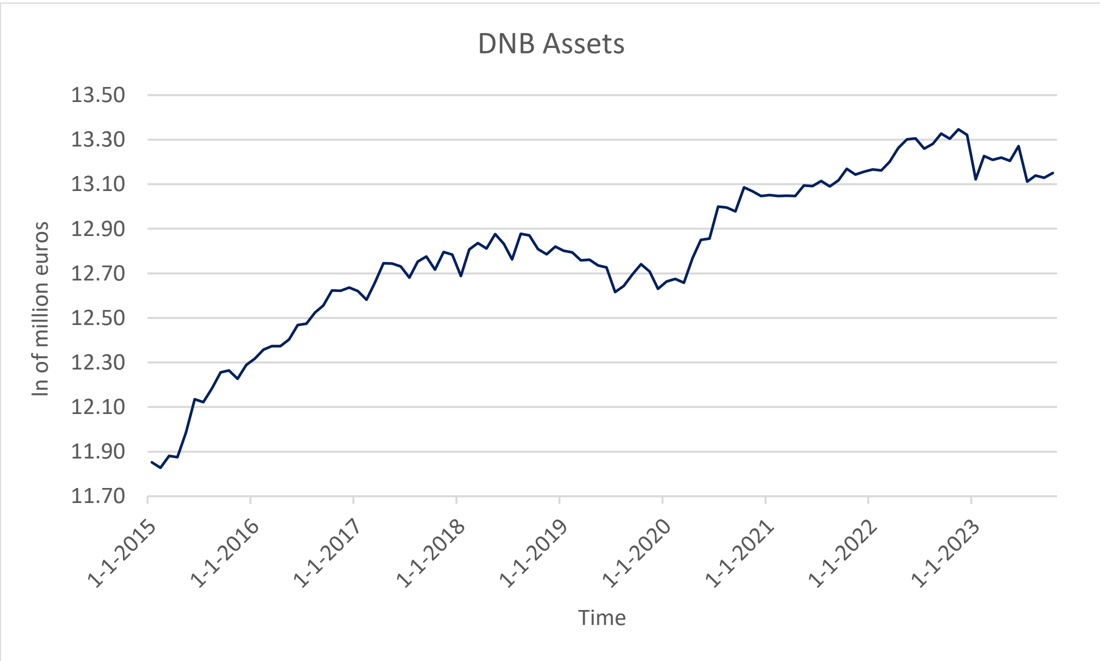

Figure 6

Total assets of DNB, in natural log form

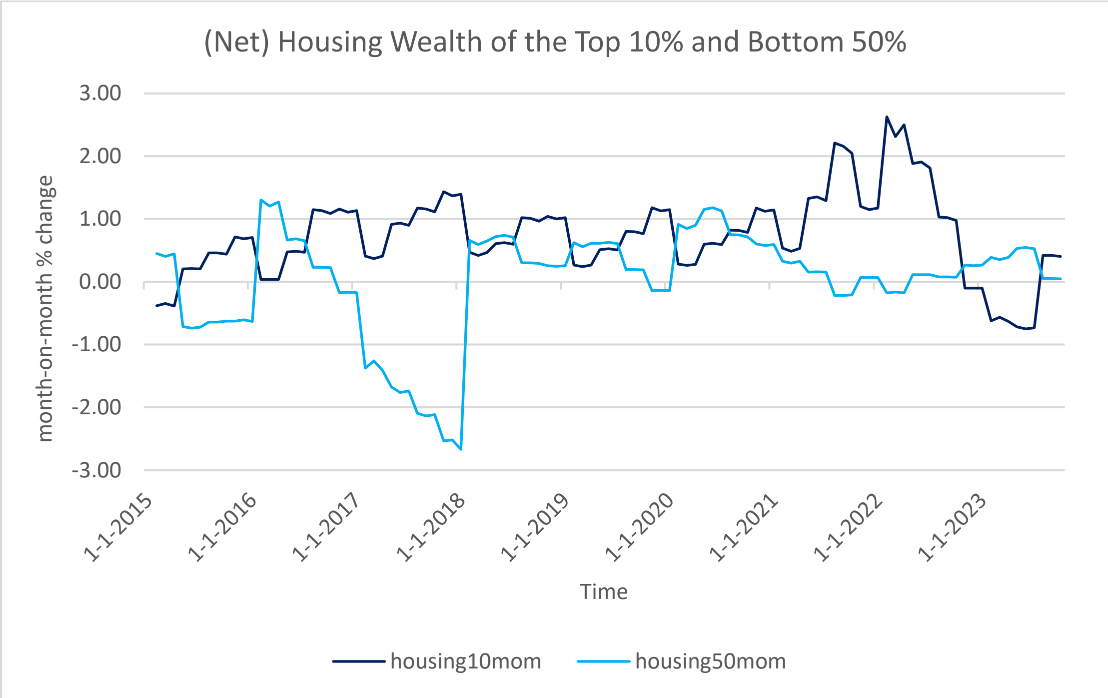

Figure 7

(Net) housing wealth of the top 10% and bottom 50% of the wealth distribution in the Netherlands, in month-on-month percentage changes

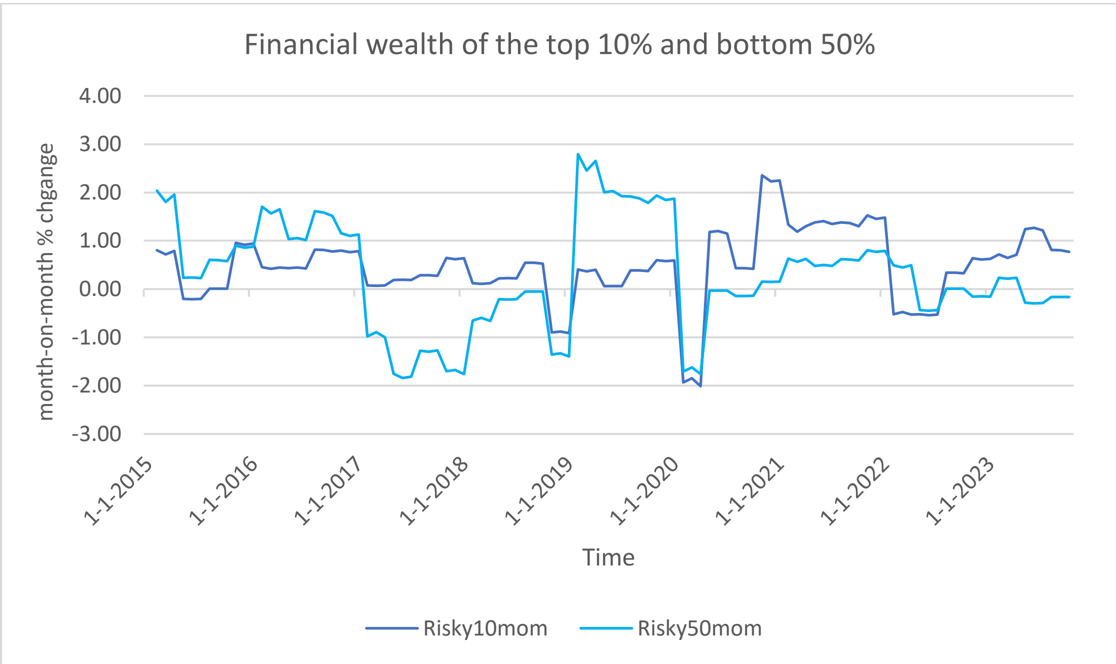

Figure 8

Financial wealth of the top 10% and bottom 50% of the wealth distribution in the Netherlands, in month-on-month percentage changes

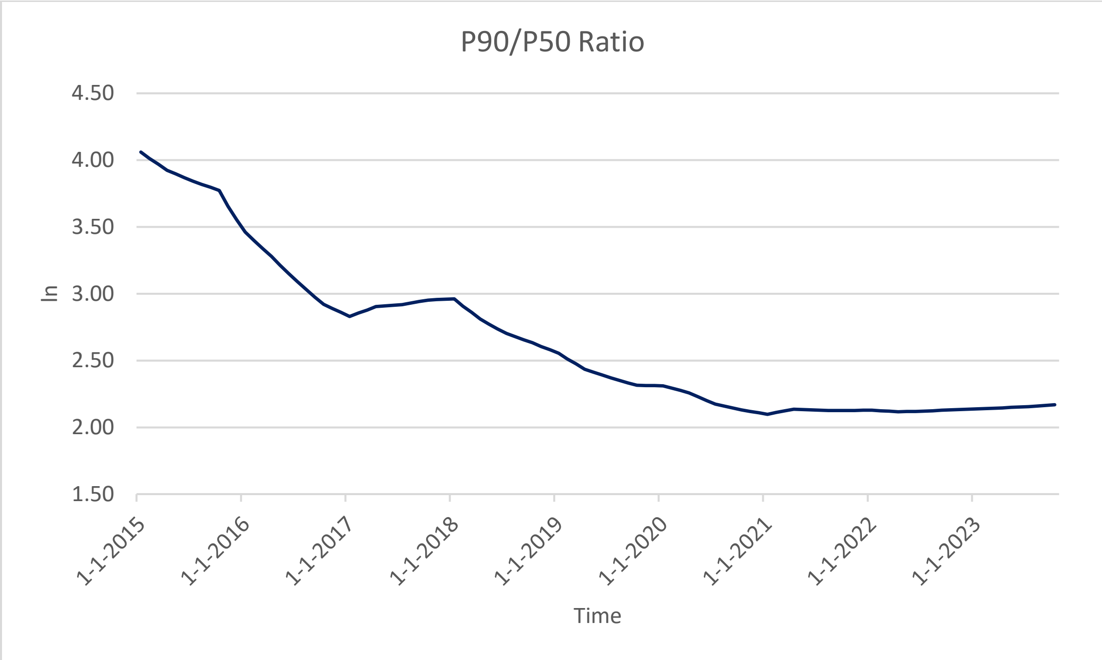

Figure 9

Ratio of total (net) wealth of the top 10% compared to the bottom 50% in the Netherlands, in natural log form

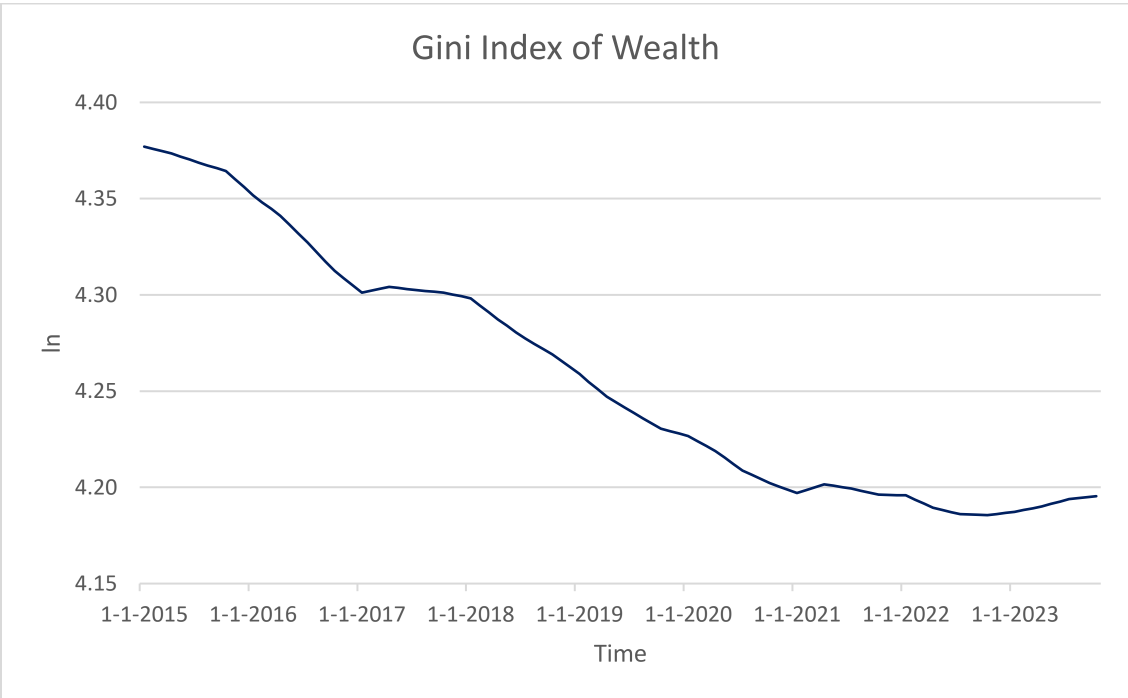

Figure 10

The Gini Index of wealth in the Netherlands, in natural log form

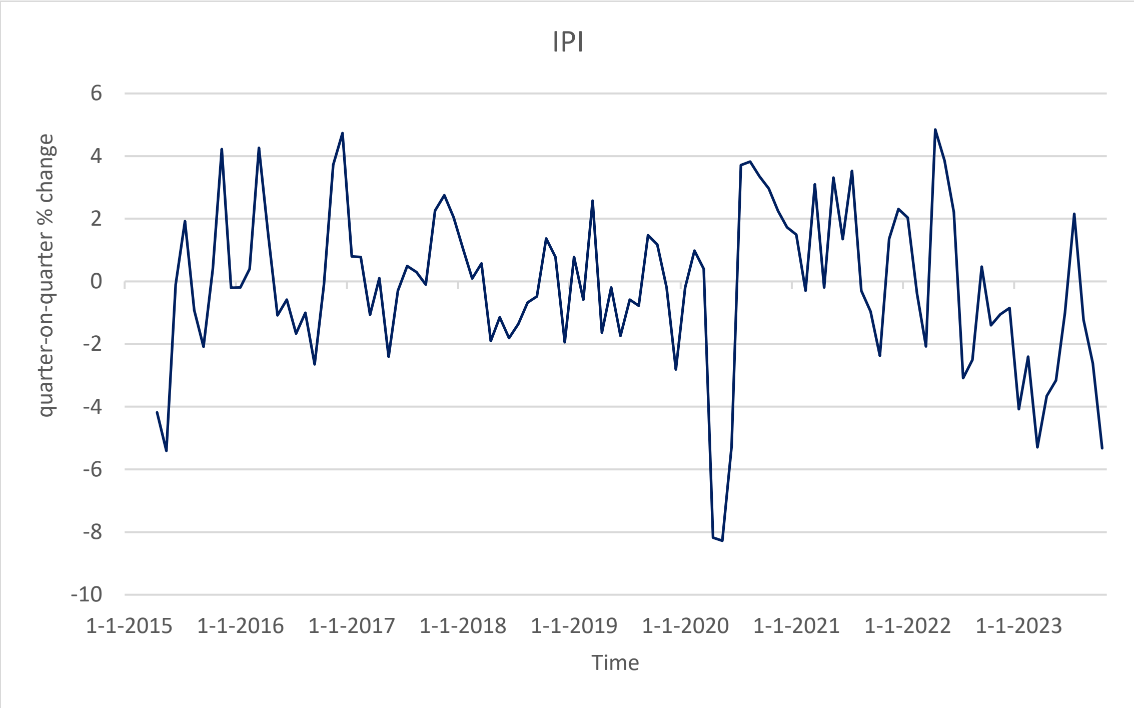

Figure 11

The Industrial Production Index (IPI) of the Netherlands, in quarter-on-quarter percentage changes

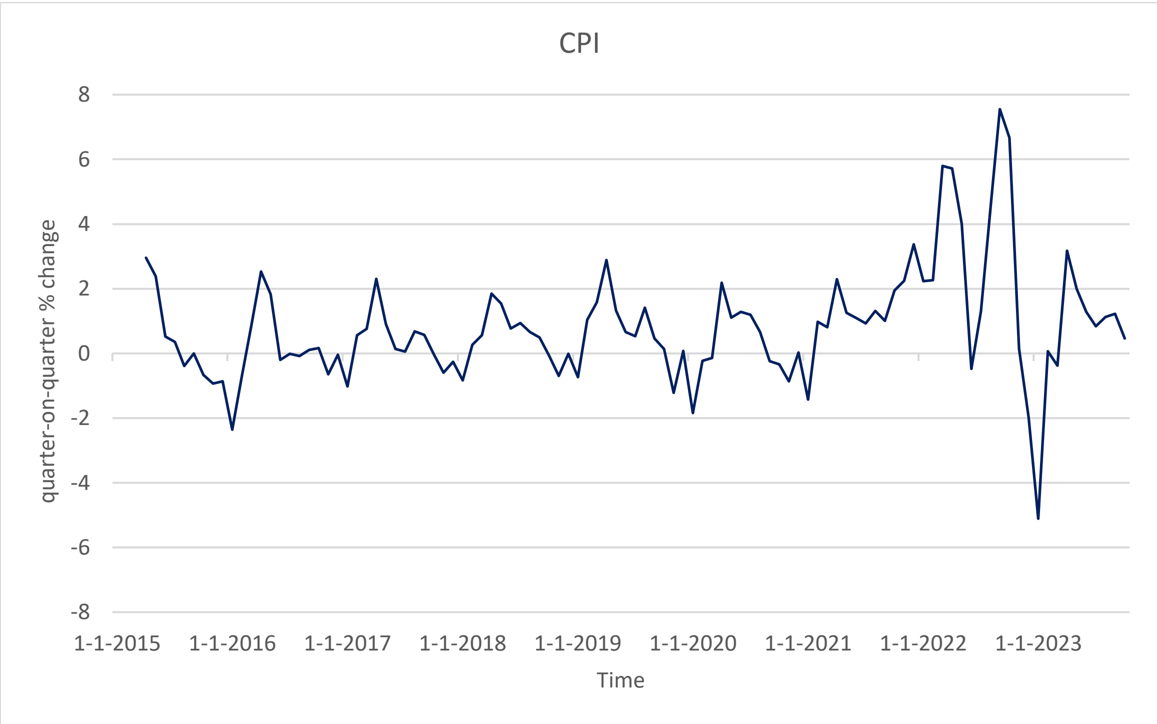

Figure 12

The Consumer Price Index (CPI) for the Netherlands, in quarter-on-quarter percentage changes

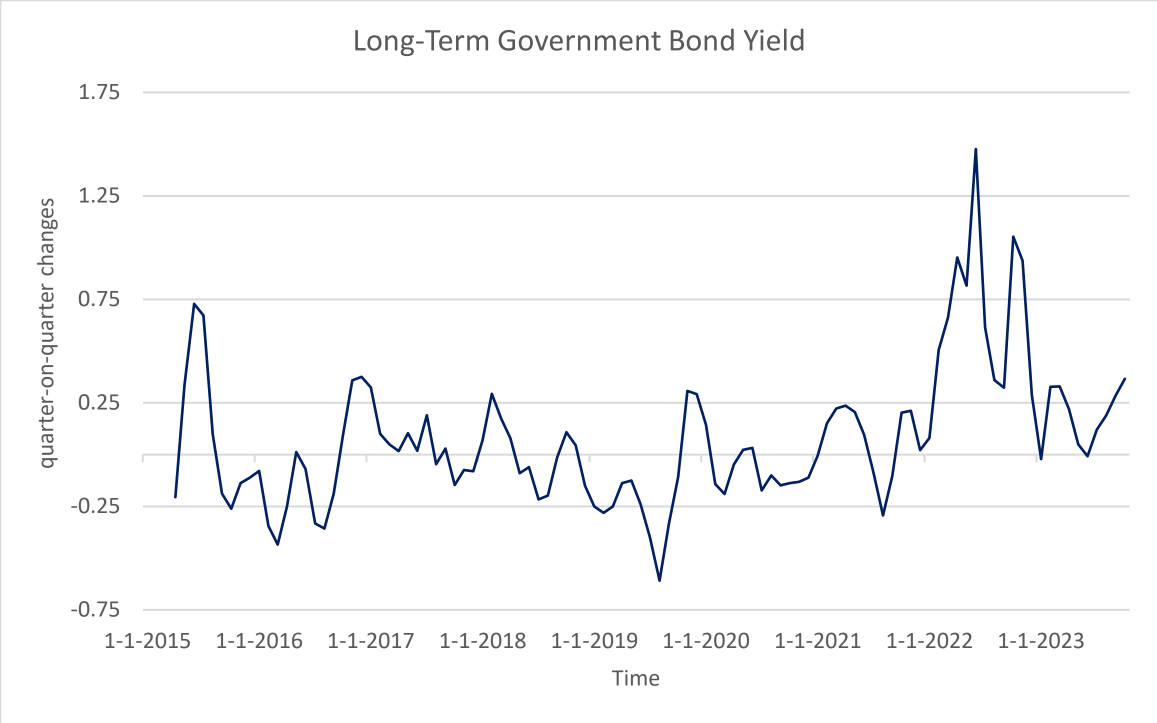

Figure 13

The 10-year sovereign yield in the Netherlands, in quarter-on-quarter differences

Table 1

Lag length criterium: (net) housing wealth of the top 10%

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-524.746	NA	0.038129	10.92259	11.05531	10.97626
1	-225.568	561.3437	0.000134	5.269444	6.065746*	5.591429*
2	-205.123	36.2527	0.000148	5.363364	6.823252	5.953671
3	-161.795	72.36181	0.000102	4.985473	7.108946	5.844101
4	-130.766	48.62312	9.20e-05*	4.861159*	7.648217	5.988109
5	-114.903	23.22208	0.000115	5.049551	8.500195	6.444822
6	-84.803	40.96114*	0.000108	4.944392	9.058621	6.607984

Notes: the results in Table 1 show the optimal lag selection according to the Akaike Information Criterium (AIC), the Hannan-Quinn Information Criterium (HQ) and the Schwarz Information Criterium (SC). The * indicates the optimal lag length. The number of observations are equal to 97. The variables that are included, are the IPI, CPI, Balance sheet of DNB, housing wealth of the top 10%, and the yield.

Table 2

Lag length criterium: (net) housing wealth of the bottom 50%

Lag	LogL	LR	FPE	AIC	SC	HQ

0	-554.445	NA	0.070339	11.53495	11.66767	11.58861
1	-253.24	565.1485	0.000237*	5.83999	6.636292*	6.161975*
2	-239.01	25.2314	0.000297	6.062065	7.521953	6.652372
3	-207.601	52.45656	0.000263	5.929917	8.05339	6.788546
4	-176.718	48.39399	0.000237	5.808618*	8.595677	6.935568
5	-156.644	29.38621	0.000271	5.910192	9.360835	7.305463
6	-128.086	38.86351*	0.000265	5.836815	9.951044	7.500407

Notes: the results in Table 2 show the optimal lag selection according to the Akaike Information Criterium (AIC), the Hannan-Quinn Information Criterium (HQ) and the Schwarz Information Criterium (SC). The * indicates the optimal lag length. The number of observations are equal to 97. The variables that are included, are the IPI, CPI, Balance sheet of DNB, housing wealth of the bottom 50%, and the yield.

Table 3

Lag length criterium: financial wealth of the top 10%

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-538.445	NA	0.050574	11.20506	11.33778	11.25872
1	-267.265	508.8128	0.000316	6.129173	6.925475*	6.451158*
2	-249.417	31.64758	0.000368	6.276642	7.736529	6.866949
3	-215.326	56.93656	0.000308	6.089185	8.212658	6.947813
4	-176.024	61.58552	0.000234	5.794313	8.581371	6.921263
5	-149.204	39.26188	0.000233	5.756793	9.207436	7.152064
6	-113.804	48.17388*	0.000197*	5.542349*	9.656578	7.205942

Notes: the results in Table 3 show the optimal lag selection according to the Akaike Information Criterium (AIC), the Hannan-Quinn Information Criterium (HQ) and the Schwarz Information Criterium (SC). The * indicates the optimal lag length. The number of observations are equal to 97. The variables that are included, are the IPI, CPI, Balance sheet of DNB, financial wealth of the top 10%, and the yield.

Table 4

Lag length criterium: financial wealth of the bottom 50%

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-580.322	NA	0.119924	12.06849	12.2012	12.12215
1	-291.164	542.5433	0.000517	6.621935	7.418237*	6.943920*
2	-276.259	26.42851	0.00064	6.83009	8.289978	7.420397
3	-245.421	51.50289	0.000573	6.709716	8.833189	7.568345
4	-213.32	50.30378	0.000505*	6.563288*	9.350346	7.690238
5	-197.275	23.4875	0.000627	6.747942	10.19859	8.143213

6	-165.476	43.27365*	0.000572	6.607745	10.72197	8.271337

Notes: the results in Table 4 show the optimal lag selection according to the Akaike Information Criterium (AIC), the Hannan-Quinn Information Criterium (HQ) and the Schwarz Information Criterium (SC). The * indicates the optimal lag length. The number of observations are equal to 97. The variables that are included, are the IPI, CPI, Balance sheet of DNB, financial wealth of the bottom 50%, and the yield.

Table 5

Lag length criterium: P90/P50 ratio

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-422.685	NA	0.004649	8.818249	8.950966	8.871914
1	47.29442	881.8172	4.82E-07	-0.35659	0.439716*	-0.0346
2	100.1969	93.80648	2.72E-07	-0.9319	0.527993	-0.341588*
3	126.9813	44.73272	2.65E-07	-0.96869	1.154786	-0.11006
4	159.7956	51.42034	2.30e-07*	-1.129806*	1.657252	-0.00286
5	177.1575	25.41641	2.78E-07	-0.97232	2.478324	0.422951
6	204.9498	37.82036*	2.76E-07	-1.02989	3.084337	0.633701

Notes: the results in Table 5 show the optimal lag selection according to the Akaike Information Criterium (AIC), the Hannan-Quinn Information Criterium (HQ) and the Schwarz Information Criterium (SC). The * indicates the optimal lag length. The number of observations are equal to 97. The variables that are included, are the IPI, CPI, Balance sheet of DNB, the ratio of wealth of the top 10% compared to the bottom 50%, and the yield.

Table 6

Lag length criterium: Gini Index

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-210.201	NA	5.82E-05	4.437132	4.569849	4.490796
1	304.9203	966.516	2.38E-09	-5.66846	-4.87216	-5.34647
2	367.4597	110.8946	1.10E-09	-6.44247	-4.982580*	-5.852161*
3	396.2918	48.15259	1.03E-09	-6.52148	-4.39801	-5.66285
4	425.455	45.69897	9.62e-10*	-6.607319*	-3.82026	-5.48037
5	444.2999	27.58736	1.13E-09	-6.48041	-3.02977	-5.08514
6	473.3562	39.54058*	1.09E-09	-6.56405	-2.44982	-4.90045

Notes: the results in Table 6 show the optimal lag selection according to the Akaike Information Criterium (AIC), the Hannan-Quinn Information Criterium (HQ) and the Schwarz Information Criterium (SC). The * indicates the optimal lag length. The number of observations are equal to 97. The variables that are included, are the IPI, CPI, Balance sheet of DNB, the Gini Index of wealth, and the yield.

Table 7

Lagrange-multiplier test: (net) housing wealth of the top 10%

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	24.03784	25	0.5172	0.962784	(25, 257.8)	0.5181
2	30.63428	25	0.2014	1.242366	(25, 257.8)	0.2022
3	45.24332	25	0.0078	1.886476	(25, 257.8)	0.0079
4	30.83162	25	0.1947	1.250836	(25, 257.8)	0.1955

Notes: the results in Table 7 show whether there is autocorrelation in the residuals of the VAR model, at several lag lengths. The null hypothesis means no autocorrelation at lag h. The last lag refers to the number of lags that is used in the VAR model, and if the p-value is larger than 10%, the null hypothesis cannot be rejected. The variables that are included, are the IPI, CPI, Balance sheet of DNB, housing wealth of the top 10%, and the yield. The number of observations are 99.

Table 8

Lagrange-multiplier test: (net) housing wealth of the bottom 50%

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	32.17536	25	0.153	1.308675	(25, 257.8)	0.1537
2	29.438	25	0.246	1.191153	(25, 257.8)	0.2469
3	47.07647	25	0.0048	1.969795	(25, 257.8)	0.0049
4	33.59913	25	0.1168	1.370275	(25, 257.8)	0.1174

Notes: the results in Table 8 show whether there is autocorrelation in the residuals of the VAR model, at several lag lengths. The null hypothesis means no autocorrelation at lag h. The last lag refers to the number of lags that is used in the VAR model, and if the p-value is larger than 10%, the null hypothesis cannot be rejected. The variables that are included, are the IPI, CPI, Balance sheet of DNB, housing wealth of the bottom 50%, and the yield. The number of observations are 99.

Table 9

Lagrange-multiplier test: financial wealth of the top 10%

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	31.98791	25	0.1584	1.304691	(25, 213.2)	0.1594
2	30.19958	25	0.2169	1.226747	(25, 213.2)	0.2181
3	42.10951	25	0.0175	1.757721	(25, 213.2)	0.0177
4	35.48075	25	0.0799	1.458726	(25, 213.2)	0.0806
5	22.83135	25	0.5874	0.912067	(25, 213.2)	0.5887
6	34.04298	25	0.107	1.39503	(25, 213.2)	0.1078

Notes: the results in Table 9 show whether there is autocorrelation in the residuals of the VAR model, at several lag lengths. The null hypothesis means no autocorrelation at lag h. The last lag refers to the number of lags that is used in the VAR model, and if the p-value is larger than 10%, the null hypothesis cannot be rejected. The variables that are included, are the IPI, CPI, Balance sheet of DNB, financial wealth of the top 10%, and the yield. The number of observations are 97.

Table 10

Lagrange-multiplier test: financial wealth of the bottom 50%

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	23.56284	25	0.5447	0.942915	(25, 257.8)	0.5456
2	36.49487	25	0.0644	1.496569	(25, 257.8)	0.0648
3	48.4361	25	0.0033	2.031959	(25, 257.8)	0.0034
4	19.55554	25	0.7697	0.776677	(25, 257.8)	0.7703

Notes: the results in Table 10 show whether there is autocorrelation in the residuals of the VAR model, at several lag lengths. The null hypothesis means no autocorrelation at lag h. The last lag refers to the number of lags that is used in the VAR model, and if the p-value is larger than 10%, the null hypothesis cannot be rejected. The variables that are included, are the IPI, CPI, Balance sheet of DNB, financial wealth of the bottom 50%, and the yield. The number of observations are 99.

Table 11

Lagrange-multiplier test: P90/P50 ratio

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	25.36124	25	0.4423	1.018327	(25, 257.8)	0.4433
2	20.8265	25	0.7022	0.829134	(25, 257.8)	0.703
3	45.28636	25	0.0078	1.888426	(25, 257.8)	0.0078
4	24.65757	25	0.4817	0.98876	(25, 257.8)	0.4826

Notes: the results in Table 11 show whether there is autocorrelation in the residuals of the VAR model, at several lag lengths. The null hypothesis means no autocorrelation at lag h. The last lag refers to the number of lags that is used in the VAR model, and if the p-value is larger than 10%, the null hypothesis cannot be rejected. The variables that are included, are the IPI, CPI, Balance sheet of DNB, the ratio of wealth of the top 10% compared to the bottom 50%, and the yield. The number of observations are 99.

Table 12

Lagrange-multiplier test: Gini Index of wealth

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	26.94794	25	0.3585	1.085281	(25, 257.8)	0.3595
2	23.27014	25	0.5618	0.930688	(25, 257.8)	0.5627
3	51.92811	25	0.0012	2.193063	(25, 257.8)	0.0012
4	24.83778	25	0.4715	0.996325	(25, 257.8)	0.4725

Notes: the results in Table 12 show whether there is autocorrelation in the residuals of the VAR model, at several lag lengths. The null hypothesis means no autocorrelation at lag h. The last lag refers to the number of lags that is used in the VAR model, and if the p-value is larger than 10%, the null hypothesis cannot be rejected. The variables that are included, are the IPI, CPI, Balance sheet of DNB, the Gini Index of Wealth, and the yield. The number of observations are 99

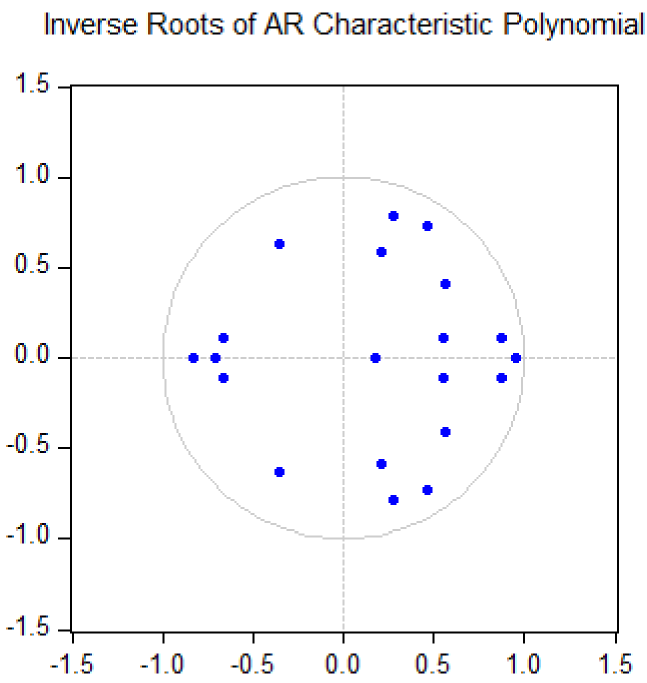

Figure 14

Stability test: (net) housing wealth top 10%

Notes: All of the eigenvalues lie within the unit circle. The variables that are included, are the IPI, CPI, Balance sheet of DNB, housing wealth of the top 10%, and the yield.

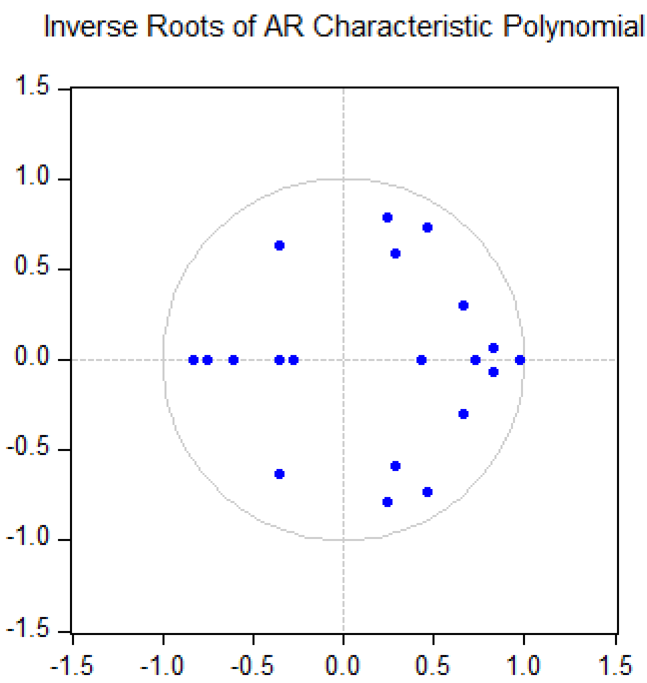

Figure 15

Stability test: (net) housing wealth bottom 50%

Notes: All of the eigenvalues lie within the unit circle. The variables that are included, are the IPI, CPI, Balance sheet of DNB, housing wealth of the bottom 50%, and the yield.

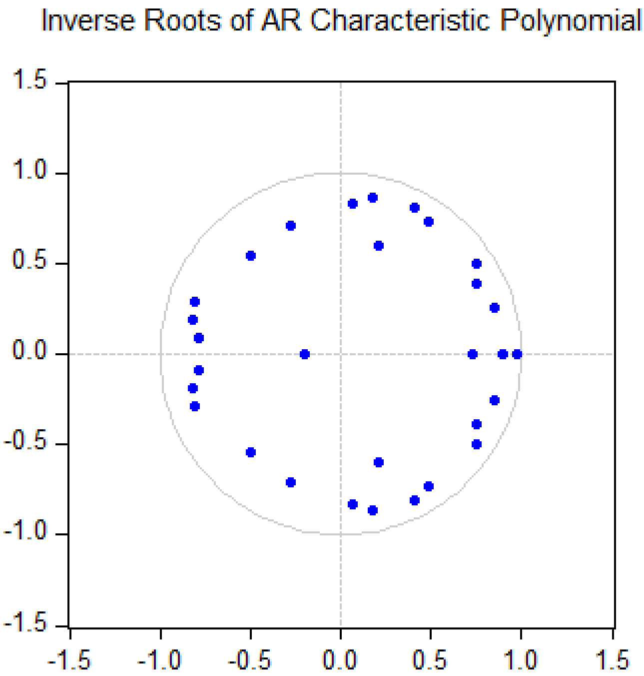

Figure 16

Stability test: financial wealth top 10%

Notes: All of the eigenvalues lie within the unit circle. The variables that are included, are the IPI, CPI, Balance sheet of DNB, financial wealth of the top 10%, and the yield.

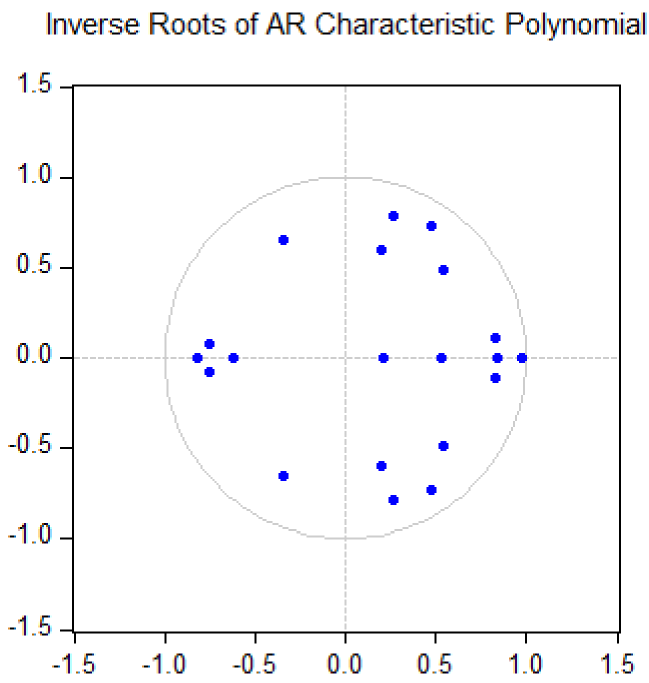

Figure 17

Stability test: financial wealth bottom 50%

Notes: All of the eigenvalues lie within the unit circle. The variables that are included, are the IPI, CPI, Balance sheet of DNB, financial wealth of the bottom 50%, and the yield.

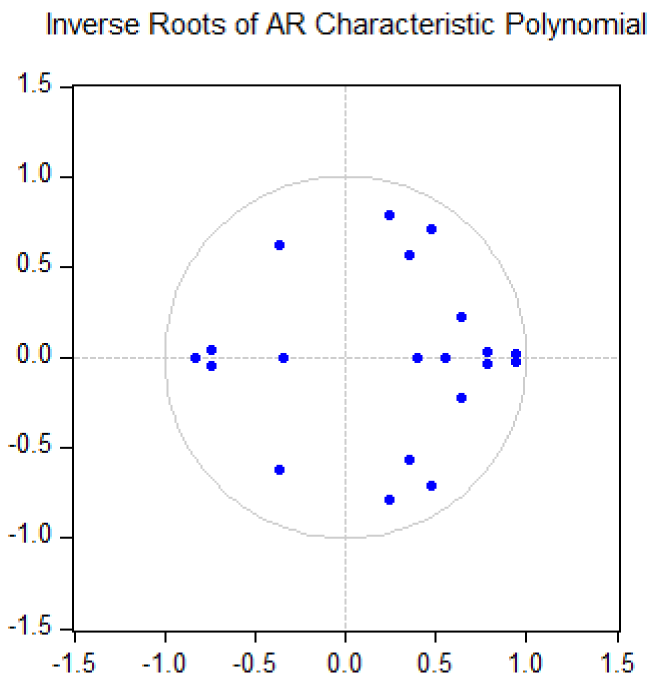

Figure 18

Stability test: P90/P50 ratio

Notes: All of the eigenvalues lie within the unit circle. The variables that are included, are the IPI, CPI, Balance sheet of DNB, the ratio of total (net) wealth of top 10% relative to the bottom 50%, and the yield.

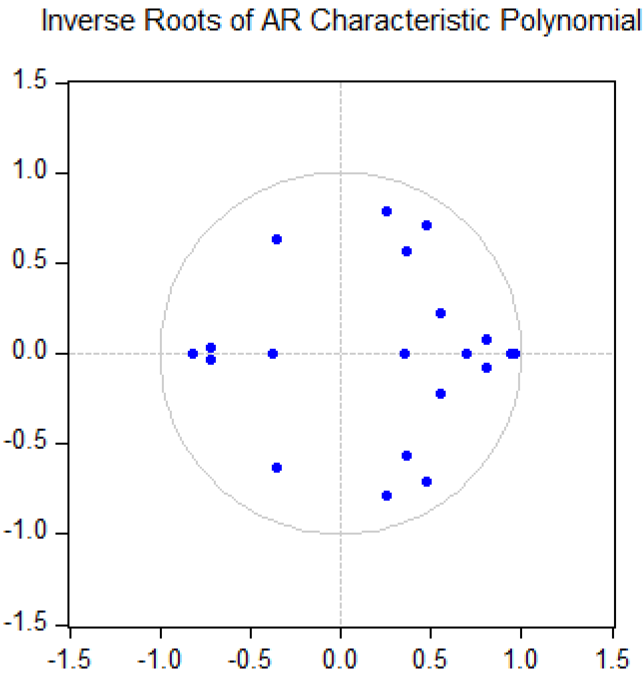

Figure 19

Stability test: Gini Index of wealth

Notes: All of the eigenvalues lie within the unit circle. The variables that are included, are the IPI, CPI, Balance sheet of DNB, the Gini Index of Wealth, and the yield.

Table 13

FEVD of the zero restricted SVAR model (robustness check): P90/P50 ratio

Steps	IPI	CPI	P90/P50	Yield
0	0	0	0	0
1	0	0	0.103593	0.086385
2	0.141216	0.074485	0.121423	0.053487
3	0.14925	0.066895	0.109196	0.077586
4	0.147145	0.074351	0.106159	0.089973
5	0.151247	0.074507	0.100842	0.096438
6	0.151991	0.074999	0.095275	0.097194
7	0.152725	0.074952	0.090312	0.097638
8	0.152833	0.075062	0.086805	0.098065

9	0.153015	0.075077	0.084363	0.098476
10	0.153114	0.075127	0.08265	0.098768
11	0.153224	0.07513	0.081406	0.098977
12	0.15329	0.075136	0.080486	0.099084
13	0.153335	0.075132	0.079797	0.09914
14	0.153359	0.075131	0.079281	0.099168
15	0.153373	0.075128	0.078897	0.099181
16	0.153379	0.075126	0.078611	0.099186
17	0.153383	0.075124	0.078399	0.099186
18	0.153384	0.075122	0.078241	0.099184
19	0.153384	0.075121	0.078125	0.099181
20	0.153383	0.07512	0.078038	0.099177

Notes: Table 13 above displays how dominant a positive APP shock is - in the Netherlands - in explaining the variance decomposition of the forecast errors of the other variables in the SVAR model, at different months. This SVAR model is estimated with quarterly observations, using standard Cholesky decomposition.

Table 14

FEVD of the zero restricted SVAR model (robustness check): Gini Index

Steps	IPI	CPI	Gini Index	Yield
0	0	0	0	0
1	0	0	0.114598	0.049699
2	0.161834	0.103219	0.105815	0.028563
3	0.15224	0.090392	0.060972	0.094458
4	0.149458	0.110301	0.040467	0.102444
5	0.158252	0.105684	0.040379	0.098639
6	0.154752	0.105141	0.045396	0.102831
7	0.152302	0.104503	0.051961	0.102196
8	0.151436	0.103507	0.059099	0.10179
9	0.155063	0.105656	0.067358	0.101332
10	0.15502	0.105123	0.073704	0.102064
11	0.154835	0.10572	0.078558	0.10296
12	0.15491	0.105871	0.081775	0.102856
13	0.154852	0.10582	0.084045	0.103375
14	0.154764	0.105879	0.085601	0.103722
15	0.154732	0.105996	0.086641	0.10385

16	0.154787	0.105958	0.087235	0.103936
17	0.154808	0.105978	0.087613	0.103982
18	0.154814	0.105974	0.087855	0.103968
19	0.154811	0.10596	0.088022	0.103981
20	0.154816	0.105956	0.088139	0.103969

Notes: Table 14 above displays how dominant a positive APP shock is - in the Netherlands - in explaining the variance decomposition of the forecast errors of the other variables in the SVAR model, at different months. This SVAR model is estimated with quarterly observations, using standard Cholesky decomposition.

Table 15

FEVD of the zero restricted SVAR model (robustness check): (net) housing wealth of the top 10%

Steps	IPI	CPI	Housing top 10%	Yield
0	0	0	0	0
1	0	0	0.041226	0.075208
2	0.138049	0.136344	0.081097	0.047727
3	0.137286	0.109852	0.08809	0.084326
4	0.126854	0.137198	0.105415	0.100752
5	0.129763	0.133882	0.099684	0.105638
6	0.126446	0.132104	0.09368	0.10766
7	0.129335	0.131379	0.093616	0.107272
8	0.127496	0.13134	0.09362	0.1086
9	0.12609	0.132034	0.092451	0.111831
10	0.125959	0.134114	0.092446	0.115591
11	0.125806	0.135741	0.093817	0.120144
12	0.125302	0.136871	0.094843	0.123612
13	0.125213	0.137058	0.0946	0.125327
14	0.12544	0.136945	0.094081	0.125986
15	0.125542	0.136943	0.093928	0.126353
16	0.125362	0.137061	0.093898	0.126826
17	0.125205	0.137285	0.093803	0.127482
18	0.125174	0.137624	0.093831	0.128295
19	0.125155	0.137973	0.094027	0.129149
20	0.125109	0.138207	0.094184	0.129845

Notes: Table 15 above displays how dominant a positive APP shock is - in the Netherlands - in explaining the variance decomposition of the forecast errors of the other variables in the SVAR model, at different months. This SVAR model is estimated with quarterly observations, using standard Cholesky decomposition.

Table 16

FEVD of the zero restricted SVAR model (robustness check): (net) housing wealth of the bottom 50%

Steps	IPI	CPI	Housing bottom 50%	Yield
0	0	0	0	0
1	0	0	0.062872	0.079108
2	0.14193	0.074067	0.05718	0.047043
3	0.146067	0.06644	0.054524	0.063242
4	0.139784	0.07837	0.054353	0.079906
5	0.140509	0.078377	0.05425	0.090646
6	0.140517	0.080743	0.054249	0.093985
7	0.142298	0.080915	0.054246	0.096372
8	0.142787	0.081696	0.054249	0.09819
9	0.143379	0.082065	0.054269	0.099682
10	0.14366	0.082561	0.054297	0.100909
11	0.143961	0.082891	0.054324	0.102008
12	0.144165	0.083223	0.054345	0.102914
13	0.144356	0.083464	0.05436	0.103672
14	0.144505	0.083675	0.054371	0.104286
15	0.144635	0.083837	0.05438	0.104787
16	0.144738	0.083972	0.054387	0.105191
17	0.144823	0.08408	0.054393	0.105519
18	0.144892	0.084169	0.054398	0.105785
19	0.144949	0.08424	0.054401	0.106001
20	0.144994	0.084299	0.054405	0.106178

Notes: Table 16 above displays how dominant a positive APP shock is - in the Netherlands - in explaining the variance decomposition of the forecast errors of the other variables in the SVAR model, at different months. This SVAR model is estimated with quarterly observations, using standard Cholesky decomposition.

Table 17

FEVD of the zero restricted SVAR model (robustness check): financial wealth of the top 10%

Steps	IPI	CPI	Financial top 10%	Yield
0	0	0	0	0
1	0	0	0.000779	0.00236
2	0.10588	0.043121	0.273274	0.004977

3	0.091006	0.034214	0.226977	0.092259
4	0.085319	0.111416	0.240937	0.12276
5	0.083604	0.11412	0.236264	0.143472
6	0.078717	0.133314	0.234038	0.189963
7	0.074458	0.144223	0.224769	0.207867
8	0.078546	0.145421	0.224028	0.226433
9	0.080542	0.142844	0.222924	0.229622
10	0.086465	0.142652	0.219669	0.231463
11	0.086424	0.142379	0.220681	0.231645
12	0.086696	0.142389	0.219731	0.232372
13	0.086453	0.143116	0.21989	0.233143
14	0.08641	0.14394	0.219683	0.23322
15	0.086453	0.144657	0.219543	0.234254
16	0.086358	0.145121	0.219082	0.234637
17	0.086708	0.145227	0.21921	0.235157
18	0.086766	0.145177	0.219145	0.235254
19	0.087028	0.145125	0.21906	0.23528
20	0.087113	0.145103	0.219035	0.235221

Notes: Table 17 above displays how dominant a positive APP shock is - in the Netherlands - in explaining the variance decomposition of the forecast errors of the other variables in the SVAR model, at different months. This SVAR model is estimated with quarterly observations, using standard Cholesky decomposition.

Table 18

FEVD of the zero restricted SVAR model (robustness check): financial wealth of the bottom 50%

Steps	IPI	CPI	Financial bottom 50%	Yield
0	0	0	0	0
1	0	0	0.02959	0.017595
2	0.125467	0.054312	0.023366	0.011352
3	0.119424	0.050565	0.021459	0.039693
4	0.11272	0.062587	0.020466	0.052322
5	0.116183	0.062091	0.021894	0.061908
6	0.117475	0.063276	0.025187	0.064149
7	0.118206	0.063307	0.028489	0.064703
8	0.118276	0.063676	0.03061	0.065238
9	0.118462	0.063901	0.031789	0.065819

10	0.11857	0.064225	0.032431	0.066411
11	0.118719	0.064451	0.032863	0.06707
12	0.118827	0.064695	0.033192	0.067647
13	0.118931	0.064871	0.033479	0.068164
14	0.119011	0.06503	0.033728	0.068587
15	0.119081	0.065149	0.033946	0.068931
16	0.119137	0.065248	0.034131	0.069204
17	0.119184	0.065326	0.034287	0.069422
18	0.119222	0.065389	0.034415	0.069597
19	0.119252	0.06544	0.03452	0.069738
20	0.119277	0.065482	0.034604	0.069853

Notes: Table 18 above displays how dominant a positive APP shock is - in the Netherlands - in explaining the variance decomposition of the forecast errors of the other variables in the SVAR model, at different months. This SVAR model is estimated with quarterly observations, using standard Cholesky decomposition.

Table 19

FEVD of the zero- and sign restricted SVAR model (robustness check): P90/P50 ratio

IPI	0.029684
CPI	0.039366
DNB Assets	0.109241
P90/P50	0.140929
long-term sovereign yield	0.176447

Notes: the middle column in Table 19 shows the part of the variance attributed to a positive QE shock, explained by each of the variables in the model. These numbers are measured in percentage points, and apply to a horizon of 24 months and 68% confidence bands. The SVAR model is estimated with quarterly observations.

Table 20

FEVD of the zero- and sign restricted SVAR model (robustness check): Gini Index

IPI	0.035822
CPI	0.038667
DNB Assets	0.109591
Gini Index	0.154898
long-term sovereign yield	0.16486

Notes: the middle column in Table 20 shows the part of the variance attributed to a positive QE shock, explained by each of the variables in the model. These numbers are measured in percentage points, and apply to a horizon of 24 months and 68% confidence bands. The SVAR model is estimated with quarterly observations.