Estimating the Effectiveness of a Negative Interest Rate Policy

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Abstract

A negative interest rate policy flips the borrower – lender relationship on its head clouding the understanding of such a policy, which this paper attempts to clear up. Using panel data from 29 countries in the euro area from Q1 2005 to Q4 2019, the impact negative interest rates have on gross domestic product per-capita and the banking sector will be observed. Employing a fixed effects approach, we estimate that the negative interest rate policy does indeed function the way it is intended too, and so far has not caused any significant problems for commercial banks in the area. On average, when the policy interest rate turns negative, GDP per-capita is increased by $1,400. However, this paper will emphasize the negative effects and diminishing returns of such a policy caused by the interest rate heading deeper into negative territory.

Table of Contents

FIGURES

TABLES

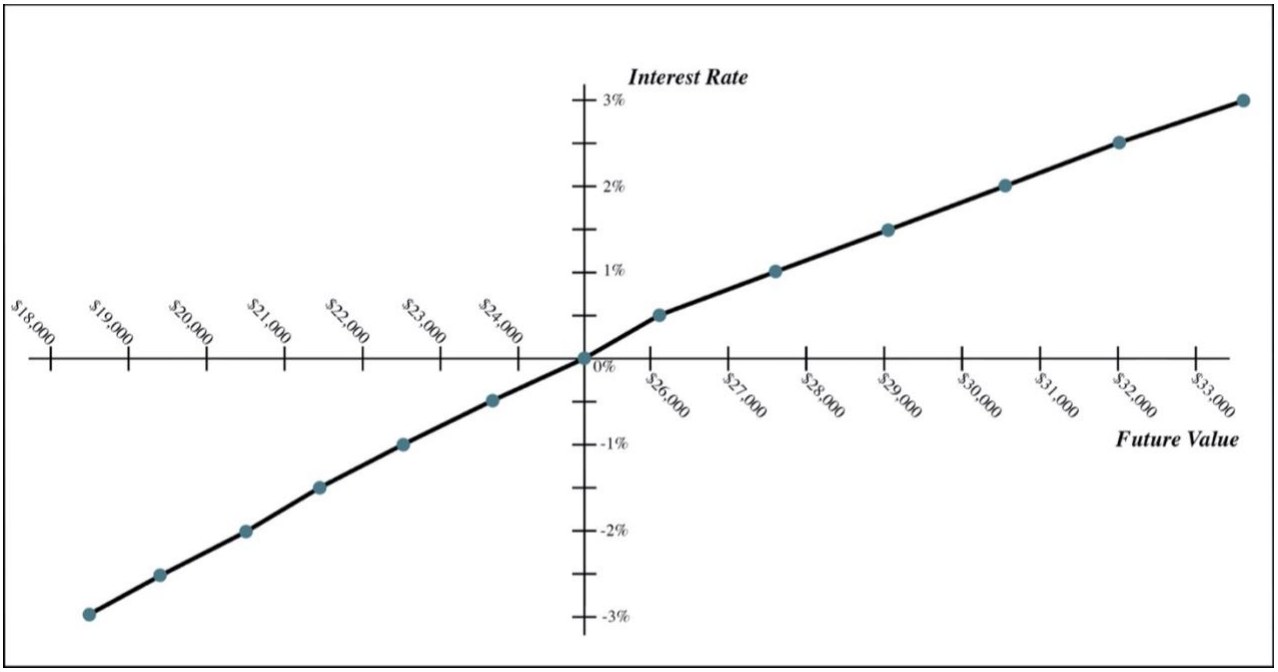
1. Introduction

Discussions surrounding a negative interest rate policy (NIRP) have been increasing in recent times. With the shutdown of the world's economies due to the COVID-19 pandemic, the vale surrounding the extent of the damage this policy response has caused is beginning to be lifted. The bifurcation of the labor force, disruption of trade flows, falling business confidence and profitability, and the realization that the 11 year bull run is over, sum up a portion of the damage caused in the name of saving lives. A strong fiscal response has been supplied in the form of the CARES act (although resembling a cushion to the economy rather than applied pressure to aggregate demand) along with a strong monetary response that has been in effect for quite some time. The addition of liquidity supplied to the financial system in the form of buying treasury bonds in the open market has increased the Federal Reserve's balance sheet to unseen levels, around 6.5 trillion.

This injected liquidity has been coupled with a return to a post-great recession federal funds target range of 0.0 – 0.25 in March of 2020. The lower limit of that range sits on the zero lower bound (ZLB), which is where conversations of pushing the interest rate lower come into play. Classical economic theory states that the interest rate resting on the ZLB hampers monetary policy's influence on the money supply, and therefore the economy. This is due to the nature of the ZLB being thought of as indeed a "bound," insisting that any attempt to cut the rate below the ZLB would hamper the transmission of monetary policy. In other words, banks will not be able to transmit a negative interest rate to households and corporations because if they do so in the form of negative deposit rates, market participants will either move their money out of the country and into higher earning deposits, or simply hoard cash. The future value of money still deteriorates when held in cash, but at a slower rate than if it was deposited with a negative interest rate. In order to color this flip flop of the borrower–lender relationship, figure 1 illustrates the effect negative interest rates have, if passed to households and corporations on a loan of $25,000 at a ten year maturity with quarterly interest payments ($FV = PV(1 + \frac{i}{p})^{pt}$). Theoretically, the effect would be a lower opportunity cost for the borrower. This will also

incentivize banks to do three things. The first being to charge negative interest rates on commercial deposits, being their main source of revenue. Second, they could simply eat the cost, or third they could increase fees to depositors while offering a positive rate. In any case, the worry is profit loss.

Figure 1. $25,000 Loan, 10 Year Maturity, Quarterly Interest Payments



Denmark, Sweden, Switzerland, and Japan have been using negative interest rate policy (NIRP) thus far, and have shown mixed results. Policy rates being the rate at which central banks set in order to influence the greater main monetary variables in an economy, i.e. consumer prices, exchange rates, etc. Sweden's last recorded policy rate rose back to zero from an average of negative 0.40% between the first quarter of 2015 to the third quarter of 2019. This "experiment" was intended to encourage price stability and anchor inflation expectations further. The Sveriges Riksbank ended the policy due to fears of unintended consequences. The data on the effects is still being collected and analyzed so we may not know the true effect of this experiment for some time. Jakob Carlsson, chief executive of the Swedish life insurer Lansforsakringar Liv, calls the negative interest rate experiment a "mistake." He takes the classical economic approach that the policy works against its intentions and influences saving rather than

spending. Stating, “Sooner or later, we will have to pay the bill for this experiment of artificially created negative rates”. Table 1 provides an overview of selected countries that have implemented a NIRP.

Table 1. Overview of Central Banks with Negative Interest Rates

		Interest Rates *(in basis points)*		
	Objective	Policy Rate	Deposit Facility	**Date of Introduction**
Denmark	Countering safe - haven inflows and exchange rate pressures	-75	-60	June, 2012
Euro Area	Price stability and anchoring inflation expectations	0	-50	June, 2014
Japan	Price stability and anchoring inflation expectations	-10	-10	March, 2016
Sweden	Price stability and anchoring inflation expectations	0	-75	December, 2014
Switzerland	Reducing appreciation and deflationary pressures	-75	-75	March, 2015

Source: National Central Banks; Interest rates depicted are recorded in the first quarter of 2020

Overnight deposit rates, the interest rate charged by the central bank for commercial banks to park their money, have also been set below zero. The European Central Bank has set its overnight deposit rate, at a recent historic low of -0.50%. This reflects a reduction of 10 basis points from Q1 2019. The ECB also has their policy rate at the ZLB, but they have not moved it into negative territory thus far. They may be reluctant to do so because this territory is fresh ground, and the implications of a NIRP are not set in stone.

To investigate the impact of a NIRP, a sample of 29 countries was collected including the eurozone, and Japan. The sample includes the countries Denmark, Sweden, Switzerland, and Japan, which have all used a negative policy interest rate ranging roughly from 2012 onward. The sample also includes the overnight deposit facility rate, with the eurozone becoming negative in 2014, and Denmark, Sweden, Switzerland, and Japan reducing their deposit rates below the ZLB roughly after their policy rates became negative. The data is sorted in a quarterly time frame ranging from Q1 2005 to Q4 2019.

The regressions employ a fixed effects panel estimation strategy in order to control for some of the heterogeneity inherent in a large sample size, including time lags where appropriate.

The first model investigates the effectiveness of the negative interest rate using GDP per capita as the independent variable, and the dependent variable of interest being a dummy variable ranging from zero to one. One dummy variable indicates when the interest rate sits at the ZLB, and the other indicates when the interest rate passes into negative territory. The second model aims to estimate how the commercial banking sector is handling the impact of a negative interest rate. To do so, a collection of these banks' balance sheets have been considered for each country, and are used as the independent variable, while the variable of interest remains the same as the previous model. The third and final model aims to estimate the effect a NIRP has on loans to the private sector, which would indicate if loans do increase with the policy implemented. Again the variable of interest remains the same. These models are explored in depth in the data and methodology section.

Ultimately, the models estimate that when the interest rate becomes negative, on average there is a $1,400 boost to GDP per-capita, and no statistically significant impact on banks' balance sheets, and loans to the private sector. Indicating that the policy is effective, and the banking sector is taking the appropriate steps to mitigate profit loss.

The rest of the paper is organized as follows. A brief literature review is followed by an exploration of monetary policy in current times. Next, data and the methodology of the study are presented, followed by a discussion of results. Finally, the paper concludes with policy recommendations.

2. Literature Review

The literature on negative interest rate policies has begun to emerge and is condensed with opposing views on the effectiveness of the policy. Empirically, Jobst and Lin (2016) estimates that the negative interest rate setting policies at the ECB and across the euro area have had a positive impact on the economy thus far. Their analysis finds that negative rates have significantly enhanced the signaling effect of the ECB's monetary stance, boosting its foreword guidance. Lowering the deposit rate into

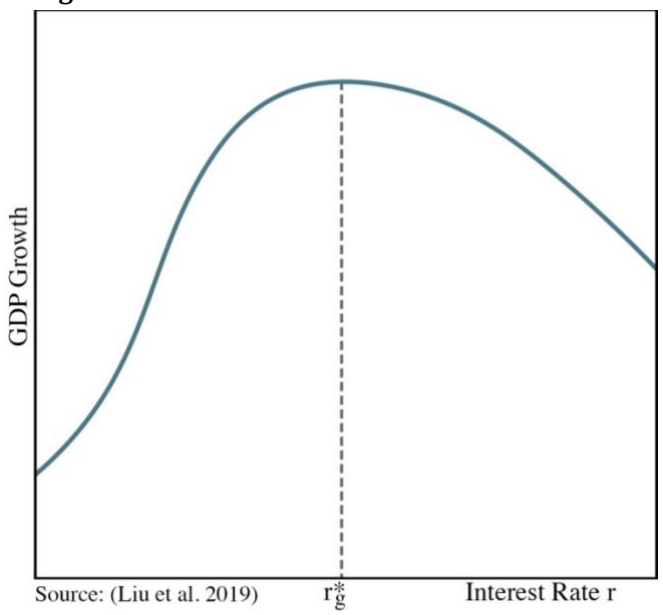
negative territory has supported the ECB's portfolio rebalancing by encouraging banks to substitute investment in riskier assets for excess reserves. In addition, some countries have been successful in transmitting the rate cuts downward to corporate and household borrowers thereby contributing to a modest credit expansion and bolstering the recovery. Concerns about bank profitability for the most part have not yet materialized.

Although these positive impacts, they report that further substantial reductions in the deposit rate will likely entail diminishing returns, since the lending channel is crucially influenced by banks profitability. So far, most banks have been able to fend off losses with higher lending volumes and the benefit of higher asset prices, lower funding costs, and possible cost saving from operational efficiency and consolidation. However, there are most definitely limitations to such mitigation measures, and the diminishing returns of the NIRP will come as their long run impacts start to materialize. Thus, indicating a non-linear or even parabolic relationship between the negative interest rates and their positive effect on the economy.

The evidence for this is reinforced by Liu, Mian, and Sufi (2019) where they estimate that a fall in long-term interest rates have been associated with rising market concentration, reduced business dynamism, a widening productivity-gap between industry leaders and followers, and slower productivity growth. The traditional expansionary effect of low interest rates where a decline in the long-term interest rate increases the incentive to invest as future cash flows are valued more ceretis paribus, is still prevalent. But, they argue that there is a second strategic effect of lower interest rates that makes industry leaders invest more aggressively to keep industry followers at bay.

Industry followers gain a lower cost of investment as interest rates remain negative over the long-term. Industry leaders perceive this as a threat and set up more barriers to entry, conduct defensive R&D, and engage in predatory acquisitions (Cunningham, Ma, Ederer, 2018). They induce an inverted-U shaped supply-side relationship between economic growth and the interest rate, detailed in figure 2. Starting from a high level of the interest rate, growth increases as the interest rate declines because the traditional

Figure 2. Low Interest Rates and GDP Growth



expansionary effect dominates the dynamic strategic effect. But, as the interest rate declines further, the endogenous investment response to the leader and follower causes the strategic effect to dominate, and economic growth begins to fall. They emphasize that the key implication of this model is that this positive relationship between the interest rate and economic growth must happen before the interest rate hits zero. Considering that many economists have stated that we are in the "great stagnation" (Cowen, 2019) with a falling natural rate of interest, and sluggish economic growth worldwide, there appears to be evidence that we are indeed on this inverted-U shaped curve.

A negative interest rate policy may exacerbate this effect and produce counter-productive impacts on aggregate demand (AD), as a NIRP's influence on AD is strongly depended on the sensitivity of investment and savings to the interest rate (Palley, 2016). In our current environment of low long term interest rates, the correct sensitivity to the interest rate may not be present. As shown in figure 3, Net savings ratios have been reluctant to move across the countries depicted. Consumers may mitigate the effects of a NIRP by moving their money through different banks, which further hampers the policy's effectiveness.

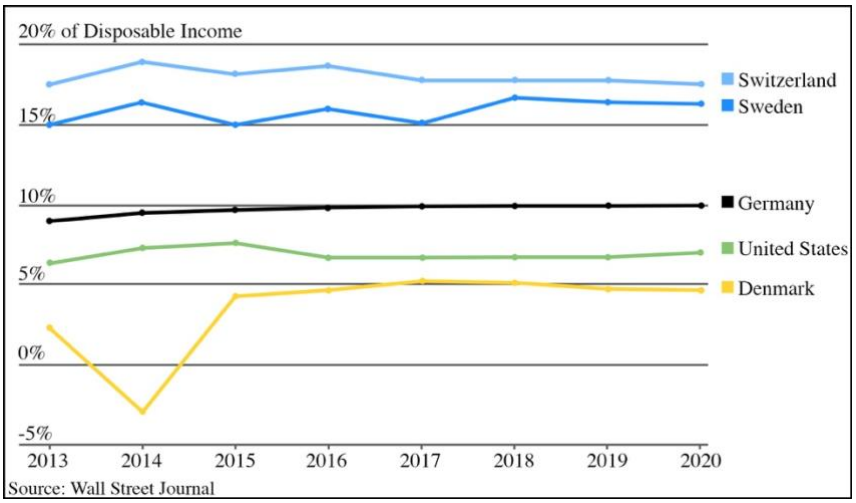


Figure 3. Net Savings Ratio of Households

In summary, there is evidence to believe that the negative rate policy has worked where implemented thus far, and the negative impacts have not yet materialized because of mitigation measures like consolidation, increasing fees, and selectively passing on the rate to corporations that can handle it. However, in our current environment of anchored inflation expectations and a falling r star, we face the negative impact from the strategic effect stated by Liu, Mian, and Sufi, (2019) of slowing GDP growth. The policy also hinges on the sensitivity of consumers and producers to the interest rate on saving and investment. If they are generally too sensitive, the policy will have adverse effects.

3. Monetary Policy in Modern Times

Effective monetary policy is key to any efficient markets attempt to operate in equilibria, but what does being in a low inflation expectation environment really mean? Inflation expectations are important to consider because if people think prices are going to go higher, workers will agitate for higher wages, businesses will believe their costs will rise, and thus the prices they can charge will rise (Derby, 2019). This psychological reasoning of expectations is how real inflation changes. Low inflation expectations may be the cause of sluggish wage growth, despite extremely low unemployment numbers, and easy monetary policy. Central banks can attempt to raise these expectations through rate cuts with the hopes of applying upwards pressure, but the problem appears to persist and contributes to sluggish growth. When you compound the fact that interest rates are already near the ZLB, the problem is self-evident.

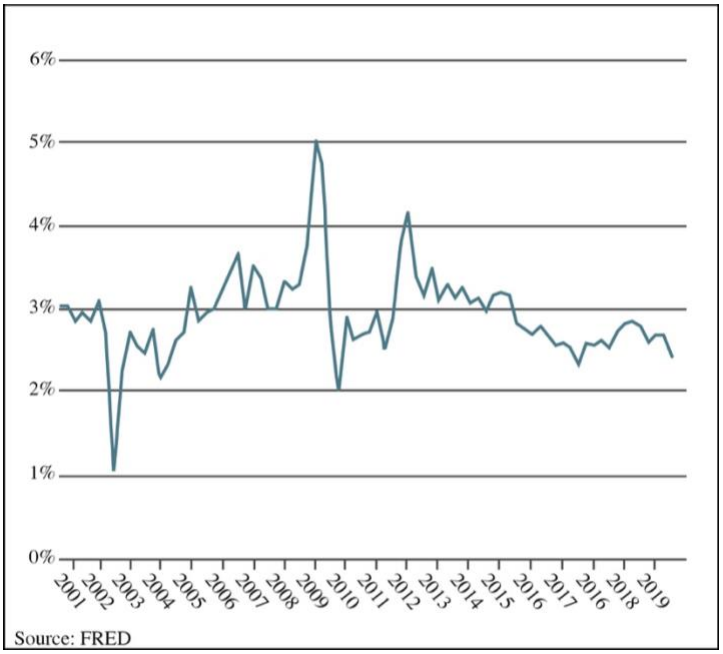


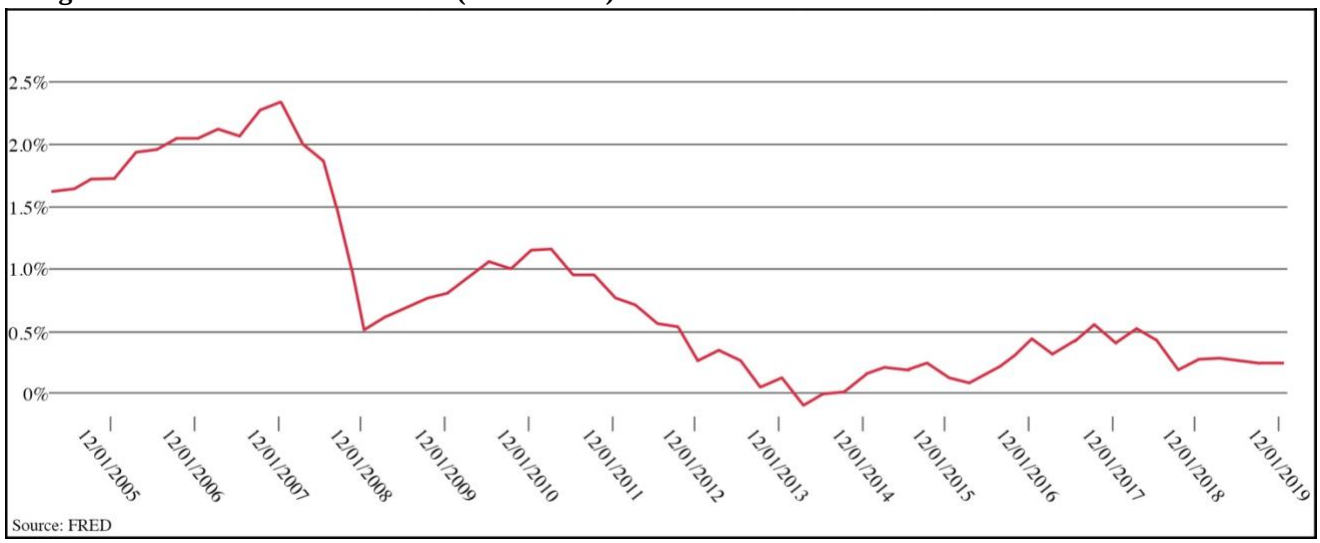
Figure 4. Inflation Expectations For the United States

The influence of the natural rate of interest is something to be considered as well. According to Holston, Laubach, and Williams (2016) R-star is what economists call the natural rate of interest. It's the

real rate that is supposed to prevail when the economy is at potential GDP. While central banks like the ECB set short-term rates, r-star is the result of longer-term economic factors beyond the influence of central banks and monetary policy.

Depicted in figure 4, the first thing to note about R-star is that it has been falling since the great recession. There are three reasons for this: changes in demographics, a slowdown in productivity growth, and heightened demand for safe assets.

Figure 5. R-Star for the Euro Area (2005 – 2019)

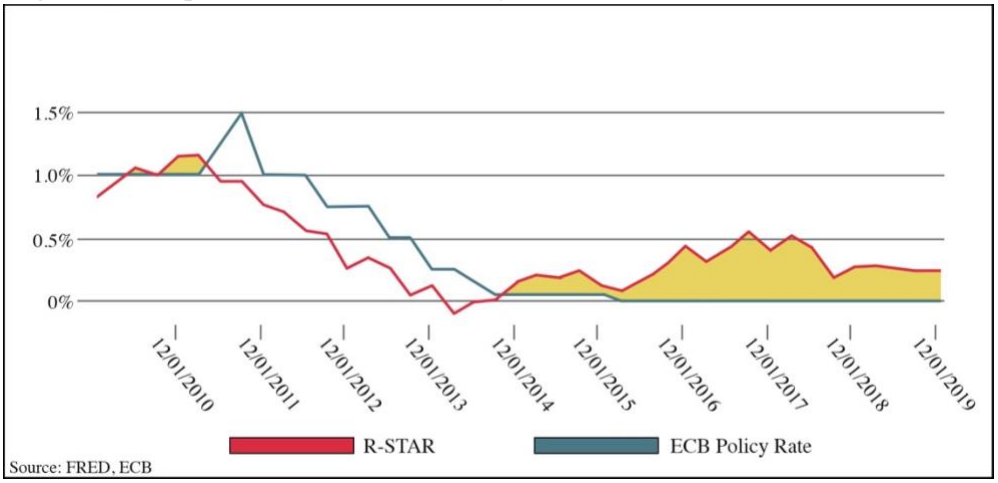


Changing demographics affect r-star in a number of ways. For one, we are living longer. Over the past three decades, life expectancies in developed economies have been rising by nearly five years and is expected to keep rising. When people live longer, they tend to save more for retirement, and increased savings puts downward pressure on interest rates.

Despite this fact, labor force productivity growth has been falling in the Euro area ever since around the 1970's, with the great recession adding to the downstroke. The cause being a mix of widespread barriers to entry; lack of competition in many industries and lax enforcement of competition law; surrealistic regulations and pervasive unjustified licensing requirements across Europe; inefficient capital markets; an absence of top universities and lower research and development spending; and finally an aging population (Villaverde, Ohanian, 2018).

The last factor being a heightened demand for safe assets is more or less a product of the other two. Nonetheless, this high demand for safe assets is indicative of an increase in savings and less risky investment behavior by consumers and producers alike. So what is the significance of r-star and why consider it? Because movements in r-star are indicative of overall consumer and producer sentiment of an increase in savings and a decrease in investment over time.

Figure 6. European Central Bank's Policy Rate: Distance from R-Star



R-star's relationship to the short term interest rates set by central banks is a clear sign of monetary policies attempt to stimulate AD. Depicted in figure 5 and highlighted in yellow, we see that the European Central Bank's policy rate has dipped below r-star ever since Q3 2014. This indicates that first; the Euro area is below potential GDP, and second; the position of r-star above the ECB's rate may make the transmission of monetary policy more effective at its current rate setting position. The combination of this and the deposit facility rate being set at -0.50 make the outlook for the effect of a NIRP more positive.

Lastly, inflated asset prices are something to seriously consider. When a NIRP is implemented, consumers will shop around for higher earning assets to store their money. They may turn to riskier assets, or continuously move their savings from bank to bank. For example, if consumers choose to park their money in real-estate, this will cause inflated gains in the asset price aiding in the formation of a bubble. If the central bank turns course and raises the rate, this will have serious consequences as consumers shift their money back to conventional means, causing the bubble to pop. In some cases where banks have set a maximum threshold on deposits where the negative rate begins to take hold, some

companies have even increased the number of banks to spread their money to (Blackstone, 2019). Thus, limiting the effectiveness of the policy. It seems as if consumers and firms have been finding ways to mitigate the loss of cash through these measures that can have detrimental consequences.

4. Data and Methodology

Table 2 provides the definitions, means, standard deviations, and labels of the data. In order to investigate the effectiveness of a NIRP and the specific impacts NIRP's have on the money supply and health of the banking sector, this paper will use a panel dataset covering quarterly data from 2005 – 2019 for 28 euro area countries, with the addition of Japan. The list of countries is displayed in the appendix in Table 6, along with their respective exchange rates used for monetary variables where applicable. Time lags were also used for each variable to ensure the estimations accuracy. These lags are fully depicted in Table 8 in the appendix. The main variable of interest being the policy rate and deposit facility rate, were collected from each country's central bank. Included with each interest rate is a set of two binary variables indicating when the rate crosses into the ZLB, and when it crosses into negative territory in order to capture the effect this has. These interest rates and their threshold indicators were lagged one year in order to accurately estimate their impact from implementation to effect. (Seabury, 2020)

The sample collected represents a broad swath of countries with the assumption of similar characteristics. The obvious problems that may arise with this sample selection is that the countries are different in socioeconomic factors, GDP, geographical size, and monetary flow. For instance, the GDP per-capita of Germany in 2019 of $46,334 is about 57% larger than Malta's GDP per-capita of $29,490. The sensitivity to changes in the interest rates across the countries are intuitively different as well, which could affect the results. This is indicated by the differences in each countries marginal propensity to save, for instance France's MPC of 0.04 compared to Japan's of 0.16 (OECD, 2019). However this will work to the effect of creating a conservative estimate when translating the results to the United States, where consumers have historically held a very low or even negative marginal propensity to save. Thus, the effects of the NIRP in the U.S. may be amplified.

Table 2. Means, Standard Deviations and Variable Descriptions

Variable	Mean (Std. Deviations)	Descriptions
pi	1.58 (2.09)	Policy Interest Rate
pineg	0.05 (0.21)	Policy Interest Rate: Negative Indicator
pizlb	0.21 (0.41)	Policy Interest Rate: Zero Lower Bound Indicator
di	0.71 (1.43)	Deposit Facility Interest Rate
dineg	0.31 (0.46)	Deposit Facility Interest Rate: Negitive Indicator
dizlb	0.15 (0.36)	Deposit Facility Interest Rate: Zero Lower Bound Indicator
intb	1.68 (2.34)	Inter-Bank Lending Rate
bbs	1,380,933 (2,450,261)	Commercial Banks Balance Sheets in Millions USD
loan	479,911.1 (886,304.1)	Total Loans to Private Sector
hpi	168.3293 (309.2455)	Housing Price Index
gdpcap	0.0347757 (0.022236)	GDP Per-Capita in Millions USD
u	8.6 (4.52)	Unemployment Rate
cspend	436,076.8 (1,554,836)	Consumer Spending in Millions USD
cconf	10.21 (46.43)	Consumer Confidence
ptax	38.77 (13.6)	Personnel Tax Rate
trade	-6,133.03 (57,779.9)	Trade Flows in Millions USD (Imports-Exports)

Other factors like the transparency and accuracy of economic data may be an issue as well. Eastern European countries like Estonia, Latvia, and Lithuania don't necessarily have well established data research and collection organizations which is evident by the missing data for some variables in these countries (Eurostat, 2016).

The overall economic health of these countries' must have a conversation as well. Greece is the classic example of a total economic collapse due to a fiscal imbalance following the great recession. With a debt to GDP ratio reaching 181.2% in 2018 due to this imbalance, and the default on the countries debt in 2015, there is only so much that monetary policy can do to spur growth and increase investment once you have fallen off the fiscal cliff.

In order to combat the heterogeneity described above, a fixed effect approach with robust standard errors clustered at the individual country level was used. Doing so assumes that the entity's error term is not correlated with the predictors, which allows for time-invariant variables to play a role as explanatory variables. Additionally, time fixed effects are included in order to control for variables that are constant across entities but vary over time.

To ensure that the FE estimator is preferred over the random effects estimator, a Hausman test is run to compare the coefficients across the two estimators, for each of the three models. The tests produced p values < 0.05, indicating the use of the FE estimator is preferred. Additionally, two versions of each model are being used to control for multicollinearity between the policy and deposit interest rates.

The first model uses GDP per-capita as the dependent variable. This data was collected through the *Trading Economics* database, and was converted into millions of U.S. dollars using the respective exchange rates. The data was also originally reported by year, but in order to have a consistent model in a quarterly time frame, the yearly data was used to create quarterly data using the logarithmic interpolation method $\left(x = x_2^f x_1^{1-f}\right)$. In order to control and isolate the effect of the NIRP on GDP per-capita, the unemployment rate: in order to control for movements in employment which indicates increases and decreases in incomes, consumer spending: to capture overall spending at the consumer level which was

also converted to millions USD, a trade flows variable: indicating trade surpluses and deficits (exports – imports) in millions USD, and lastly each countries personal tax rate: which will indicate the level of constraint on consumer income since ($Y = C(Y - T) + I + G + NX$). Economic indicators such as the unemployment rate and consumer spending was collected through the *Federal Reserve Economic Database* and the *Trading Economics database*. The following equations represent the models using the policy interest rate and deposit interest rate respectfully.

$$gdpcap_{i,t} = \beta_0 + \beta_1 pi_{i,t} + \beta_2 pizlb_{i,t} + \beta_3 pineg_{i,t} + \beta_4 u_{i,t} + \beta_5 cspend_{i,t} + \beta_6 cconf_{i,t} + \beta_7 trade_{i,t} + \beta_8 ptax_{i,t} + T_t + \pi_i + e_{i,t}$$

$$gdpcap_{i,t} = \beta_0 + \beta_1 di_{i,t} + \beta_2 dizlb_{i,t} + \beta_3 dineg_{i,t} + \beta_4 u_{i,t} + \beta_5 cspend_{i,t} + \beta_6 cconf_{i,t} + \beta_7 trade_{i,t} + \beta_8 ptax_{i,t} + T_t + \pi_i + e_{i,t}$$

The second model estimated in this paper uses the total amount of commercial banks' balance sheets converted to millions USD, as the dependent variable. The use of this variable allows us to estimate the movements in the balance sheet, where an increase or decrease would reflect an increase or decrease in assets, which can be interpreted as profitability. Again, the variable being observed is the interest rate, with its respective indicators. In order to control for movements in the balance sheet, we first use the amount of loans to the private sector converted to millions USD; to control for changes in lending flows, the Housing Price Index; in order to control for movements in housing prices that will affect the profitability of these banks; consumer spending; to control for spending output in each countries economies, the unemployment rate; to control for employment flows, and consumer confidence; in order to control for shifts in the perceived confidence of the economies.

Again, the following equations represent the models using the policy interest rate and deposit interest rate respectfully.

$$bbs_{i,t} = \beta_0 + \beta_1 pi_{i,t} + \beta_2 pizlb_{i,t} + \beta_3 pineg_{i,t} + \beta_4 loan_{i,t} + \beta_5 hpi_{i,t} + \beta_6 u_{i,t} + \beta_7 cconf_{i,t} + \beta_8 cspend_{i,t} + T_t + \pi_i + e_{i,t}$$

$$bbs_{i,t} = \beta_0 + \beta_1 di_{i,t} + \beta_2 dizlb_{i,t} + \beta_3 dineg_{i,t} + \beta_4 loan_{i,t} + \beta_5 hpi_{i,t} + \beta_6 u_{i,t} + \beta_7 cconf_{i,t} + \beta_8 cspend_{i,t} + T_t + \pi_i + e_{i,t}$$

The third and final model's goal is to estimate the effect of the NIRP on the loans to the private sector. We use loans as the dependent variable, with the interest rate and its indicators as the variables of interest. To control for changes in the loans made to the private sector, we use the unemployment rate; to account for changes in employment, consumer confidence; to control for the overall perceived health of the economy, the housing price index; again to control for fluctuations in housing prices, and the interbank lending rate; to control for the bank-to-bank interest rate, which banks take into consideration when pricing loans.

Lastly, the following equations represent the models using the policy interest rate and deposit interest rate respectfully.

$$loan_{i,t} = \beta_0 + \beta_1 pi_{i,t} + \beta_2 pizlb_{i,t} + \beta_3 pineg_{i,t} + \beta_4 u_{i,t} + \beta_5 cconf_{i,t} + \beta_6 hpi_{i,t} + \beta_7 intb_{i,t} + T_t + \pi_i + e_{i,t}$$

$$loan_{i,t} = \beta_0 + \beta_1 di_{i,t} + \beta_2 dizlb_{i,t} + \beta_3 dineg_{i,t} + \beta_4 u_{i,t} + \beta_5 cconf_{i,t} + \beta_6 hpi_{i,t} + \beta_7 intb_{i,t} + T_t + \pi_i + e_{i,t}$$

With these models, we will be able to assess the impact a NIRP has on GDP per-capita, the banking sector, and the actual effect in loans made to the private sector, at both the policy interest level, and the deposit interest level.

5. Results and discussion

Table 3 reports the results from the FE specification for the GDP per-capita model. For a given country, on average as the presence of the negative *policy* interest rate varies across time by one unit, GDP per-capita increases by $1,400 dollars, and the presence of the interest rate being at the ZLB increases GDP per-capita by $1,100. Although the significance of the ZLB estimator is just below the 90% confidence level, the negative indicator is statistically significant at the 95% level. However, there is a difference between the policy rate and the deposit rate. For the *deposit* interest rate reaching negative territory, on average as the presence varies across time by one unit, GDP per capita increases by $870,

Table 3. GDP per-capita: Fixed Effects Panel Estimation

	gdpcap (Policy)	gdpcap (Deposit)
_i	0.00006	0.00018
	(0.68)	(1.20)
_izlb	0.0011	0.0005
	(1.62)	(0.68)
_ineg	0.0014	0.00087
	(2.33)**	(1.37)
u	-0.00037	-0.00037
	(-4.89)***	(-4.79)***
cspend	2.93e-09	3.07e-09
	(12.81)***	(12.83)***
cconf	0.00004	0.00004
	(1.27)	(1.18)
trade	4.83e-09	5.16e-09
	(12.34)***	(14.72)***
ptax	0.00004	0.00004
	(0.93)	(0.93)
_cons	0.03	0.03
	(14.29)***	(13.95)***
R^2	0.39	0.38
N	1,708	1,708

and when reaching the ZLB, on average it increases GDP per-capita by $500. The difference in these estimates come from their respective significance levels as well. We observe that for the deposit rate, both estimators are not statistically significant at the 90% or above confidence interval.

We also observe that the unemployment rate, consumer confidence, and trade flows are statistically significant for both the policy and deposit rate models at the 1% level. One percentage point decrease in the unemployment rate, on average adds $370 to GDP per-capita. This aligns with classical macroeconomic theory that as unemployment rises, GDP per-capita falls because less people are employed and incomes fall. With one percentage point increase in consumer confidence, on average GDP per-capita is increased by a very small fraction of a cent. Consumer confidence obviously contributes a larger portion to overall GDP, but when that number is per capita it will come down to the estimations we see here. The trade flows estimator also follows this same logic, and positively effects GDP per-capita because of their inclusion in the GDP equation ($GDP = C + I + G + (X - M)$), net exports being the trade balance variable.

From these results we deduce that first, the policy rate is statistically significant in its transmission of monetary policy and its influence on overall GDP, and second that the NIRP does in-fact have a causal effect. The deposit rates reduced effectiveness may be derived from the banking sectors reluctance to communicate these ultra-low interest rates because of their reduced profitability in doing so. Which is where the next model comes in.

Table 4 reports the next models results, aiming to estimate the impact the NIRP has on the banking sector. The model estimates the impact of the *policy* interest rate that, on average as the presence of the rate becoming negative and varies across time, the bank's balance sheet increases by $88,219.95 million. When crossing the ZLB and varying across time, on average it decreases the balance sheet by $12,619.05 million. For the *deposit* rate, as the interest rate crosses into negative territory and varies over time, on average this is estimated to increase the Bank's balance sheet by $9,173.86 million. When the deposit rate reaches the ZLB and varies over time, on average this will also decrease balance sheets by

$16,261.3. However, these estimates are not statistically significant, which is indicative of the commercial banks efforts to mitigate the effects of such a policy. As previously stated, in some cases mitigation occurs by selectively passing on the negative interest rate to corporations that can handle the negative deposit rates, cost saving from consolidation, or increasing fees to consumer depositors. As indicated by

Table 4. Banks Balance Sheet: Fixed Effects Panel Estimation

	bbs (Policy)	bbs (Deposit)
_i	4,164.505 (0.88)	2,004.43 (0.14)
_izlb	-12,619.05 (-0.31)	-16,261.3 (-0.59)
_ineg	88,219.95 (0.81)	9,173.86 (0.21)
loan	1.85 (4.11)***	1.87 (4.37)***
hpi	-1,276.95 (-3.35)***	-1,261.87 (-3.14)***
u	-13,899.05 (-1.93)*	-14,175.68 (-1.89)*
cspend	3.44 (1.39)	3.26 (1.19)
cconf	1,902.21 (1.38)	1,584.21 (1.09)
_cons	754,958.4 (3.47)***	767,398.9 (3.30)***
R^2	0.68	0.68
N	1,092	1,092

Jobst and Lin (2016), this mitigation can only last for so long, and as the rate crosses more and more into negative territory, commercial banks will begin to truly feel the pain of negative rates on loans and possibly fall into profitability issues.

As for the loans to the private sector, we make the logical conclusion that with increased loan volume to the private sector, the banks' assets increase through net interest margins, on average by $1.85 to $1.87 million for the policy rate and deposit rate models respectfully, which are both statistically significant at the 1% level. The housing price index is also statistically significant at the 1% level, but interestingly enough, on average holds a negative coefficient of -$1,276.95 to -$1,267.87 million for the two models respectfully. One explanation for this could be the falling homeownership rates depicted in figure 6. Meaning, that as housing prices increase, less people take out mortgages because they believe the properties to be overpriced, thus homeownership rates fall which decreases overall mortgage loans in the balance sheet.

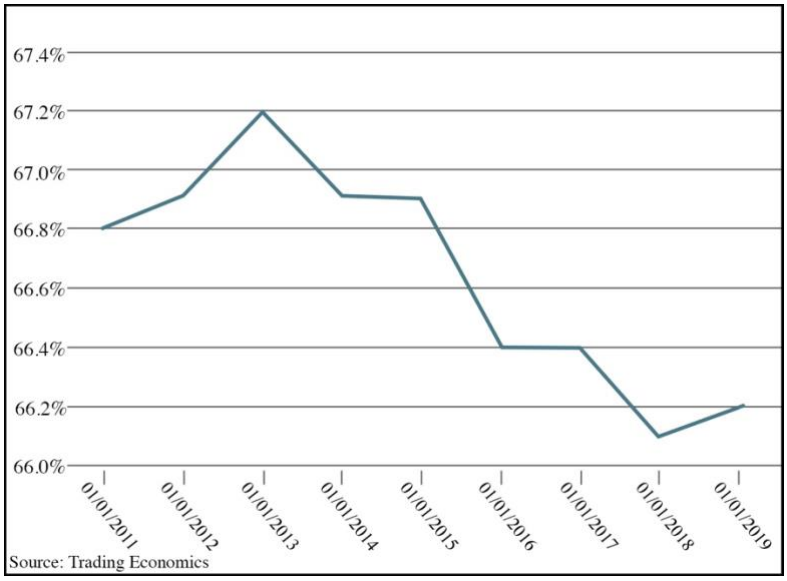


Figure 7. Home Ownership Rate in the Euro Area

It could also fall to a more simple explanation of inaccurate data, as these countries outside the eurozone have significantly less quality and accuracy at their data recording centers. Lastly we observe that the unemployment rate for both models is statistically significant at the 10% level, meaning that on average as the unemployment rate falls by one percentage point, the balance sheet rises by $13,899.05 to $14,175.68 million. This is indicative of the increased monetary flow for consumers, corporations, and the overall economy as the unemployment rate decreases.

Results for the third and final models investigating the effect of the NIRP on loans to the private sector are reported in Table 5. From these estimates, we observe for the *policy* interest rate that as the rate crosses into the ZLB and varies over time, on average loans to the private sector are reduced by $11,956.95 million, and when the rate crosses into negative territory and varies over time, on average loans are increased by $83,925.57 million. For the *deposit* rate, as the interest rate crosses into the ZLB

and varies over time, on average this will reduce loans by $14,531.43 million, and when crossing into negative territory and varying over time, on average this will also decrease loans by $4,081.91 million.

Table 5. Loans to the Private Sector: Fixed Effects Panel Estimation

	loan (Policy)	loan (Deposit)
_i	8,874.40	11,832.92
	(1.30)	(1.05)
_izlb	-11,956.95	-14,531.43
	(-0.32)	(-0.63)
_ineg	83,925.57	-4,081.91
	(0.94)	(-0.14)
u	981.85	623.84
	(0.23)	(0.14)
cconf	-1,403.9	-1,883.7
	(-2.89)***	(-2.38)**
hpi	793.41	827.2
	(5.52)***	(6.70)***
intb	10,001.21	7,276.07
	(1.33)	(1.03)
_cons	345,707.7	352,924.4
	(2.85)***	(3.65)***
R^2	0.30	0.27
N	1,142	1,142

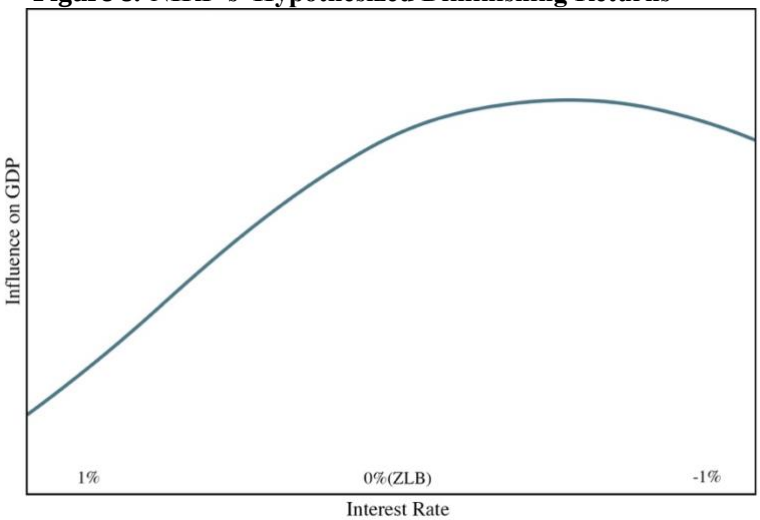
Again, we note the significance of these estimations being not statistically significant, indicating that the effect may vary greatly across the zero axis. This is indicative of the banking sectors reluctance to transmit the NIRP to the private sector, limiting the effect of the NIRP. As for other significance, we observe the impact that consumer confidence and the housing price index have.

With consumer confidence we observe the negative sign of the coefficient, and come to the conclusion that for each model, on average as confidence decreases by one percentage point $1,403.9 to

$1,883.7 million more loans are produced. This seemingly odd relationship may occur because when consumer confidence is high, intuition tells us that they also tend to spend more. This increased spending translates into increased profits for firms, which they can then use to invest in themselves. On the other hand when confidence is down, firms will take in less profit to invest with, and may have to turn to higher lending volumes to invest in themselves. The last significant variable to note being the housing price index, is indicative of the relationship between the higher price of households and the higher price of loans. As the price of households increase in the overall economy, on average we estimate that $793.41 to $827.2 million loans are produced.

Using the models reported above, we estimate that a NIRP has a positive impact on the overall economy, encouraging growth and investment and decreasing savings at this current point in time. On average, the NIRP increases GDP per-capita by $1,400. The banking sector has also handled the policy well thus far, thwarting conversations of profit loss through their various mitigation measures such as increased fees and the selective transmission of the NIRP. However, the NIRP may be hampered due to the fact that we see no statistically significant change in loans generated to the private sector, showing banks reluctance to pass the rate on.

Figure 8. NIRP's Hypothesized Diminishing Returns



This brings the conversation back to the diminishing returns of such a policy. We very well may be seeing the beginning of these returns being diminished because the banking sector cannot sustain such a policy decreasing further into negative territory. In an attempt to colorize these diminishing returns, figure 7 depicts the path they may take, and the diminishing positive impact on GDP that the interest rate holds. This parabolic nature is

simply due to the sustainability of a NIRP. Along with this, the strategic effect that occurs during oligopolistic competition where industry leaders see a low or negative interest rate as a threat, they will strategically set up barriers to entry and take over market share through aggressive acquisitions, adding to the eventual downward trend. As to when this will occur, it is unclear. What is clear is the variance in severity will depend on the health of banking sectors, as well as consumers sensitivity to the interest rate, effecting savings and investment.

6. Conclusion

The waters surrounding a negative interest rate policy (NIRP) remain murky, which this paper attempts to clear up to some degree. Through modeling the effect of a NIRP on GDP per-capita using the fixed effects approach, we conclude that across the sample selected, on average the policy interest rate reaching negative territory has an estimated positive effect on GDP of $1,400. The other two models included in this paper attempt to deduce a more focused understanding of the effects on commercial banks and the loans they produce to the private sector. Both models estimate the negative interest rate having no statistically significant effect on bank balance sheets, or the loans they produce. The first insight produced from these results is that the banking sector has thus far been successful in its mitigation of the NIRP, and has been able to thwart conversations of profit loss. They have done this through various tactics of increasing fees, selectively imposing the negative rates to corporations that have the capacity to handle it, and improving cost savings through consolidation.

The second insight from these estimates brings a conversation of diminishing returns, due to the insignificance of the interest rate effecting loans to the private sector. A NIRP will hold diminishing returns at a point where the banking sector can no longer mitigate the policy and must impose negative deposit rates to a greater number of corporations and households. This will inevitably lead consumers to hoard cash or move their deposits into higher earning accounts, inflating asset prices and creating a bubble, which will begin to negatively impact economic growth. However, when this point will occur is unclear. Another insight is also shared by Liu, Mian, and Sufi (2019) that estimates long-term low interest

rates will further decline GDP growth, in that during oligopolistic competition a low or negative interest rate will cause industry leaders to begin to set up barriers of entry and take on aggressive mergers. This is because industry followers see the low interest rate environment as an advantage to grow, threatening market share of the larger market leaders.

Being that the federal reserve has not yet crossed the ZLB and entered negative territory, and that Americans on average are less prone to saving than most other developed economies, instituting a NIRP could be effective, but should be viewed as a last ditch effort due to the negative pressure imposed on bank profitability. Depending on consumers and firms sensitivity to the interest rate, the policy also may create asset bubbles from the incentive to store cash elsewhere which could cause negative effects across an economy that is already in desperation. However, at a time where a pandemic has initiated a total shut down of the American economy, putting millions out of work and pushing us far below potential GDP, the Federal Reserve still has room to operate below the ZLB, and may want to impose negative rates if growth continues to stagnate.

Further research on this topic should focus on the importance of data quality, and may want to include only countries that have strong and politically independent data research centers. Further research will also hopefully include more data across time, since NIRPs are relatively new and their long lasting effects may begin to emerge in the data at a later time. The banking sector also needs a deeper dive using micro data on the commercial banking level in order to more accurately estimate the health of these banks during the NIRP.

7. References

Altavilla, C., Burlon, L., Giannetti, M., & Holton, S. (2019). Is There a Zero Lower Bound? The Effects of Negative Policy Rates on Banks and Firms. *European Central Bank*. doi: 10.2139/ssrn.3460947

Arrondel, L., Lamarche, P., & Savignac, F. (2015). Wealth Effects on Consumption Across the Wealth Distribution: Empirical Evidence. *SSRN Electronic Journal*. doi: 10.2139/ssrn.2607504

Blackstone, B. (2019, May 20). Negative Rates, Designed as a Short-Term Jolt, Have Become an Addiction. Retrieved from https://www.wsj.com/articles/negative-rates-designed-as-a-short-term-jolt-have-become-an-addiction-11558363559?mod=article_inline

Brunnermeier, M., & Koby, Y. (2018). The Reversal Interest Rate. doi: 10.3386/w25406

Cowen, T. (2011). *The great stagnation: how America ate all the low-hanging fruit of modern history, got sick, and will (eventually) feel better*. New York: Dutton.

Cunningham, C., Ma, S., & Ederer, F. (2018). Killer Acquisitions. *Academy of Management Proceedings, 2018*(1), 11001. doi: 10.5465/ambpp.2018.301

Danthine, J.-P. (2017). The Interest Rate Unbound? *Comparative Economic Studies, 59*(2), 129–148. doi: 10.1057/s41294-017-0019-3

Demiralp, S., Eisenschmidt, J., & Vlassopoulos, T. (2017). Negative Interest Rates, Excess Liquidity and Bank Business Models: Bankss Reaction to Unconventional Monetary Policy in the Euro Area. *SSRN Electronic Journal*. doi: 10.2139/ssrn.2941377

Derby, M. S. (2019, October 15). Long-Term Inflation Expectations Hit Record Low: N.Y. Fed. Retrieved from https://www.wsj.com/articles/three-year-ahead-inflation-expectations-hit-record-low-n-y-fed-says-11571151699

Deserno, M. (2004, March 24). Linear and Logarithmic Interpolation - CMU. Retrieved from https://www.cmu.edu/biolphys/deserno/pdf/log_interpol.pdf

Eggertsson, G. B., & Michael, P. W. (2003). Zero Bound on Interest Rates and Optimal Monetary Policy. *Brookings Papers on Economic Activity*, *2003*(1), 139–233. doi: 10.1353/eca.2003.0010

Eurostat. (2016, May). Quality report on National and Regional Accounts - 2016 data. Retrieved from https://ec.europa.eu/eurostat/web/products-statistical-reports/-/KS-FT-18-004

Federal Reserve Economic Data: FRED: St. Louis Fed. (n.d.). Retrieved from https://fred.stlouisfed.org/

Galli, A. (2018). Sticky Consumption and Wealth Effects in Switzerland. *Review of Income and Wealth, 65*(4), 930–952. doi: 10.1111/roiw.12378

Germany: Selected Issues. (2019, June 21). Retrieved from https://www.elibrary.imf.org/view/IMF002/26217-9781498324632/26217-9781498324632/26217-9781498324632_A001.xml?rskey=IW7fAa&result=2&redirect=true

Gustafsson, P., Hesselman, M., & Lagerwall, B. (2017). Staff memo How are household cashflows and consumption affected by higher interest rates? *Sveriges Riksbank.* Retrieved from https://www.riksbank.se/globalassets/media/rapporter/ppr/engelska/2017/171220/staff-memo-how-are-household-cashflows-and-consumption-affected-by-higher-interest-rates.pdf

Holston, K., Laubach, T., & Williams, J. C. (2016). Measuring the Natural Rate of Interest: International Trends and Determinants. *Federal Reserve Bank of San Francisco, Working Paper Series*, 01–43. doi: 10.24148/wp2016-11

Jobst, A., & Lin, H. (2016). Negative Interest Rate Policy (NIRP): Implications for Monetary Transmission and Bank Profitability in the Euro Area. *IMF Working Papers*, *16*(172), 1. doi: 10.5089/9781475524475.001

Lahart, J. (2019, October 26). What to Expect When You're Expecting Less Inflation. Retrieved from https://www.wsj.com/articles/what-to-expect-when-youre-expecting-less-inflation-11572098580

Liu, E., Mian, A., & Sufi, A. (2019, August 1). Low Interest Rates, Market Power, and Productivity Growth. Retrieved from https://scholar.princeton.edu/sites/default/files/ernestliu/files/lms20190111.pdf

OECD (2000), "OECD Economic Outlook No. 68 (Edition 2000/2)", OECD Economic Outlook: Statistics and Projections (database), https://doi.org/10.1787/data-00098-en (accessed on 05 May 2020).

OECD (2019), *OECD Economic Outlook, Volume 2019 Issue 2*, OECD Publishing, Paris, https://doi.org/10.1787/9b89401b-en.

Palley, T. I. (2016). Why Negative Interest Rate Policy (NIRP) is Ineffective ... Retrieved from http://www.thomaspalley.com/wp-content/uploads/2016/06/negative_interest_rates.pdf

Palley, T. I. (2018). The Natural Interest Rate Fallacy: Why Negative Interest Rate Policy May Worsen Keynesian Unemployment? *Investigación Económica*, *77*(304), 7. doi: 10.22201/fe.01851667p.2018.304.66398

Rachel, Ł., & Summers, L. H. (2019, March 7). On falling neutral real rates, fiscal policy, and the risk ... Retrieved from https://www.brookings.edu/bpea-articles/on-falling-neutral-real-rates-fiscal-policy-and-the-risk-of-secular-stagnation/

Rognlie, M. (2016). What Lower Bound? Monetary Policy with Negative Interest Rates. *Mattrognlie*. Retrieved from http://mattrognlie.com/negative_rates.pdf

Seabury, C. (2020, March 20). How Interest Rates Affect the U.S. Markets. Retrieved May 08, 2020, from https://www.investopedia.com/articles/stocks/09/how-interest-rates-affect-markets.asp

Torres-Reyna, O. (n.d.). Panel Data Analysis Fixed and Random Effects using Stata ... Retrieved from https://www.princeton.edu/~otorres/Panel101.pdf

TRADING ECONOMICS: 20 million INDICATORS FROM 196 COUNTRIES. (n.d.). Retrieved from https://tradingeconomics.com/

Villaverde, J., & Ohanian, L. (2018, December 4). The Lack of European Productivity Growth: Causes and Lessons for the United States. Retrieved from https://www.cato.org/publications/research-briefs-economic-policy/lack-european-productivity-growth-causes-lessons-united

8. Appendix

Table 6. Country List and Respective Exchange Rates

Country	Exchange Rate
Austria	EUR/USD 1.09
Belgum	EUR/USD 1.09
Bulgaria	BGN/USD 0.56
Croatia	HRK/USD 0.14
Cyprus	EUR/USD 1.09
Czech Republic	CZK/USD 0.040
Denmark	DKK/USD 0.15
Estonia	EUR/USD 1.09
Finland	EUR/USD 1.09
France	EUR/USD 1.09
Germany	EUR/USD 1.09
Greece	EUR/USD 1.09
Hungary	HUF/USD 0.0031
Ireland	EUR/USD 1.09
Italy	EUR/USD 1.09
Japan	JPY/USD 0.0093
Latvia	EUR/USD 1.09
Lithuania	EUR/USD 1.09
Luxemburg	EUR/USD 1.09
Malta	EUR/USD 1.09
Netherlands	EUR/USD 1.09
Poland	PLN/USD 0.24
Portugal	EUR/USD 1.09
Romania	RON/USD 0.22
Slovakia	EUR/USD 1.09
Slovenia	EUR/USD 1.09
Spain	EUR/USD 1.09
Sweden	SEK/USD 0.10
Switzerland	CHF/USD 1.03

Table 7. Regression Equations

$$gdpcap_{i,t} = \beta_0 + \beta_1 pi_{i,t} + \beta_2 pizlb_{i,t} + \beta_3 pineg_{i,t} + \beta_4 u_{i,t} + \beta_5 cspend_{i,t} + \beta_6 cconf_{i,t} + \beta_7 trade_{i,t} + \beta_8 ptax_{i,t} + T_t + \pi_i + e_{i,t}$$

$$gdpcap_{i,t} = \beta_0 + \beta_1 di_{i,t} + \beta_2 dizlb_{i,t} + \beta_3 dineg_{i,t} + \beta_4 u_{i,t} + \beta_5 cspend_{i,t} + \beta_6 cconf_{i,t} + \beta_7 trade_{i,t} + \beta_8 ptax_{i,t} + T_t + \pi_i + e_{i,t}$$

$$bbs_{i,t} = \beta_0 + \beta_1 pi_{i,t} + \beta_2 pizlb_{i,t} + \beta_3 pineg_{i,t} + \beta_4 loan_{i,t} + \beta_5 hpi_{i,t} + \beta_6 u_{i,t} + \beta_7 cconf_{i,t} + \beta_8 cspend_{i,t} + T_t + \pi_i + e_{i,t}$$

$$bbs_{i,t} = \beta_0 + \beta_1 di_{i,t} + \beta_2 dizlb_{i,t} + \beta_3 dineg_{i,t} + \beta_4 loan_{i,t} + \beta_5 hpi_{i,t} + \beta_6 u_{i,t} + \beta_7 cconf_{i,t} + \beta_8 cspend_{i,t} + T_t + \pi_i + e_{i,t}$$

$$loan_{i,t} = \beta_0 + \beta_1 pi_{i,t} + \beta_2 pizlb_{i,t} + \beta_3 pineg_{i,t} + \beta_4 u_{i,t} + \beta_5 cconf_{i,t} + \beta_6 hpi_{i,t} + \beta_7 intb_{i,t} + T_t + \pi_i + e_{i,t}$$

$$loan_{i,t} = \beta_0 + \beta_1 di_{i,t} + \beta_2 dizlb_{i,t} + \beta_3 dineg_{i,t} + \beta_4 u_{i,t} + \beta_5 cconf_{i,t} + \beta_6 hpi_{i,t} + \beta_7 intb_{i,t} + T_t + \pi_i + e_{i,t}$$

Figure 9. ECB Policy Rate: Distance from R-Star (2005 – 2019)

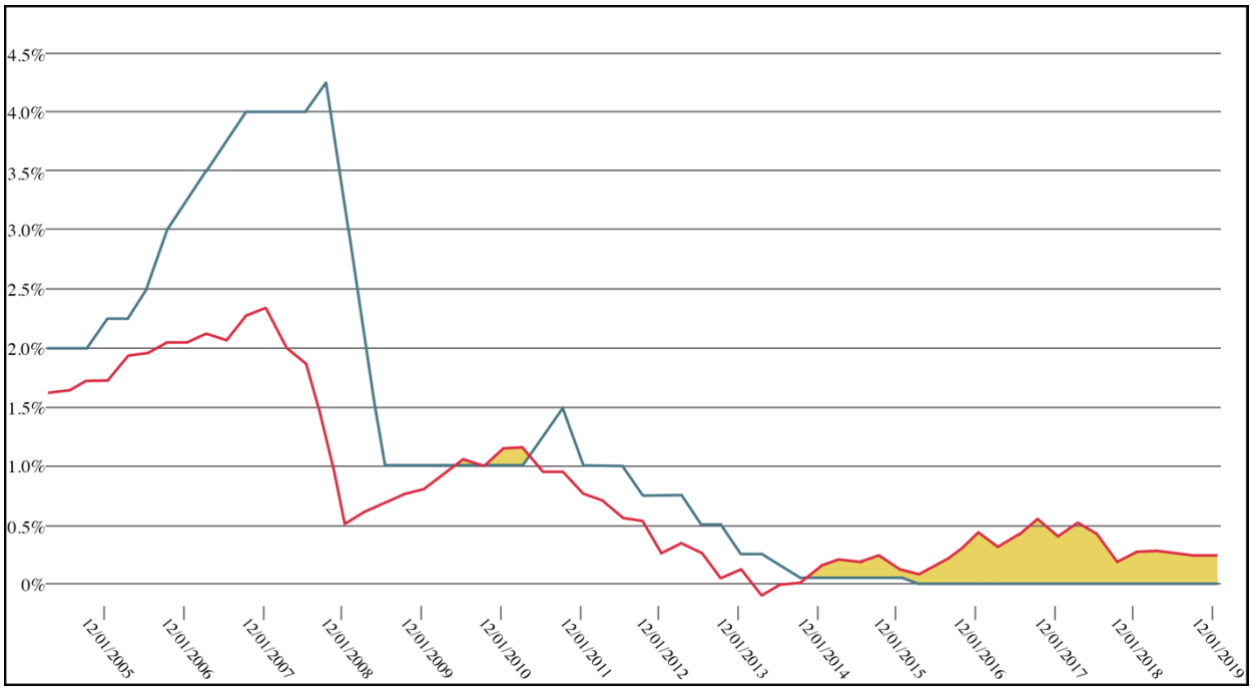


Table 8.Time Lags with Description of Purpose

Dependent Variable	Lags	Description
pi	4 Quarters	Each interest rate variable was lagged for 4 quarters because generally, from the time the interest rate is set, to when it takes effect on the economy, there is usually a 12-month lag (Seabury, 2020). The same intuition is applied to the interbank - lending rates. The lag is estimated to be shorter than the official interest rate because it is directly connected to the banking sector. So the transmission of interbank lending rate which effects loan prices will take a shorter amount of time that say the policy rate. As for the unemployment rate, from the time changes happen to the rate in an economy, there is always perceived lag to which the extent of the effect is felt. Lastly, the personnel tax rate was lagged by two quarters because from the time the tax code is changed, to the time that consumers and producers respond to this change will not be instant.
pineg	4 Quarters	
pizlb	4 Quarters	
di	4 Quarters	
dineg	4 Quarters	
dizlb	4 Quarters	
intb	2 Quarters	
u	2 Quarters	
ptax	2 Quarters	