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MASTER THESIS

The Effect of Negative Interest Rate Policy on Private Savings: A European Panel Data Study

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Abstract

Negative interest rate policy (NIRP) was implemented to increase stagnant inflation towards the target level and promote economic growth. This comprised of the decreasing of the interest rate offered on excess reserves of banks at the central bank, below zero percent. While current empirical literature on NIRP, illustrates the effects of NIRP on bank lending. This research examines the relation between NIRP and private savings. This is an important relation as central banks seek to disincentive private saving relative to consumption, in order to stimulate economic growth and inflation. The research question is, "To what extent is there a negative relation between NIRP and private savings?". To research the relationship between NIRP and private savings this paper employs a panel data analysis for multiple countries which have implemented NIRP. The findings of the empirical models are inconclusive in the determining the relationship between NIRP and private savings. Where the different empirical models indicate both a positive and a negative relationship. The robustness of the empirical findings by this research is problematic due to inflated parameters as the result of serial correlation. This research concludes that there is no evidence for a negative relationship between private saving and NIRP.

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1. Introduction

In June of 2014 the European Central Bank (ECB), for the first time ever in its history, implemented negative interest rate policy (NIRP). This constituted the decreasing of the deposit facility rate, the policy interest rate on excess liquidity of banks stored with the ECB, into negative territory from 0% -0.1% in 2014 upwards to -0.5% in 2019 (ECB, 2020). These cuts in the deposit facility rates followed preceding cuts in the deposit facility rate starting in October of 2008, when the deposit facility stood at 3,25%, as a reaction to the Financial Crisis of 2008. In combination with targeted long-term refinancing operations (TLTRO's) and the asset purchase programme (APP), NIRP was part of the "combined arms" approach of the ECB (Altavilla et al., 2019; Rostagno et al., 2019). The TLTRO's offered long-term credit to banks under favourable conditions in order to support the banks in providing more loans to companies in need of investment. The APP involved the purchasing of private and public securities to support the monetary transmission mechanism. Following up with forward guidance (FG), where the ECB provided information about the future duration and size of the APP.

With the implementation and continuation of NIRP, the ECB was the first central bank to execute this type of unconventional monetary policy. With its European counterparts of the Danmark Nationalbank, Sveriges Riksbank and Swiss National Bank adhering to NIRP shortly after. Outside Europe, the Bank of Japan implemented NIRP in January of 2016. This type of unconventional monetary policy was implemented to achieve the goal of price stability and to increase the supply of credit to the economy. In theory the inflation rate and interest rate have a negative relationship, where lower interest rates allow individuals to borrow and therefore consume more. The increased consumption causes the inflation to increase. Decreasing the policy interest rate does not translate immediately to lower market interest rates, these have to be transmitted by banks. In 2014 low cost-side inflationary pressure, low global economic growth and low inflation expectations pressured the above stated countries to implement NIRP in order to stimulate inflation (Arteta et al., 2016).

In times of economic crisis governments wishes to incentivize consumption and investment, rather than private savings as the former stimulates economic growth. When considering that the relationship between private savings and inflation is negative, as money that is privately saved could also be consumed leading to increased levels of inflation. Monetary policy that leads to the disincentivizing of private saving can potentially lead to higher levels of inflation (Aizenman et al., 2019; Serres & Pelgrin, 2003). Therefore, reducing private savings in favour of consumption can be deduced as an implicit objective for the central banks. As the result of NIRP banks are paying interest on their excess liquidity stored at the central banks. This has caused banks to decrease their interest rates for private savings to the point where they are either zero percent or close to zero. This in turn should incentivize individuals

to decrease their private savings share of their disposable income and increase their share of consumption and or investment (Bech & Malkhozov, 2016; Eisenschmidt & Smets, 2019).

During and after the financial crisis of 2008, central banks implemented unconventional monetary policies in order to counteract decreasing economic growth and to stabilize inflation. This research concentrates on NIRP and the potential effect on private savings, in European Monetary Union (EMU), Denmark, Sweden and Switzerland. In order to specify private savings, this research takes net savings to be the sum of public savings and private savings, following the literature on private savings determination (Aizenman et al., 2019; Giovannini, 1983; Masson et al., 1998; Ramajo et al., 2006). Where private savings is defined as the sum of the household savings and corporate savings (Aizenman et al., 2019; Masson et al., 1998; Ramajo et al., 2006). The empirical literature on NIRP and its effects is inconclusive, divided between papers which find that NIRP is effective in increasing bank lending (Altavilla et al., 2019; Demiralp et al., 2019). On the other hand, there is research which finds that monetary policy is less effective at lower or negative values of the policy interest rate (Apergis & Christou, 2015; Basten & Mariathasan, 2018; Goodhart & Kabiri, 2019; Heider et al., 2019; Molyneux et al., 2020). The central banks implementing NIRP have continued and intensified this policy well into 2020. When regarding the most recent economic forecasts we see that the world economy experiencing economic stagnation and a potential recession as the result of the crisis concerning the Coronavirus (COVID-19) (OECD, 2020).

When regarding the projections by the Organisation for Economic Co-operation and Development (OECD), real gross domestic product (GDP) in the Euro-area will decrease by 9.1% in the single-hit[1] scenario and by 11.5% in the double-hit scenario (OECD, 2020). While unemployment in the Euro-area will increase to 11.1% in the single-hit scenario and by 12.6% in the double-hit scenario. In order to prevent their economies experiencing a deep recession under this peculiar economic crisis, central banks can turn towards expansionary monetary policy of further decreasing the policy interest rate into the negative terrain. While effects of NIRP from the empirical literature are inconclusive, the effects of even more negative policy interest rates are unknown as central banks have never enacted them (Altavilla et al., 2019; Apergis & Christou, 2015; Basten & Mariathasan, 2018; Demiralp et al., 2019; Goodhart & Kabiri, 2019; Heider et al., 2019; Molyneux et al., 2020). This research builds on econometric analysis using data on private savings and the policy interest rate and examines whether further decreasing the policy interest rate leads to a reversal effect as proposed by Brunnermeier & Koby (2017). The reversal interest rate is the rate at which the effects of the policy interest rate reverse. Results from this particular

[1] The single-hit scenario assumes that there will be no second wave of large scale COVID-19 infections, while the double-hit scenario does assume a second wave of large scale COVID-19 infections.

analysis could be useful in determining whether further decreasing the policy interest rate has the desired effect on the economy.

From the literature on determination of private savings state that private savings is only partly determined by interest rates. This relationship switches between a positive and a negative relation in different papers where the effect of the real interest rate is -0.84 for industrial countries (Aizenman et al., 2019) or -0.04 and 0.05 for OECD countries (Ramajo et al., 2006; Serres & Pelgrin, 2003). Due to ambiguous nature of the relationship between the interest rate and private savings, further research on this topic is necessary to identify the direction of the relationship between interest rates, in this case the policy interest rate, and private savings. The policy interest is the interest rate paid to banks on their excess reserves stored at the central bank and is labelled differently in the different monetary systems[2], throughout this research these different interest rates will be named the policy interest rate. This relation between the deposit facility interest rate and private saving is an indirect relation, as the deposit facility interest rate is transmitted through monetary transmission channels to the deposit interest rate which in turn affects the private savings. Therefore, the relation between NIRP and the monetary transmission channel is relevant for the research on the relation between NIRP and private savings. The different monetary transmission channels examined in this research are the interest rate channel, the bank-lending channel and the risk-taking channel. For this research taken together these channels constitute the monetary transmission mechanism, consistent with the literature on NIRP and bank profitability (Arteta et al., 2016; Basten & Mariathasan, 2018; Borio et al., 2017; Borio & Gambacorta, 2017; Bräuning & Wu, 2017; Demiralp et al., 2019; Drechsler et al., 2017; Eggertsson et al., 2017; Eisenschmidt & Smets, 2019; Goodhart & Kabiri, 2019; Lopez et al., 2018; Molyneux et al., 2020).

Furthermore, from the literature on NIRP and bank profitability the conclusion is drawn that negative policy interest rates resulted in more loan extensions by the banks (Borio & Gambacorta, 2017). However, this effect becomes insignificant after a critical value of the policy interest rate. The latter result is similar to the findings of Molyneux et al. (2020) which found a negative effect of the introduction of NIRP on the extension of loans relative to banks in countries which did not implement NIRP. Secondly, Molyneux et al. (2020) found evidence for the hypothesis of the reversal interest rate as proposed by Brunnermeier & Koby (2017). As the effects of further NIRP are unknown because central banks have never encountered them on this scale before, the reversal interest rate is an interesting hypothesis which requires further research. The question is to what extent are these findings confirmed by the findings in the field on private savings.

[2] For the ECB this is the deposit facility rate, for Sveriges Riksbank this is the deposit rate, Swiss National Bank this is the policy rate and fort he Danmark Nationalbank this the interest rate of the certificates of deposit

As NIRP has only been implemented recently, the effects of this unconventional monetary policy require more research to fully understand. The available research indicates contradictory results from NIRP. The intended effects of decreasing the policy interest rate are increased loan extension by banks and a decrease in private savings. However, in the literature there is a discussion whether the effects of NIRP are consistent with the aims of NIRP (Altavilla et al., 2019; Demiralp et al., 2019), diverge from the desired effects (Goodhart & Kabiri, 2019; Heider et al., 2019; Jobst & Lin, 2016) or even change from a positive to a negative relation after a specific reversal interest rate (Brunnermeier & Koby, 2017; Eggertsson et al., 2017). To what extent are these findings for the loaning markets reflected by the private savings. Thereby this research pursues to contribute on filling the gap in the literature on the relationship between NIRP and private savings. As the current state of the empirical literature only includes research of the effect of NIRP on bank lending (Altavill et al., 2019; Apergis & Christou, 2015; Basten & Mariathasan, 2018; Demiralp et al., 2019; Goodhart & Kabiri, 2019; Heider et al., 2019; Molyneux et al., 2020). To add to the literature on this research subject the aim of this research is to analyse the relationship between private savings and NIRP. Thereby, answering the research question "To what extent is there a negative relation between NIRP and private savings?" Where a possible negative relationship between private savings and NIRP, would indicate the reverse effect from what is desired by the central banks.

In order to estimate the relationship between private savings and NIRP this research employs empirical methods, specifically panel data regression analysis. The estimation is complicated due to the fact that the relation between the decreasing policy interest rate and private savings is an indirect relationship. Secondly, NIRP is merely one of multiple conventional and unconventional monetary policies implemented, complicating the distillation of the effect of NIRP on private savings. In order to research the relationship between the policy interest rate and the private savings, the paper examines the relationship using different empirical models. The base regression model estimates the relationship between the policy interest rate and private savings, with two separate models for negative and positive values of the policy interest rate. Furthermore, the research employs an empirical model featuring a dummy variable for NIRP. This paper will consider all countries which have implemented NIRP in the analysis. These countries include Denmark, Sweden, Switzerland, the Euro-area[3]. In addition, to the policy interest rate and consistent with the literature on private saving determination the analysis includes public savings, the working population, economic uncertainty and economic volatility as independent variables (Aizenman et al., 2015, 2019; Doménech et al., 2000; Loayza et al., 2000b; Masson et al., 1998; Masson & Tryron, 1990; Nabar, 2011; Ramajo et al., 2006; Serres & Pelgrin, 2003).

[3]Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia and Spain. However, Cyprus, Estonia, Latvia, Lithuania, Malta, Slovakia and Slovenia are excluded for reasons later demonstrated.

The methodology for the empirical analysis has been advanced by development economists which have been analysing the relationship between private savings and different variables including the interest rate. The literature on the relationship between the interest rate and private savings is inconclusive on the nature of the relationship. The different authors found both results indicating a positive (Loayza et al., 2000b; Masson et al., 1998) and negative (Aizenman et al., 2019; Ramajo et al., 2006) relation between interest rates and private savings. The literature on NIRP, zero lower bound (ZLB) and the transmission mechanism provides us with a direction that this relationship could alter when the policy interest rate moves further into negative territory. The current hypothesis in the literature is that predominantly prolonged negative policy interest rates could lead to a reversal in the effects of this unconventional monetary policy (Arteta et al., 2016; Brunnermeier & Koby, 2017). Given both positions, this research combines both methodological approaches into one, where the private savings are determined by the policy interest rate combined with different variables which affected the private savings as found in the literature on private savings determination.

The results from the all the empirical models of this research are inconclusive, where the NIRP model indicates a positive relationship between NIRP and private savings. Here decreasing negative values of the policy interest rate would lead to lower values of private savings. In contrast to the dummy empirical model which suggests a negative relationship between NIRP and private savings. Indicating that lower negative values of the policy interest rate lead to increased values for private savings.

The structure of the remainder of this thesis will be as follows. The second chapter contains the literature review where the different theoretical backgrounds of the effects of NIRP, the determination of private savings and the transmission of monetary policy through the bank profitability will be presented. Furthermore, the methodology and data section expand on the quantitative research strategy and the data used for the econometric analysis. The fourth chapter contains the results from the econometric analysis, followed by the discussion and conclusions of these results including limitations of the research.

2. Literature Review

2.1 Negative Interest Rate Policy (NIRP)

Before the implementation of NIRP economists and central banks followed the idea of the ZLB of zero percent policy interest rate. Where central banks could not decrease the policy interest rate beyond the ZLB as the expectation was that it would lead to mass conversion from savings to cash (Heider et al., 2019; Rogoff, 2017). This idea is supported by the concept of opportunity costs, where if the opportunity cost of holding savings is equal to that of cash, individuals would convert it all (Altavilla et al., 2019). Due to the costs of transport, storage and insurance the effective lower bound at which a mass conversion from savings to cash would initiated would slightly smaller than zero (van Riet, 2017). As interest rate below the ZLB for deposits as these can be converted to paper currency with a zero nominal interest (Agarwal & Kimball, 2015).

This theory, however, does not take into account any other reasons for saving aside from earning interest. However, as central banks lowered their nominal interest rates further without achieving the desired effects of price stability and economic growth, the central banks moved to NIRP (Palley, 2016b). In theory a decrease of the policy interest rate into negative territory should have the same effect as a cut in the positive territory (Arteta et al., 2018). As central bank further lowered the policy interest rate, the inflation rate was still under the target value. Furthermore, private savings were abundant in contrast to shortcoming in investment. This caused the central banks to implement NIRP to stabilize inflation and support economic growth.

Under NIRP a central bank charges interest on the excess reserve deposits at the central bank instead of paying interest on these excess reserves in conventional monetary policy. This unconventional monetary policy is implemented in order to further stabilize inflation expectations and promote economic growth. The NIRP was unprecedented and there was fear of mass conversion to cash, when deposit rates would decrease below zero percent. On the contrary survey evidence by the ING bank states that 76% of the surveyed individuals would convert their deposits to cash if their bank would set negative deposit rates (Eggertsson et al., 2019). This mass conversion from bank assets to cash did not occur during the writing of this paper. However, this could occur in the long run. As there are no precedents of higher negative policy interest rates, the fact we can state is that there did not occur any mass conversion to cash under the lowest Danish policy interest rate of -0.75% (Jensen & Spange, 2015).

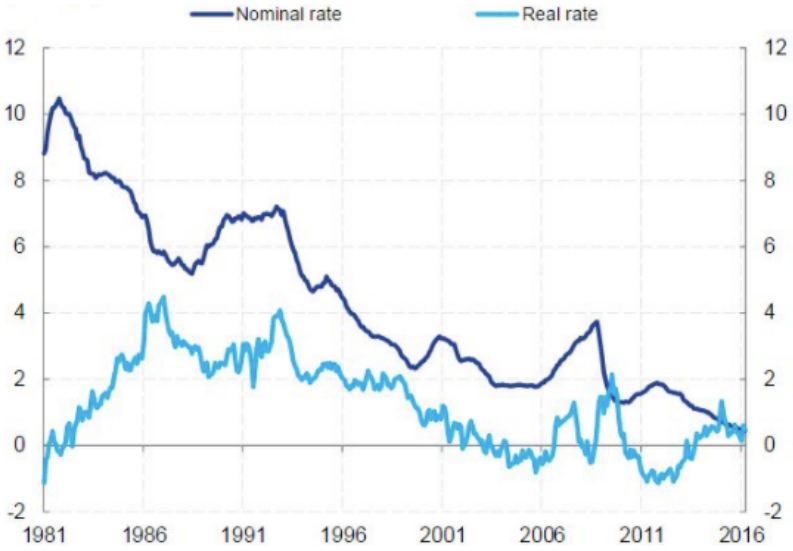
While lower interest rates in general incentivize increased lending by banks, which should spur investment and consumption and thereby inflation and economic growth (Bech & Malkhozov, 2016;

Eisenschmidt & Smets, 2019). However, the transmission of the monetary policy may be impaired due to the ZLB on deposits. The effect of this differs between small banks for the larger part funded by deposits and the larger banks which rely more on wholesale banking activities (Claessens et al., 2018; Eisenschmidt & Smets, 2019). The larger banks are able to manage the interest rate risk to a greater extent and are less likely to impair the transmission of monetary policy. Early results from the NIRP are the boosting of asset prices, helping to provide loans and supporting the rebalancing of bank balance sheets (Jobst & Lin, 2016).

The empiric literature on the effects of NIRP on bank lending is inconclusive in the direction of the relationship. As different empirical papers draw alternate conclusions on the effect of NIRP on bank lending. Firstly, Demiralp et al. (2019) finds that NIRP imposed increased bank lending on highly exposed banks, highly exposed to the extra costs levied on the excess reserves, with the prospect of lower bank profitability effects of NIRP (Demiralp et al., 2019). Secondly, Altavilla et al. (2019) finds that the rebalancing of assets by banks to prevent costs of holding excess reserves. Thereby, transmitting NIRP to the economy and increasing bank lending (Altavilla et al. 2019). Furthermore, Albertazzi et al. (2016) finds that the difference in transmission of conventional and unconventional monetary policy. For bank lending capital and economic constraints are the main determinants for bank lending. Alternatively, Molyneux et al. (2020) shows that after implementing NIRP bank lending was limited relative to non-NIRP countries. Secondly, Goodhart & Kabiri (2019) confirmed that the decrease in bank profitability countered the expansionary effects on bank lending. Thirdly, Apergis & Christou (2015) demonstrates that at lower policy interest rates, monetary policy is unable to increase bank lending. Furthermore, Basten & Mariathasan (2018) finds that relative to cuts in positive territory, NIRP is less effective in promoting bank lending. Lastly, Heider et al. (2019) shows that increases in the risks taken by bank contrasted by lower bank lending.

The effect of NIRP on private savings is an indirect effect as it is based on the pass-through of monetary policy towards the interest rate channel of the monetary mechanism. The unconventional monetary policy managed to decrease the interest rates in the Euro area (van Riet, 2017). The nominal deposit rates for households and corporations follow a zero bound level, which is a deposit interest rate close to or equal to zero percent (Eggertsson et al., 2019). While inflation is beneath the target level, close to 2% inflation. The inflation rate still exceeds the deposit rate, making the real deposit interest rate negative, as illustrated by graph 1 (van Riet, 2017). While banks are not passing on the negative policy interest rates onto their depositors, aside from a few select cases where corporate depositors were charged interest on their deposits (Bech & Malkhozov, 2016). Despite not decreasing the deposit rate into negative territory, increases in fees and other non-interest income have been observed (Claessens et al., 2018; Eggertsson et al., 2019). This translates to a decrease in the real return from deposits. Banks

increased lending after the first period of NIRP, as the unconventional monetary policy managed to decrease the interest rates in the Euro-area (van Riet, 2017).



Graph 1, The difference between nominal and real interest rates on short-term bank deposits in euro area countries from 1981-2016 (Source ECB)

When regarding the long-term effects of NIRP when the unconventional monetary policy is prolonged and extended, there are multiple problems. To begin with financial stability of the countries where NIRP is implemented. As the lower interest rates forced financial intermediaries to search for a yield in riskier assets and markets (Nucera et al., 2017; van Riet, 2017). The increased demand for risky assets could lead to the formation of asset price bubbles (Arteta et al., 2018; Nucera et al., 2017). When the asset price bubbles burst this could lead to an economic recession, as in the dot-com bubble burst of 2000 and housing bubble burst of 2008. Furthermore, the cheap credit could lead to higher debts for corporations or individuals, which can only be sustained due to NIRP. Following on, institutional investors like pension funds and life insurance companies are faced with higher liabilities, as these are discounted at a lower level of interest. As the result of the increased liabilities, pension funds face a dubious decision between raising pension contributions or lowering future pension entitlements (van Riet, 2017). Finally, the lower costs of debt can lead to irresponsible fiscal policy, forming a disincentive for structural reforms of public expenditure. Taken together these negative externalities of NIRP pose a serious threat to financial stability (van Riet, 2017).

Another issue with long term effects of NIRP are the redistribution effects. While redistribution is conventionally determined by the central government and agreed upon by parliament, the decision now lies to some extent with the central banks. As income from interest decreased since the implementation of NIRP while the remaining gains are taxed in most countries (Bindseil et al., 2015; van Riet, 2017). This can be seen as a double taxation of savers, a group which is formed of the lower income level individuals. In contrast, assets prices have soared due to the lower costs of liquidity and shareholders

have profited from this effect. Concluding that there has been a redistribution from savers to the borrowers, which follows the lines of demarcation from the poor to the rich (Bindseil et al., 2015). Therefore, the sustainability of the NIRP in the case that goals of the unconventional monetary policy are not achieved is taken into question (Summers, 2014).

2.2 Monetary Transmission Mechanism

The relation between bank profitability and NIRP is relevant for this research as it gives an indication of the functioning of the monetary transmission mechanism. Due to NIRP the interest rate margin is decreased and as deposit rates are downwards sticky, this affects the profitability of banks with regard to their traditional banking activities such as lending and borrowing (Altavilla et al., 2018; Lopez et al., 2018; Molyneux et al., 2020). If this process continues banks will not increase lending, thereby impairing the monetary transmission mechanisms. In the literature there are two different positions, debating whether monetary policy, in this case NIRP, has or has no or little effect on bank profitability (Altavilla et al., 2019; Demiralp et al., 2019) and therefore does or not affect the monetary transmission mechanism. On the other hand, there economists who argue that the NIRP negatively affects bank profitability (Borio et al., 2017; Borio & Gambacorta, 2017; Drechsler et al., 2017; Goodhart & Kabiri, 2019; Lopez et al., 2018; Molyneux et al., 2020; Nucera et al., 2017) and thereby impairing the monetary transmission mechanism. The monetary transmission mechanism is determined by three different channels, the interest rate channel, the bank-lending channel and the risk-taking channel. These channels are an indication of how and to what extent, monetary policy is transmitted to the economy through the financial system.

2.2.1 Channels

According to the interest rate channel monetary policy is passed on to loan and deposit interest rates in the corresponding financial system. However, when the effective lower rate is reached for deposits the transmission mechanism is limited in theory. As banks do not or are not allowed to charge their deposits negative rates, the policy interest rate at NIRP cannot be transmitted (Eisenschmidt & Smets, 2019). Therefore, NIRP disturbs the mechanism at this point as the projected loss from not lowering the deposit rate could be reduced by raising the interest rate on loans, instead of lowering it. In order to prevent a decrease in bank profitability (Demiralp et al., 2019). Empirical findings on the topic indicate that after a period of NIRP the bank fees and lending interest rates increased observed in Switzerland and Sweden (Basten & Mariathasan, 2018; Eggertsson et al., 2017).

The bank lending channel states that expansionary monetary policy increases the supply of loans by banks as the expansionary monetary policy incentivizes the banks to provide loans. It is on this point that economists debate each other on whether this channel stays intact or ceases to transmit monetary

policy in the case of NIRP. The costs of excess liquidity can push banks to decrease excess liquidity by providing more loans or the decreased profitability, as the most prevalent argument is made the channel is left intact by NIRP (Arteta et al., 2016; Bräuning & Wu, 2017; Demiralp et al., 2019).

The lower policy interest rate can lead to the interchanging of relatively safe assets to more risky assets in search of a yield. The risk-taking channel is further amplified by the NIRP. Furthermore, targets for the rate-of-return push banks to accept higher risk in return for demand rate-of-return under the lower return from interest. When the NIRP becomes more strongly negative this channel can be of great importance as it provides support for the reversal policy by (Brunnermeier & Koby, 2017). As the policy interest rate would reach a critical level where the banks are not able to adapt and make profits on retail banking activities and adjust their approach. The alternative strategy of the banking sector could potentially lead to adverse economic results in contrast to the desired outcome of the NIRP.

2.2.2 Transmission intact

Following the earlier rationale why banks are unlikely to charge negative rates to their depositors, this leads to NIRP having a different outcome relative to the conventional decreasing of the policy interest rate. The competition between banks, regulation and the paper currency as an alternative form or currency with zero yield all prevent negative deposit interest (Demiralp et al., 2019). Furthermore, the current ease and low switching costs for households incentivize depositors to switch when their bank charges negative interest rate on their deposits. The argument for the interest channel to remain intact in transmitting monetary policy argues that narrowing the profit margin can weaken the interest rate channel as banks could be incentivized to raise the loan rates due to the lower profit margins. However, Euro banks were more likely to charge negative interest rates after NIRP (Demiralp et al., 2019). The transmission channel from monetary policy to deposit rates is not impaired beyond the ZLB.

The NIRP has been expansionary by causing banks which are exposed to NIRP, as they have high excess liquidity to increase their lending thereby reducing to have their profitability affected by NIRP. Expansionary monetary policy should incentivize banks to increase their provision of loans. There is a division in the literature whether this channel stays intact during NIRP. The paper by Demiralp et al. (2019) argues that it is strengthened as less excess liquidity translates to more loans. Consequently, there is a decrease in the opportunity costs for holding deposits which supports the bank-lending mechanism.

As the banks change their asset composition in favour of high-yielding assets to compensate for the lower interest profit margin, as stated by the risk-taking channel (Demiralp et al., 2019). The alternating from very safe central bank assets for more risky assets, loans or bonds, in a search for yield. Thereby, increasing the supply of loans to the economy supporting the monetary transmission mechanism.

Furthermore, aside from the high demand for safer assets banks have experienced a contraction in deposits even when the banks charged negative interest rates (Altavilla et al., 2019).

2.2.3 Transmission disrupted

When the policy interest rate reached the ZLB, banks started to have concerns about losing depositors when further reducing the deposit interest rate. Therefore, banks are unwilling to charge negative interest rates to their depositors (Lopez et al., 2018). This is one of the reasons why the monetary transmission mechanism is disrupted by NIRP, the downward sticky deposit rate combined with NIRP is therefore a threat to the funding of banks (Borio & Gambacorta, 2017; Molyneux et al., 2020). Secondly, the low interest rate environment is a risk to bank profitability as it tightens the margins on interest rates, which makes retail deposit banking less profitable (Borio & Gambacorta, 2017; Lopez et al., 2018). The result is that bank profitability is unaffected by negative nominal interests in general, but they do endure significant net interest income losses. While nominal deposit rates are sticky at zero. Overall NIRP has a small positive but insignificant effect of net income (Goodhart & Kabiri, 2019). Although, the general effect is low, as it is affected by a decline in net interest income by non-interest income. When the policy rates are below 1,5% the margins are squeezed progressively (Goodhart & Kabiri, 2019).

About the question whether NIRP affects bank profitability and thereby negatively influences bank lending, there has been a lot of research. One of the findings indicates a positive relationship between the short term interest rate and the return on assets (Borio et al., 2017). This empirical research paper demonstrates that the lower interest rate margins dominates the effect of increased loan provision in the profitability of banks in fourteen advanced countries during the period 1995-2012. This empirical finding is corroborated by Drechsler et al. (2017), which found that as the difference between short rates and policy interest rates increased, deposits decrease which triggers a decrease in bank lending. This supports the argument that when bank profitability is decreased, the bank lending follows a negative movement which also found by Molyneux et al. (2020). Finally, Borio & Gambacorta (2017) found that the lower level of policy interest rates, the policy is less effective at supporting to increase bank lending, compared to higher levels of policy interest rates.

2.3 Determination of Private Savings

When considering which factors influence private savings, the most evident variable is the interest rate. The Neo-classical economic theory asserts that lower interest rates encourage individuals to increase the present day consumption, as it lowers the cost of present consumption relative to future consumption (Aizenman et al., 2019; Serres & Pelgrin, 2003). Lower interest rates make not postponing consumption more attractive, yet negative interest rates make postponing consumption even costly to individuals.

Accordingly, interest rates would seem a powerful motivator for private savings. Nonetheless, individuals save to meet savings targets for retirement and consumption smoothing. When the return on savings decreases people still need their requirement and move to other investments to compensate for the lower return of their savings, consumption smoothing (Aizenman et al., 2019; Giovannini, 1983; Nabar, 2011; Palley, 2016a).

The economic theory is ambiguous on the relation between the interest rate and the private savings. As the determining factor is whether the income effect or the substitution effect prevails. The substitution effect states that a lower interest rate leads to the substitution of savings by consumption. Whereas, the income effect assets that the decrease in interest income from the lower interest rate leads to lower consumption relative to saving. In the literature there are different positions on this matter. On the one hand there are results show that the income effects outweigh the substitution effects, here the real interest rate has a negative effect on the private savings (Loayza et al., 2000b; Ramajo et al., 2006). Whereas other research shows that there is a positive relation, corroborating the substitution effect (Masson et al., 1998). The effect of the policy interest rate on private savings is exceedingly ambiguous due to the indirect nature of the relationship. In addition, the effect of the policy interest rate is dependent on the monetary policy transmission mechanism. Furthermore, monetary mechanism is potentially impaired as the result of NIRP. Altogether, the prolonged negative policy interest rate can potentially alter the effect of the policy interest on private savings (Brunnermeier & Koby, 2017; Eggertsson et al., 2017). Consequently, this paper hypothesizes a negative effect of NIRP on private savings. Thereby, deviating from the regular effect of the policy interest rate on private savings which this research hypothesizes as displaying a positive relationship. In the case of the positive values of the policy interest rate, this paper expects the regular positive relationship between the policy interest rate and private savings.

In addition, the effect of changes in the demographics characteristics of a country are on private savings have been proven. Here the dependency ratio has a negative effect on private savings (Giovannini, 1983; Loayza et al., 2000b; Masson et al., 1998) following the life-cycle hypothesis by Modigliani (1966). This hypothesis states that at a young age individual consume most of their income, while individuals of the working age save for their retirement. This retirement fund is then completely consumed during the retirement. Therefore, countries with a higher dependency ratio, indicating a higher representation of young and old individuals results in lower private saving. As the former consumes most of his disposable income and the latter is consuming its savings during retirement. Contrarily, the working demographic section of the population saves to pay off debts and saves for future retirement. Empirical research on the relation between private savings and the dependency ratio indicates a negative relationship (Masson & Tryron, 1990). However, the relationship between the dependency ratio and private savings becomes more ambiguous if the different types of pension systems are taken into

account. Where some require more private savings, which are taken into account, and others save the majority for their retirement at pension funds (Serres & Pelgrin, 2003).

The influence of disposable income on private savings is also of importance in conventional economic theory. Where higher disposable income leads to an increased share of private savings. The effect of income is stronger for developing countries with respect to developed countries (Masson et al., 1998). The relation between income growth and private savings was examined by Carroll & Weil (1994) and this paper found that income growth Granger causes increased private savings. To understand their findings, the paper advises to look at the relationship between income and private savings as habit formation instead of the regular consumption versus savings. Furthermore, Masson et al. (1998) also deviates from the standard model in their research stating that instead of consumption being planned for a lifetime, like in the life-cycle hypothesis, consumption and therefore private savings is planned around changes in income. Lastly, the effect of income on private savings is the largest at lower levels of income. For the more developed countries this relationship is close to zero or even negative (Masson et al., 1998). Therefore, disposable income is not included in the empirical analysis, as the research focusses on developed European economies.

The fiscal position of the national government is another variable to consider, where a government deficit leads to public borrowing affecting private saving. The government budget balance has a negative relation with private savings, where a government budget surplus has a negative effect on private savings, following the Ricardian equivalence where public savings offsets private saving (Vanlaer et al., 2020). Where the Ricardian equivalence states that without tax distortions present there is a one on one trade-off between public and private savings (Aizenman et al., 2019; Loayza et al., 2000a; Masson et al., 1998). The full Ricardian equivalence is rejected in the empirical literature and estimation of the effect range between 0.25-0.60 (Aizenman et al., 2019; Loayza et al., 2000b). Where Doménech et al. (2000) found evidence supporting that shocks in government budget balances were only compensated for a factor of 0,4 of their respective GDP. While these empirical papers reject the full Ricardian equivalence, the relationship between private savings and public savings is established. Lastly, taxes being a part of fiscal policy, do not significantly affect private savings (Loayza et al., 2000a).

Finally, private saving also has a precautionary motive as an insurance against income loss due to economic recessions. In the literature there is a distinction between volatility and uncertainty, where volatility is defined as the tendency of economic variables to fluctuate and uncertainty as the unpredict ableness of fluctuations (Aizenman & Marion, 1999). Increased volatility makes risk-averse individuals more cautious about their consumption and increases the precautionary motive for private savings (Aizenman et al., 2019). While this argument is refuted empirically by (Aizenman et al., 2015) who finds a negative relationship between economic volatility and private savings. These findings stem from

the fact that most databases do not make a distinction between household and firm data with respect to the private savings data. When countries have a large informal sector, this increases the effect of economic volatility on private savings (Aizenman & Marion, 1999). Additionally, uncertainty could partially explain why the retired individuals still save some part of their income despite being retirement. Where in contrast to the life-cycle hypothesis, the retired individuals still save some part of their income (Skinner, 1988; Zeldes, 1989). Uncertainty is mostly expressed as the level of inflation. The relationship between private savings and inflation is twofold. Besides the precautionary motive, inflation leads to a lower real interest rate which should lead to lower private savings (Schrooten & Stephan, 2004). Furthermore, Loayza et al. (2000b) found that with increasing inflation, a proxy for economic uncertainty, savings increased. This precautionary saving is also related to the state of the welfare system, where in more developed welfare systems the relation between private savings and economic uncertainty is weaker (Aizenman et al., 2019).

3. Methods & Data

3.1 Methodology

For the methodology of this research, the paper bases the methodology on earlier research on the determination of private savings (Aizenman et al., 2015, 2019; Doménech et al., 2000; Loayza et al., 2000b; Masson et al., 1998; Masson & Tryron, 1990; Ramajo et al., 2006; Serres & Pelgrin, 2003). In addition, this methodology is adapted to fit the direction of this research, that is including the policy interest rate a few of the empirical models and other control variables. Additionally, the research employs a dummy variable empirical model. Using these empirical models this research means to estimate the effect of NIRP on private savings.

In order to operationalize the research question, this paper formulates different empirical models to estimate the determination of private savings. These models will feature variables from the literature of the determination of private savings. Three models include the policy interest rate variable relating to a part of the research on bank profitability. Thereby, estimating the relationship between the policy interest rate and private savings using a base model and the effects of the NIRP on private savings using a separate model. The other strand in the literature on bank profitability does use the interest rate as a numerical variable (Altavilla et al., 2018; Borio et al., 2017; Borio & Gambacorta, 2017; Goodhart & Kabiri, 2019). This paper builds on the latter strand of bank profitability and operationalizes NIRP as the value of the policy interest rate. This decision is based upon the research question at hand, which specifies not only the implementation of NIRP but also the severity of the negative policy interest rates. The last model employs a dummy for the implementation of NIRP in order to estimate the magnitude of its effect. Where the dummy variable has the value of 1 if the policy interest rate is negative and a

value of 0 when the policy interest rate is positive. In the use of this empirical model this paper follows another section of the literature on bank profitability. In the empirical literature on the relation between NIRP and bank profitability, the effect of NIRP is estimated by using dummies from the implementation of NIRP and onwards (Demiralp et al., 2019; Heider et al., 2019; Lopez et al., 2018; Molyneux et al., 2020; Nucera et al., 2017).

The regression analysis will take the form of a panel regression analysis where private savings is the dependent variable and the nominal policy interest rate is the main independent variable. Additionally, the first three regression analyses include five control variables; public savings, the dependency ratio, economic uncertainty and economic volatility as used in preceding empirical research (Aizenman et al., 2015, 2019; Loayza et al., 2000b; Nabar, 2011; Ramajo et al., 2006; Serres & Pelgrin, 2003). The regression equation is stated by equation 1.

$$PS_{it} = \beta_0 + \beta_1 PIR_{it} + \beta_2 PubS_{it} + \beta_3 WorkPop_{it} + \beta_4 EconUn_{it} + \beta_5 EconVol_{it} + \nu_i + \gamma_t + u_{it}$$

Equation 1, the regression equation for the base, NIRP and PIRP model

Where PS_{it} is private savings, PIR_{it} is the policy interest rate, $PubS_{it}$ is the public savings, $Demo_{it}$ is the demographic variable, $EconUn_{it}$ represents the economic uncertainty, $EconVol_{it}$ represents the economic volatility, γ_t represents the time fixed effects, ν_I represents the country fixed effects and ε_{it} is the error term which are robust standard errors. Where the theoretical expectations of the coefficients are $\beta_1 > 0$, $\beta_2 < 0$, $\beta_3 > 0$, $\beta_4 > 0$ and $\beta_5 > 0$. The subscript t denotes the year and i denotes the country.

The regression formula represented by equation 1, is the base regression model where all the values for the policy interest rate are included. Additionally, the two other empirical models which employ only values of larger of equal than zero and smaller or equal than zero for the policy interest rate. Using these two separate models this paper aims to distinguish between the effects of positive and negative interest rate policy. The second empirical model, the NIRP model, will contain only values of the policy interest rate smaller than zero. Therefore, the theoretical expectation for β_1 is that it is smaller than zero. The third, positive interest rate policy (PIRP), will contain only values of the policy interest rate larger or equal to zero. The theoretical expectation for β_1 will be larger than zero as for the base regression. In the interpretation of the coefficient for the NIRP empirical model, the sign should be interpreted in reverse as the negative values of NIRP give an automatic negative coefficient. Therefore, this is not an indication of a negative relationship but a mathematical consistency.

$$PS_{it} = \beta_0 + \beta_1 NIRP_{it} + \beta_2 PubS_{it} + \beta_3 WorkPop_{it} + \beta_4 EconUn_{it} + \beta_5 EconVol_{it} + \nu_i + \gamma_t + u_{it}$$

Equation 2, the regression equation for the dummy model

For the dummy model the expectation for β_1 is in accordance with β_1 of the NIRP model, where expectation is that β_1 is smaller than zero. Furthermore, the expectations for the coefficients of the other variables remain the same as in the base model and the two variants. The regression formula for the dummy regression is given by equation 2.

The result for the Hausman test where the null hypothesis is that the random effects models is appropriate was rejected. This indicates that the regression model should use the fixed effects model. The advantage of the Fixed effects model is that it gets rid of the time country variation that does not change over time. The empirical analysis does not suffer from the drawback of the Fixed effects model, which is that it does not capture effects that do not change over time due to the time demeaned observations. Secondly, when testing for heteroskedasticity using the Breusch-Pagan test for the joint significance of the explanatory variables on the variance of the error term. This was the case for the dataset, forcing the regression the use robust standard errors. Lastly, the regressions were tested for autocorrelation using a Woolridge test for autocorrelation. The null hypothesis of no autocorrelation was not rejected, and the autocorrelation can explain some inflated results. The positive serial correlation affects the coefficients of the regression analysis, making them less reliable.

3.2 Data

For the regression analysis the research opted for a large selection of countries. While obviously limited to countries which have implemented NIRP. These countries of the initial selection are; Denmark, Sweden, Switzerland, the EMU countries (Austria, Belgium, Estonia, Finland, France, Germany Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Portugal, Slovakia, Slovenia and Spain) and Japan. The dataset of the OECD suffers from a few drawbacks. To begin with, Malta and Cyprus were not selected for the analysis as these countries are no members of the OECD, and therefore are not present in the dataset. The second problem resulted in Japan being dropped from the country selection for missing data on policy interest rates, public saving and net saving, making the country unfit for the empirical analysis. Secondly, Japan is the only non-European country in the dataset, making the analysis more prone to suffer from a misdirected analysis due to idiosyncratic shocks that are not administered in European countries.

The data is for the larger part collected from the OECD databank of National Accounts and Demography and Population, which publishes annual and quarterly data. From this dataset the observations for private savings, public savings, economic uncertainty, economic volatility were collected or estimated using this dataset. The data on the policy interest rate are collected from the ECB for the deposit facility rate of the EMU and from the others policy interest rates were collected from the Bank for International Settlements (BIS) (Bank for International Settlements (BIS), 2020). The ECB provides an extensive dataset on the deposit facility rate per day of the year. The BIS is a financial institution that provides banking services to central banks. The dataset covers a period of 20 years, ranging from the start of the EMU to the last available data. The data is long panel data set with 15 countries and 20 years of observations. The panel is unbalanced missing the demographic observations of the year 2019.

One problem facing this particular research set-up faces is that some countries joined the EMU at a later point in time with regard to the original countries. Malta, Cyprus, Slovenia, Slovak Republic, Estonia Latvia and Lithuania joined the EMU in the period from 2007 to 2015. In the dataset these countries would have the same policy interest rate as the original EMU countries as historic policy interest rates from the period before joining the EMU are not available. Therefore, these countries are dropped as well from the regression analysis as the information is missing.

3.3 Variables

Private savings is defined in the literature as the difference between the general government budget balance from the domestic savings (Aizenman et al., 2019; Giovannini, 1983; Masson et al., 1998; Ramajo et al., 2006). However, as most empirical studies include developed and developing studies, private savings is chosen over household savings data as the latter is less defined in developing countries. This is the consequence of that in developing countries the demarcation between corporate and household saving is ambiguous (Aizenman et al., 2019). Thereby, rendering the usage of household savings ambiguous.

Secondly, household saving data are regularly comprised of government surveys and other methodological approaches making the data difficult to compare. Therefore, this research follows the literature on the operationalization of private savings (Aizenman et al., 2019; Loayza et al., 2000b; Masson et al., 1998; Ramajo et al., 2006). The raw data on net savings were in the thousands of the local currency, which was divided by the GDP to match the public savings stated as a percentage of GDP. In the dataset the private savings were calculated as the difference between the net savings, which in turn was first adjusted by dividing it by GDP, and the public savings, thereby including household savings and corporate savings

The policy interest rate is given per day of the year and if adjusted by the central bank, this does not occur at a standard day of the month. This makes incorporating the policy interest rate and especially the changes in the policy interest rate in the regression analysis problematic. The other variables are computed annually, therefore the policy interest data requires adjustments. Either taking the arithmetic mean for the policy interest rate for a given quarter or year or stating the value of the policy interest rate at the end of the stated quarter or year. This paper opted for the arithmetic mean of the policy interest rate, to account for the duration of different values of the policy interest rate, this approach is not consistent with the literature (Altavilla et al., 2018; Borio et al., 2017; Borio & Gambacorta, 2017; Goodhart & Kabiri, 2019). The disadvantage of using the arithmetic mean of the policy interest rate is that outliers influence the observations to a greater extent. However, this argument does not go up for the policy interest rate as decreases or increases are minor.

To account for the public savings this paper employs the government budget balance following other research papers (Aizenman et al., 2019; Doménech et al., 2000; Loayza et al., 2000b, 2000a). This variable is expressed as the net lending or borrowing by the central government as a percentage of GDP. This variable aside from the regression analyse employed to calculate the private savings dependent variable, as described in the methodology section.

To express the different age structure in a country or the ageing of society the regression analysis applies a variable for encompass the difference in demographics. This is expressed in the regression analysis as the old-age dependency ratio, this is the ratio between the individuals typically not in the labour force (0-20 and 64+) and the individuals of working age (20-64). Thereby, following the literature (Giovannini, 1983; Masson et al., 1998; Masson & Tryron, 1990; Serres & Pelgrin, 2003). The dataset on the dependency ratios was incomplete as the observations for the year 2019 is missing for all the countries. Therefore, the observation of 2019 equals the observation of 2018.

Following the research by (Aizenman & Marion, 1999) this paper distinguishes between economic uncertainty and economic volatility. Economic uncertainty is expressed as the inflation rate, which is operationalized as the percentual change in the consumer price index relative to the previous year. Economic volatility is expressed as the standard deviation from GDP growth over the span of this research.

4. Results

4.1 Summary Statistics

Tables 1 up and until 4 indicate the summary statistics of the different empirical models. Where private savings as a percentage of GDP varies between -7.3% and 33.6% in the dataset. Negative private savings rates were expected as the dataset covers two major economic recession, the dot-com bubble burst of 2000 and the financial crisis of 2008, where massive unemployment was observed. The maximum value of 33.6 private savings of GDP indicates vast differences between the observations, also seen in the standard deviation of 4.26. The summary of the policy interest rate variable displays a mean above zero, indicating that the NIRP is not the predominate policy in effect throughout the dataset. Public savings in this dataset have a negative mean indicating that central governments, on average, have a general budget deficit. Furthermore, the minimum and maximum values of the observation display the reverse of the minimum and maximum values of private savings. This is an indication of the validity of the partial Ricardian equivalence.

The mean for the dependency ratio is relatively high, which is expected of European countries where the population is generally aging. The economic uncertainty variable displays a mean which is close to the inflation target of 2% of maintained by central banks of the countries in this dataset. The minimum value of negative 4.4 is found in Ireland in 2009, indication strong deflation during the Financial crisis. Finally, economic volatility is on average 1.7 so the standard deviation from economic growth. Lastly, the mean of the dummy variable NIRP is 0.1557 indicating the skewedness of the data towards the positive values of the policy interest rate.

	Mean	*Standard Deviation*	*Minimum*	*Maximum*
Private Savings	8.99	4.26	-7.34	33.65
Policy Interest Rate	1.15	1.40	-0.73	5.52
Public Savings	-1.77	3.86	-32.06	6.85
Working Age Population	60.44	1.63	55.96	64.09
Economic Uncertainty	1.66	1.28	-4.48	5.59
Economic Volatility	1.74	2.05	0.01	19.90
Observations	315			

Table 1, Summary statistics table main regression

	Mean	*Standard Deviation*	*Minimum*	*Maximum*
Private Savings	7.43	4.72	-7.34	14.02
Policy Interest Rate	-0.34	0.15	-0.73	-0.02
Public Savings	-1.02	2.19	-7.36	3.66
Working Age Population	59.44	1.90	55.96	64.09
Economic Uncertainty	0.81	0.80	-1.74	2.63
Economic Volatility	1.06	2.19	-1.74	2.63
Observations	84			

Table 2, Summary statistics table NIRP regression

	Mean	*Standard Deviation*	*Minimum*	*Maximum*
Private Savings	9.58	3.94	-2.65	33.65
Policy Interest Rate	1.69	1.25	0	5.52
Public Savings	-2.05	4.29	-32.06	6.85
Working Age Population	60.80	1.36	57.48	63.83
Economic Uncertainty	1.97	1.28	-4.48	5.59
Economic Volatility	1.99	1.94	0.02	10.34
Observations	231			

Table 3, Summary statistics table PIRP regression

	Mean	*Standard Deviation*	*Minimum*	*Maximum*
Private Savings	8.99	4.26	-7.34	33.65
NIRP	0.27	0.36	0	1
Public Savings	-1.77	3.86	-32.06	6.85
Working Age Population	60.44	1.63	55.96	64.09
Economic Uncertainty	1.66	1.28	-4.48	5.59
Economic Volatility	1.74	2.05	0.01	19.90
Observations	315			

Table 4, Summary statistics table Dummy regression

4.2 Results

When examining the regression output for the base Fixed effects model the adjusted r-square indicates a low goodness of fit for this model, explaining only 29.2% of the variation of private savings. When delving into the coefficients of the model the policy interest rate is significantly different from zero, at least 10% significance level. The coefficient is positive which contradicts the hypothesis of this paper, where the coefficient would negative or close to zero. The coefficient of the policy interest rate indicates a positive relationship between the policy interest rate and private savings. This positive relationship indicates that lower values of the policy interest rate result in lower values of private savings.

The coefficient of public savings is highly significant and the coefficient is negative as the theoretical framework on Ricardian equivalence predicted (Aizenman et al., 2019; Loayza et al., 2000b; Masson et al., 1998). The value of negative 0.486 fits in the range, negative 0.25-0.6 indicated by earlier empirical estimations of the relation between private and public savings (Aizenman et al., 2019; Doménech et al., 2000; Loayza et al., 2000b). Rejecting a full version of Ricardian equivalence, although still confirming the relationship. The demographic variable states a negative relationship with private savings, as described in the literature review. However, this coefficient is not significant at, at least 10% significance level. Furthermore, the economic uncertainty coefficient is not significant as well, however the sign does corroborate the empirical findings in the literature. Lastly, economic volatility deviates from the estimates in the empirical literature as it indicates a negative relationship and the coefficient is insignificantly different from zero.

	Base	*NIRP*	*PIRP*	*Dummy*
Policy Interest Rate	0.675*	-1.486*	0.781***	
	(0.322)	(0.697)	(0.231)	
Public Savings	-0.540***	-0.756***	-0.509***	-0.445***
	(0.110)	(0.429)	(0.112)	(0.123)
Working Age Population	-0.540	-1.557***	-0.581	-0.506
	(0.575)	(0.429)	(0.506)	(0.574)
Economic Uncertainty	0.176	-0.0946	-0.277	0.239
	(0.247)	(0.185)	(0.190)	(0.252)
Economic Volatility	-0.0725	0.0332	-0.337**	-0.0962**
	(0.0595)	(0.0325)	(0.119)	(0.0423)
NIRP				-1.692*
				(0.940)
Constant	39.72	98.65***	43.75	39.00
	(34.42)	(25.55)	(38.57)	(34.71)
Observations	315	96	231	315
R-squared	0.303	0.711	0.93	0.281
Adjusted R-squared	0.292	0.695	0.278	0.270

Standard in parentheses
** p<0.10, ** p<0.05 and *** p<0.01*

Table 5, regression output Base model, NIRP model and PIRP model and Dummy model with robust standard errors

Most importantly for answering the research question of the research, are the results from the NIRP empirical model. The coefficient for the policy interest rate variable is strongly negative and significant at the 10% significance level. When reversing the sign of the coefficient this indicates a positive relationship between NIRP and private savings. When considering the rest of the coefficients, the values seem inflated. Most notably, when comparing these coefficients to the other two models the coefficients are much higher save for the coefficient for economic volatility. Furthermore, the adjusted r-squared of 0.711 confirms the above stated troubles of this empirical model. Lastly, the constant has the value of 98.65. This value is quite unreal as it would suggest that if all the variables are kept at zero the value for private savings would be 98.65% of GDP. These results indicate towards an inflationary bias of the results for the NIRP model.

The dummy model has as much observations as the base model and most coefficients of the different variables are comparable to the base model and the PIRP model. However, this model is only significant at the 10% significance level. The coefficient for the dummy variable is strongly negative in contrast to the other empirical models. The adjusted r-squared has a value of 0.270, comparable to the base and PIRP regressions.

5. Discussion and Conclusion

5.1 Discussion

The results from the base, PIRP and NIRP empirical models indicate that the relation between the policy interest rate and private savings is a positive relationship. Where cuts in the policy interest rate in the positive and negative territory resulted in decreasing private savings. However, the dummy empirical model shows a negative relationship between the policy interest rate and private savings. This implies that negative values of the policy interest rate lead to an increase in private savings.

Thereby, this research, for the larger part, has found different results in comparison to most other papers on the effects of NIRP on bank lending. Where the results from the dummy variable empirical model deviate from these findings, indicating a negative relationship between private savings and NIRP. Since multiple papers showed that the relationship between bank lending and policy interest rate changed with the introduction of NIRP (Borio & Gambacorta, 2017; Heider et al., 2019; Molyneux et al., 2020). Research which found the same results are for example (Altavilla et al., 2019), which found no lower bound for the effectiveness of monetary policy effecting bank lending. Or Demiralp et al. (2019) which found that the monetary transmission mechanisms remain intact during the period of NIRP, thereby the policy interest rate still affected deposit rates in regular fashion

There are some limitations of this study, first of all the country selection. While this research poses as a European study, there are a lot of countries missing from the analysis. These countries were not selected for joining the EMU later than the original countries. Secondly, generalizing these findings to other countries may be difficult due to the European perspective, making it not possible to apply the conclusion to for example Japan which also implemented NIRP. Therefore, the limitation from this study stems the early stage of NIRP, being first introduced in 2014. Thereby, limiting the time frame and country selection in severe form. The base regression and dummy model have sufficient observations (312), but the NIRP empirical model only has 94 observations. Furthermore, it is difficult to control for the other conventional or unconventional monetary policies implemented by the central banks.

The indirect relation makes generalizing the results even more difficult as changes in the monetary transmission mechanism influence the results. Furthermore, interest rates have shown a downwards movement for almost three decades (Caballero & Farhi, 2018; Eggertsson et al., 2017; Eggertsson &

Mehrotra, 2014; Summers, 2014). Accordingly, this movement can be held responsible for a large part of the effects. Therefore, the question arises whether NIRP caused the effect or whether these are the results from the economic crisis (Claessens et al., 2018). Finally, the endogeneity issue at hand should be discussed, as the negative policy interest rates were implemented during the years of economic crisis and continued as inflation did not increase.

The findings for the NIRP model of the empirical analysis of this research are quite unexpected as they give an unrealistic view of situation. Where in the NIRP regression the constant has the value of 98.65, indicating in the case of all the independent variables having the value of zero, 98.65% of GDP is privately saved. Leave for the economic volatility variable all the variables and the constant seem inflated making the drawing of conclusions unreliable. These findings could be the cause of the low number of observations of this empirical model.

In contrast to previous studies on the effects of NIRP which considers the effect on bank lending (Apergis & Christou, 2015; Arteta et al., 2016; Borio & Gambacorta, 2017; Demiralp et al., 2019; Eggertsson et al., 2019; Heider et al., 2019; Molyneux et al., 2020), this research examines the effect of NIRP on private savings. And differently than earlier findings on the relation between NIRP and bank lending, the results are inconclusive in indicating whether there is a difference between the regular decreasing of the policy interest rate and NIRP in its effect on private savings.

5.2 Conclusion

This paper studied the relationship between private savings and NIRP in multiple European countries. This research hypothesized to find a negative relationship between NIRP and private savings, deviating from the standard positive relationship between the policy interest rate and private savings. Secondly, the expectation was that the positive observations of the policy interest rate would display a positive relationship following the ordinary. The results from the different empirical model partially reject the hypothesis of this paper. The empirical findings are ambiguous where the NIRP empirical model finds a positive relationship and the dummy model a negative relationship between NIRP and private savings. Thereby, there is no clear indication whether that the continuation of the unconventional monetary policy would decrease private savings and instead promote consumption and investment. Through the increased consumption and investment, the central banks could achieve the goals of increasing inflation and economic growth.

Therefore, in answering the research question of this paper this research cannot state an unambiguous indication of the relationship between NIRP and private savings. As the empirical findings both confirm and reject the hypothesis of the negative relationship between NIRP and private savings.

The limitations in country selection, the indirect nature of the relationship between the policy interest rate and private savings and the inflated results from the regression analysis pose heavy limitations to the conclusion of this study. Thereby, decreasing the significance of this research. While the subject could bring about future research, which is needed as there is little research on the relationship between NIRP and private savings.

In future research the extended empirical research can look further into the relationship between NIRP and private savings. As with the availability of more data more reliable results can be expected. Furthermore, this research could delve into empirical corroboration of the reversal interest rate. Current evidence for the phenomenon is funded in economic modelling, which could benefit from empirical corroboration (Brunnermeier & Koby, 2017; Eggertsson et al., 2017). In addition, the link to lending as affected by NIRP and a possible difference between the both in the monetary transmission of policy could be interesting.

Appendix

A1 Hausman test results

	Coefficients (b) fe	(B) re	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
polintrate	.6399188	.626682	.0132368	.0131617
pubsave	-.5348494	-.5133637	-.0214858	.0031583
workpop	-.494699	-.4198852	-.0748139	.04822
infla	.1803357	.1510512	.0292845	.
SD	-.076322	-.0795808	.0032589	.

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 163.37
Prob>chi2 = 0.0000
(V_b-V_B is not positive definite)

A2 Breusch-Pagan test results

	Error term
Policy interest rate	-0.396
	(1.439)
Public savings	-0.647
	(0.496)
Working age population	-4.450***
	(1.883)
Economic uncertainty	-2.453*
	(1.415)
Economic volatility	0.186
	(-0.786)
Constant	292.9***
	(112.7)
Observations	312
R-squared	0.068
Adjusted R-squared	0.007

Standard errors in parentheses
* p<0.10, ** p<0.05 and *** p<0.01

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