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Negative Interest Rates Policy and Investment Trends

Prof. Guido Traficante

SUPERVISOR

Prof. Ugo Zannini

CO-SUPERVISOR

Valentino Mazzariello
ID No. 714031

CANDIDATE

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1. Introduction

For decades, the idea of breaking the zero-lower bound, charging depositors with a negative rate was perceived as something unfeasible. After the breakout of the subprime mortgage crisis, however, this perception changed.

Several central banks, to provide additional easing, control inflation and stimulate consumption decided to apply the negative interest rates policy. In 2014, in fact, European Central Bank, Swedish Central Bank, Swiss National Bank and Danmarks Nationalbanks decided to exploit the possibility of breaking the zero-lower bound applying a negative deposit facility rate.

The goal of this study is to describe how this policy works, understand the monetary mechanisms associated with NIRP, and analyze the pros but especially the implications and the side effects related with the 2014 experience and in general with the implementation of a negative rates policy.

Moreover, the idea that lays behind the work is to describe how Negative Interest Rates Policy influence the investors' risk-taking profile. One of major critics moved to NIRP, indeed, is related to a likely behavior by investors rebalancing their portfolios towards riskier asset classes. Negative interest rates, in fact, will shift down the yield curve at all maturities, with "safe assets", like government bonds, providing a negative yield. This behavior will be analyzed running a portfolio rebalancing exercise using the *portfolio selection method* by Harry Markowitz.

Finally, after each chapter there will be a comparison about how *Federal Reserve* and *European Central Bank* relate with negative rates. If on one side, ECB has been one of the first central banks adopting this unconventional policy, on the other side FED still avoids its adoption and keeps exploiting exclusively the benefits of Quantitative Easing. As a result, it will be interesting to understand why the Federal Reserve is not concerned in applying negative rates and whether these reasons should be taken into account also by other central banks.

2. Historical overview about negative interest rate analyzing main theories that lead to the presence of negative interest rates in the markets.

Once rates have been approaching to zero all over the world, several central banks have opted for breaking through the Zero Lower Bound. Even if, at first glance, this idea was perceived as impossible, negative interest rates policy has become part of the monetary policy tool kit when a further ease of a government economy is required.

During the last decades scholars have been discussing about the effectiveness of Negative Interest Rates Policy. The first NIRPs were implemented in Switzerland from 1972 to 1978. In June 1972 Switzerland decided to impose a penalty rate of 2% on foreigners parking money in Swiss Franc to keep their safe-haven currency from appreciating too much. When in the 1971, U.S. President Richard Nixon suspended the conversion of dollars into gold, currencies began to float against each other, the capital poured into this tiny country started to skyrocket and this policy was perceived as the only measure able to prevent this trend. However, during these years the swiss franc appreciation in comparison to dollar did not stop and the export sector of the country stumbled. Swiss central bank abandoned then this approach and negative interest policies were not considered anymore until the 2014 experience.

More recently, in 2009, Gregory Mankiw, from Harvard University, in an article published by the New York Times, expressed the possibility of negative interest rates to revive lending. In the article, Mankiw was in favor of NIRP. However, throughout the article the way he proposes to break the zero-lower bound was different from the NIRP policies formulation we are used to see. He proposed, in fact, to obtain negative rates with the FED committing itself to produce significant inflation. If this would be the case, even if the nominal interest rates would be set at zero, producing a significant inflation will set the real interest rates below the zero-lower bound.

But it is in the aftermath of 2007 crises that several governments decided to adopt this unconventional monetary policy. Between those Euro Area countries, Sweden, Japan and once again Switzerland could be mentioned. 2014 is a real turning point for the way negative rates were perceived. Some positive experiments and their use for even longer period of times than expected, changed the way scholars and the general public look at this unconventional monetary policy class.

The history behind negative interest rates policy is therefore quite recent, however NIRP seems to have been firstly proposed by Silvio Gesell, a German merchant, in the early 20th century. His

particular way of describing the possibility of having a tax on cash held by market participants is widely considered as the first very theorization of the NIR policies.

If on one side Gesell got several devotees from the early days of his publication, he never convinced the general public being strongly criticized by economists like John Maynard Keynes and Irving Fisher, that looked at him as a quasi-economist, more focused on political matters rather than on the economic research. In this chapter we will review his ideas and the main criticism brought up by the scholars at the time.

2.1. Gesell's theory (The natural economic order, Gesell 1958)

The academic debate about negative interest rates and their effectiveness has its roots in the late 19th century, but the heart of the debate was during 1930s. The great depression lead to an investigation for alternative solutions to give stimulus to the economy. The majority of these solutions were never taken into account and most of them were never applied because perceived as impossible, among which, one of the most prominent was the *"The Free Money"* theory by Silvio Gesell.

Silvio Gesell, German merchant, and autodidactic economist, commonly recognized as the founder of NIRP, was the first to propose a system of stamped money in order to accelerate monetary circulation.

Indeed, his theory was slightly different from the modern framing of negative interest rates. What Gesell proposed in its masterpiece *"The Natural Economic Order"* consisted in a tax on money having as a background a libertarian economic theory, aiming to create a truly competitive market that would have ensured the fair distribution of income.

His idea has to be addressed as a resistance against Marxist economic theory of collective property that Gesell himself identifies as *"the death of personal freedom"*. In doing so, he proposes the embracement of the so called "*Manchester System"* where everybody would be remunerated by the proceed of his own labor.

Gesell began its autodidactic economic reflections on the monetary system during the on-going economic crisis in 19th century Argentina. In his first work *"Die Reformation im Munzwesen als Brucke zum Sozialen Staat"* he introduces the concept of taxing money giving also a suggestion about the practical implementation of this measure. Gesell, in fact, explains that in order to remain legal tender, a stamp worth a thousand of the note's face value has to be attached, to the note itself, once a week in order to amount to an annual depreciation rate of approximately 5%.

But it's in "*The natural economic order"* that he shapes his idea offering an economic theory to justify and sustain the proposal of taxing money. Gesell, as also Keynes will do some years later, condemned the money hoarding, even intended as deposits in financial institutions, in favor of a monetary system that does not rewards who actually hoards cash.

It is for this idea that Gesell should be recognized as a founder of negative interest rates policy. He probably doesn't have the merit of creating the policy instrument itself, but rather he has merit in his radical theory of interest which later on would have shaped Keynes's deliberation on interest as a monetary phenomenon.

In his treatise, Gesell starts pointing out that there is no charge associated with holding money. On the other side, goods are subject to a natural deterioration and depreciation, hence their holders incur in considerable costs. Consequently, if there is an economic downturn, money holders may withhold their money from circulation to avoid losing value, while producers, merchant and goods' holders cannot.

What Gesell is afraid money holders will do is to withhold from buying, this way producers and suppliers of goods will be left with their goods subject to their natural decay. If this is going to happen, suppliers and producers will be available to pay what Gesell defines as *"bribe"* to money holders to avoid the depreciation of the produced goods.

At this point according to Gesell, there will be a mismatch between supply and demand. Supply in fact is constant in the short run while the velocity of money circulation will depend on the money holders' behavior.

Money holders will therefore bring their money into circulation only if they receive a profit margin basic interest, and this is why in Gesell vision, aggregate supply and demand are in equilibrium only if the supply side is able to generate a profit margin above the production costs in order to pay the abovementioned bribe.

According his point of view, if there is a crisis, the number of goods available in the market will start rising, while their prices will start to fall lowering capital productivity. Because price have fallen, demand withdraws. Merchants and consumers will not buy for fear that the already cheap prices will start to get even worse. If the government will inject money in the system, the additional money will just be horded.

Gesell's idea to prevent this, consists in money exposed to natural decay, like goods, via taxation. If money will be taxed, money holder will not be driven anymore to hoard money since the currency will involve some carrying charges. The velocity of circulation and the effective demand will be then

constant. At the same time authorities will be able to achieve the price stability steering, when needed, the amount of money in circulation. Money holders will not be able anymore to exercise a sort of contractual power, therefore and still according to Gesell, this will come up with a rise in output and employment.

2.2. Fisher and Keynes's ideas about Gesell's theory

Even if Gesell's theory was shortly experimented in the Austrian town on Wörgl and in 450 United States municipalities, it did not have any practical follow-up. The experiments trying to replicate the idea of taxing cash never lasted for more than few months, and many remained fairly skeptical about this theory.

Irving Fisher, for example, if on one hand promoted the idea of negative interest rates, did not gave much recognition to Gesell's idea, addressing Gesell as a *"quasi-economist"* and a man into "*depression to bring about any practical efforts to make use of his Stamp Scrip[1] idea"*. Still, the American economist writing about Gesell, continues as following:

"There is much in Gesell's philosophy to which, as an economist, I cannot subscribe, especially his theory of interest; but Stamp Scrip, I believe, can, in the present emergency, be made at least as useful an invention as Manuel Garcia's [a singer] *laryngoscope"*

Indeed, in 1933 Fisher wrote a book titled *Stamp Scrip*, that has been dismissed by the memory of many economists. In this book, Fisher proposes the idea of setting up a nationwide system of accelerated money, like Gesell suggested, with a depreciation stamp of 2% per week, to achieve an accelerated version of money circulation and to give a stimulus to the prices recovery. Fisher tried also to convince president Roosevelt about the soundness of his idea, but he was unable to convince him to pursue this new version of the free money theory.

John Maynard Keynes gives his idea about Gesell's theory in *"General Theory of Employment, Money and Interest"*. Keynes introduces Silvio Gesell calling him "*unduly neglected prophet"* and arguing *"I treated his profoundly original strivings as being no better than those of a crank"*[2].

[1] The Stamp Scrip is a substitute for a legal tender. In this case the term is referred to the notes Gesell wanted to attach to the currency in order to make a constant annual depreciation possible.
[2] J. M. Keynes. "*General theory of employment, money and interest"*. Book VI, Chapter 23, 1936.

The main criticism the American economist addresses to Gesell is the fact that his book is driven by a quest for social justice rather than the search for an economic theory. Keynes looks at the script more like as an *"establishment of an anti-Marxian socialism"* and a *"reaction against laissez-faire built on theoretical foundation"* rather than an economic script.

Nonetheless, Keynes gives credit to part of Gesell's theory. According Keynes, he indeed deserves merit to have successfully addressed the interest rates as purely monetary phenomenon, however he insists that this theory is nothing more than **half a theory of the rate of interest**.

Gesell in fact, in Keynes point of view, fails to explain why the money rate of interest is not governed by the standard set by the yield on productive capital, and because of this, blames Gesell in the following way: *"the notion of liquidity-preference has escaped him"*

Summing up, Keynes appreciates Gesell's approach to describe interest rates as a monetary phenomenon and uses this idea to criticize the literature took liable because of its failure to come out with a valuable theory about interest rates.

On the other side he looks at Gesell's idea as **simply unfeasible**. He gives merit to the idea behind stamped money, but still undermines the German author because according to him, he seems to be unaware about the liquidity premium attached to the money. If the currency notes will be deprived by their liquidity-premium by the stamping system, several substitutes would step in like foreign money, or precious metal, and we would find ourselves, once again, at the starting point.

What is more, the depreciation process proposed by Gesell, namely a system that would charge an annual depreciation around 5%, is perceived by Keynes as too high considering the market condition when The Natural Economic Order was written.

In summary, Gesell has been seen as the founder of an incomplete and unfeasible idea, but before going on with the todays' evolution of NIRP we will look at Prof. Dudley Dillard perception of The Natural Economic Order. Back in the days, professor Dillard was one the Gesell's great admirer, and he looks at the German economist in the following way:

"Gesell's standpoint is both anticlassical and antimarxist... The uniqueness of Gesell's theory lies in his attitude to social reform. His theory can only be understood considering his general point of view

as a reformer ... His analysis is not completely developed in several important points, but all in all his model shows no fault." [3]

Once again, Gesell is recognized as a sort of antimarxist bastion. This should also be the way in which as of nowadays we look at him. Looking at him as an economist could be perceived as an exaggeration, but still, he deserves the merit of introducing the world the possibility of breaking the zero-lower bound, which today seems pretty straightforward.

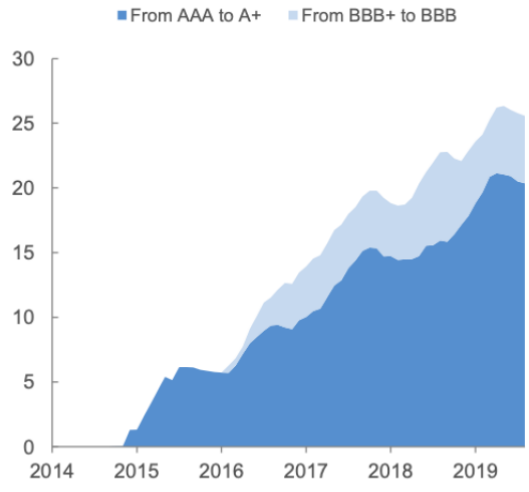
[3] Proudhon, Gesell and Keynes: An Investigation of Some "anti-Marxian Socialist" Antecedents of Keynes' General Theory of Employment, Interest and Money (Dillard, 1940)

3. Assessing the implication of negative interest rates on government bonds, financial stability, and investments

Negative interest rates are a way to provide additional easing to an economic system when usual monetary policy seems to not work out anymore, however the prolonged use of such measures could have several implications on the abovementioned system, throughout this chapter we will try to assess and analyse them.

3.1. Implications on financial stability

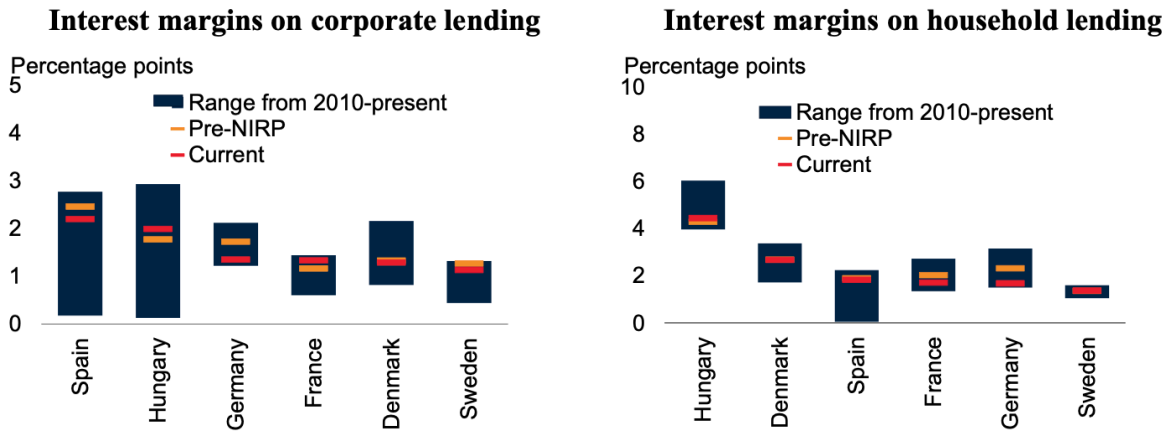
The experience with negative interest rates is still short, the debate between scholars it's more open than ever. Some argue that NIRP are useful to complete the tools of expansionary measures a central bank can use. Some others are more concerned about the risks associated with NIRP like the reduction in banks' willingness to lend and yet the fact that monetary policies become ineffective below the zero-lower bound. Market participants could prefer to hold cash and banks could not be able anymore to lower interest rates on deposits, potentially losing one of their main sources of financing.
Also, central banks might be heavily affected, once reached the zero-lower bound in fact they would not be able anymore to stimulate lending by lowering short term interest rates.
At this point it is automatic starting questioning the impacts and implication of such a measure on the financial stability of a certain market, thus analyse what happened during the first experience Euro Area had with NIR based policies might be helpful. At the time, interest rates became negative for around 5% of total deposits and around 20% on corporate deposits in the markets, and at the time the ability to pass through NIR was largely concentrated in solid banks as the following graph shows.



Sources: Altavilla et al. (2019).

On the $y - axis$, in fact, it has been displayed the percentage of deposits with negative rates held by such banks, while on the $x - axis$ there is their evolution throughout the years.

As said above, NIRP will put pressures on bank profitability narrowing the gap between commercial banks' lending rate and the deposit rate. Actually, if we look at the euro area *Bank Lending Survey*[4] of April 2016, 80% of the banks participating in the survey declared that negative deposits rates end up into a decrease in their net interest income.



During the implementation of NIRP, banks that rely primarily on retail deposits are likely to suffer more rather than other banks, like the ones relying mainly on wholesale funding. Bank profitability, therefore, would depend on the diversification of income sources.

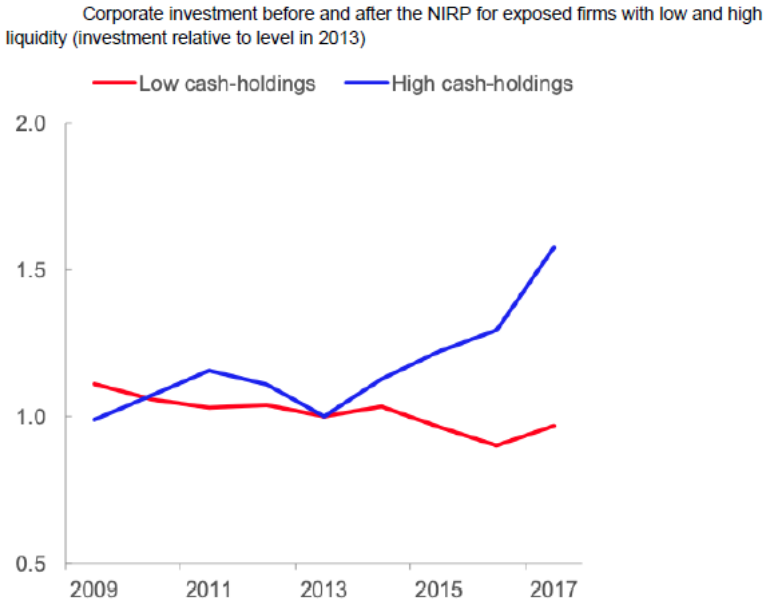
However, should be kept in mind that bank profitability depends, as well, on the state of the economy and volume of lending, hence margins showed above are likely to be affected not only by the introduction of negative rates, but also by the downturn period itself.

In fact, deposits during the considered period increased in a consistent way with high demand for liquidity and safe assets and in NIRP countries, banks' lending margins remained fairly consistent within other post crisis ranges.

What we can draw from this, is that typical arguments against overcoming the ZLB are not reflected on the market as soon as agents don't lack confidence in the banking sector.

[4] The **euro area bank lending survey (BLS)** provides information on bank lending conditions in the euro area. The BLS focus on credit standards and credit terms and conditions, as well as the various factors that may have caused them to change.

Another implication that is likely to occur is a relatively decrease in firm's short-term asset and cash to make room to fixed investments because firms with high cash-holdings are more exposed to negative rates effect on their liquid assets.



Sources: Altavilla et al. (2019).

This behaviour could impact all the funds investing in high liquid assets and could create issues in assessing all the valuations made using discounted cash flows-based approach. Having, after all, interest rates used as discount factor in a negative field, is likely to lead to an overestimation of the assets.

Nevertheless, those most affected should be **institutional investors**, like pension funds and insurance companies, that often hold significant position in government bonds. Under low or even negative yielding bonds, they could struggle to generate significant positive returns. For this type of investors, a range of products, like *fixed rate annuity* – that are going to be affected by the problems associated with mispriced assets - might become less attractive.

Similar issues could be drawn for **money market funds**. These kinds of funds make investments in highly liquid near-term instruments such as cash, cash equivalent securities, and high credit rating debt-based securities with a short-term maturity. Because of the effect of short-term rates cuts they could face challenges even working with very low but still positive rates. Moreover, these funds earn from investors a management fee, that will impact further their overall return, the diminished return is then likely to be counterbalanced investing in riskier assets. However, Danish experience with NIRP seems to suggest that money market fund can pass through negative rates.

European money market fund sector, during 2014, have shown a general growth pattern receiving continued inflows. The maturities of securities held by these funds did not changed significantly, promoting the opposite idea that even during the implementation of NIRP their business model have not been changing and they reacted to this rates environment fairly good.

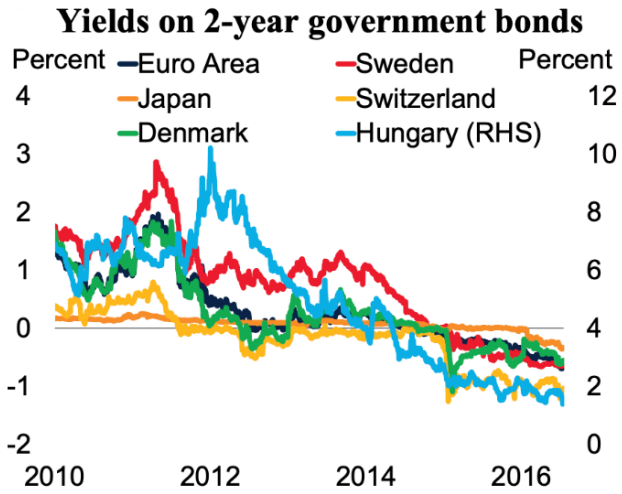
Lastly, several scholars argue that a general effect of the unconventional monetary policies is the rise of misallocation of resources and distortion of income and distribution, some others have concerns regarding the fact that unconventional policies will impact central bank credibility if these measures will be used for a long period. This very last point indeed is the most agreed, if NIRP are going to be used for a prolonged period and the rates will go substantially below zero, the erosion of banks' and other financial intermediaries' profitability will not be a possible scenario, but rather the reality.

By the way, the experience with negative rates, doesn't give a change yet to understand which is the ultimate lower bound or which is the maximum time horizon to keep using this tool wisely. On the contrary, the 2014 experience suggests that negative rates are a valuable policy when extraordinary downturn periods, like the 2008 sub-prime crisis, happen.

3.2. Implications on Government bond

Negative interest rates policies are associated with a downward shift in the yield curve and especially during the 2014 experience with NIRP, rates on government bonds in the Euro Area, in particular for Denmark and Switzerland went negative on short maturities. Several factors can be highlighted to explain what was happening at that time, like a very low inflation rate, and an increasing preference towards savings by the households or towards fixed yield instruments for most investors. Or even, the effect of Quantitative Easing, with central banks buying bonds, with an increase in the demand for these assets that contributed to a reduction of their yields.

Taking into account these factors associated with declining growth expectations, and a diminishing interest in highly rated low-risk investments, the impact of NIR on bond yield seems to reflect the downward shift in central banks' credibility about future paths of policy rates.



In the states where the Central Bank implemented the NIRP, approximately the 40% of sovereign maturities between one and three years turned to a negative yield in mid-2016.

Switzerland, Japan and Germany used to have the highest percentage of bonds trading negative, especially in Japan and Germany maturities until 10-years were trading negative, and at the same time Switzerland's sovereign debt was trading at negative yield for maturities till 50-years.

Still, this effect in the short run is likely to dampen in areas like the Euro Zone because of the propagation of **systemic risk**, that generates a contagion amplifying the sovereign debt problems, that several governments in the EU have.

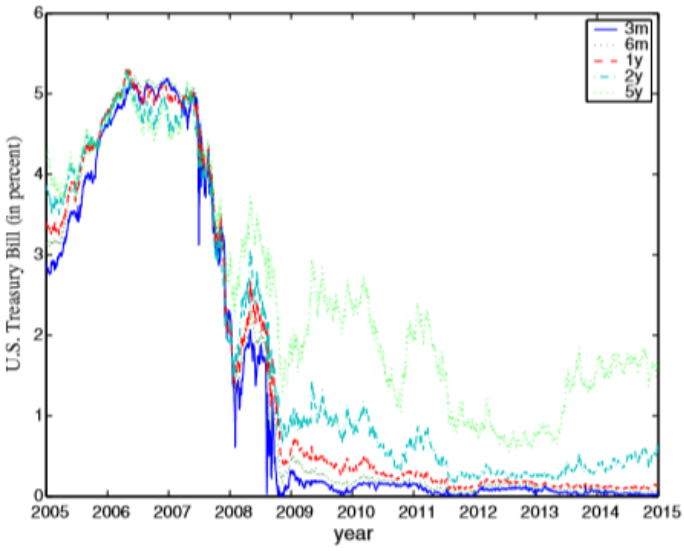
Should be kept in mind that the dampening of the systemic risk could lead to a **spill-over** effect towards *Emerging Markets and Developing Economies (EMDE)*. In particular, during post-2006 crisis period, after the application of unconventional monetary policies in advanced economies, there was an acceleration of capital inflows towards EMDE. Even if there is no major consensus towards this theory, it has been observed that unconventional policy measures were mostly associated with EMDE stronger capital inflows (Lim, Mohapatra, and Stocker 2014) and supported EMDE equity prices (Chen 2014).

However, to have a better understanding about NIRP influence on the long-run government bond yield, we can have a look to an article by Recchioni and Tedeschi[5] that assesses the influence on bond yield of macroeconomic instability, namely a period in which unconventional measures could be used.

[5] *From bond yield to macroeconomic instability: A parsimonious affine model* (Recchioni, Tedeschi, European Journal of Operational Research, April 2017)

What the scholars do throughout this paper is to describe convergence and divergence phenomena among government bond yields. To get to this point a hybrid Heston model[6] with a common stochastic volatility to describe government bond yield dynamics is used.

Looking at the U.S. Treasury Bills in the aftermath of 2008 crisis, they find that even if the main impact of a NIR measure could be visible on short-term maturities, since they are riskier and more related to market sentiment, this effect will vanish and will not affect long run fundamentals.



3.3. Implications on investments

Moving the discussion to the implication on investments, what could be expected from a negative rates environment consists in agents that will prefer to withdraw their deposits, to avoid losing money that they will be likely to spend or to invest in riskier assets like corporate bonds.

Following this idea, agents would behave like in a **prospect theory**[7] framework, preferring the possibility of losing money with the hope of a higher return rather than allocate their resources in a low risk environment that involves a reduction in their wealth.

However, a behaviour like this one has still to be observed during the short experience scholars have in real life. Actually, in a working paper by Anat Bracha dated November 2017, this idea is completely disrupted.

[6] The Heston model is a stochastic model describing the evolution of the volatility of an underlying asset.
[7] Prospect theory is an economics theory developed by Daniel Kahneman based on results from controlled studies, it describes how individuals assess in an asymmetric manner their loss and gain perspectives.

In a series of controlled experiments, random participants were asked to invest their money in two available portfolios, both of them with possible rates of returns and probability of a certain event to happen displayed in advance. The participants were asked to invest money in the mentioned portfolios behaving like they were earned, or they were "house-money", allocating them in investment stakes varying from 20 to 1000 USD.

The first portfolio was a risk free one, with a sure return but likely to be negative under the effect of negative interest rates (the sure return associated with this portfolio ranged from -3% to 1%), the other one was riskier but with the possibility of yielding between 3% and 7% in domestic currency.

Following the prospect theory, we might be conducted to think that the majority of the investors would prefer to hold the riskier one in a desperate pursuit for yield, however the results from the study show a different pattern.

No evidence was found reflecting the prospect theory, no evidence of excessive investment in the riskier portfolio was found and participants exhibited risk-neutrality suggesting no loss-aversion, maximizing the expected return and yet, in the loss domain[8] there is some evidence of risk-aversion.

[8] Participants that ended up with a negative return on their portfolios.

4. Usual monetary policy conduct

Further in this work, we are going to talk about the monetary policy that should be applied when **extraordinary facts**, like an economy's downturn period, happen, but our aim now is to highlight which could be a *usual* conduct for a central bank.

At the same time, to try getting closer to the purpose of the thesis, we consider an optimal monetary policy in a New Keynesian model, designed by Nakata and Schmidt, in which an occasional decline in agents' confidence could lead to persistent liquidity trap episodes for which unconventional monetary policies could be desired.

The private sector behaviour is described by a Phillips curve and a consumption equation:

$$\pi_t = \kappa y_t + \beta E_t \pi_{t+1}$$

$$y_t = E_t y_{t+1} - \sigma(i_t - E_t \pi_{t+1} - r_t^n)$$

Where π_t is the inflation rate, y_t is the output gap and i_t is the level of riskless nominal interest rate between periods t and t+1.

The households' welfare is given by the expected discount sum of current and future utility flows:

$$V_t = -\frac{1}{2} E_t \sum_{j=0}^{\infty} \beta_t \left[\pi_{t+j}^2 + \bar{\lambda} y_{t+j}^2\right]$$

The steady state of this formulation is a **sunspot equilibrium** with occasional liquidity trap that can be defined as the following vector:

$$\{y_H, \pi_H, i_{H,} y_L, \pi_L, i_{L,}\}$$

and satisfies the following two inequality constraints:

$$i_H > 0$$

$$\kappa(\pi_L - \pi *) + \lambda y_L < 0$$

Where κ represents the slope of the Phillips curve at the base of the model and λ and $\pi *$ are parameters set by society when designing the central bank's objective function.

In such a model the policy maker has only one instrument to influence the monetary policy, namely the **short-term interest rate**.

Instead of what is supposed by the existing literature about models with fundamental-driven liquidity trap, in Nakata and Schmidt's model an increasing inflation target reduces output and inflation in the state in which confidence is low, the lower bound is binding and the optimal inflation target could be negative or positive.

As baseline setup, the scholars assume that there's no uncertainty about economy's fundamentals and agent's expectations could be affected by **confidence shock $\boldsymbol{\xi_t \in (\xi_L, \xi_H)}$**. Such a confidence shock, that follows a two-state Markov process, occurs when an equilibrium in which $\{\pi_L, y_L, i_L, V_L\} \neq \{\pi_H, y_H, i_H, V_H\}$ is reached. ξ_L will be the low confidence state, while ξ_H will be the high confidence state, having as transition probabilities:

$$Prob(\xi_{t+1} = \xi_H | \xi_t = \xi_H) = p_H$$

$$Prob(\xi_{t+1} = \xi_L | \xi_t = \xi_L) = p_L$$

Summing up, $p_H \in (0,1]$ will be the probability of being in the high-confidence state in period t+1 conditional on being in the high-confidence state in t, while $p_L \in (0,1)$ will be the probability of being in the low-confidence state in period t+1 conditioning on being in the low-confidence state in t. These probabilities could be seen also as the persistence of one of the two states. What is more the high confidence state has been modelled as an absorbing state.

Because of the purpose of the thesis, we are interested in a sunspot equilibrium in which the economy is subject to liquidity trap episodes that are associated with the low-confidence state.

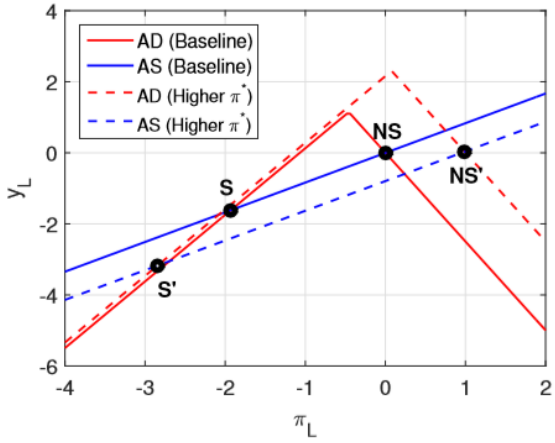
The sunspot equilibrium has been built up associated with rare spells at the lower bound and chronic deflation, hence a way to assess stabilization outcomes and welfare could be setting up a **non-zero inflation target**.

The effect of a change in the target inflation rates will be the determined as follow

$$\frac{\partial \pi_L}{\partial \pi^*} < 0, \frac{\partial y_L}{\partial \pi^*} < 0, \frac{\partial \pi_H}{\partial \pi^*} > 0, \frac{\partial y_H}{\partial \pi^*} > 0$$

A marginal increase in inflation target lowers output and inflation in the low-confidence state and raises output and inflation in the high-confidence state. The rationale behind is that all else equal, once the absorbing state is reached, if the gap between the inflation target and the actual inflation widens, the central bank will tolerate a positive output gap to bring inflation close to its target as soon as we are in the high-confidence state and the public still believe in the Central Bank credibility. The other way around is true in the low confidence state.

To understand this trade-off between the inflation target and output gap we refer to the following graph in an AD-AS framework.



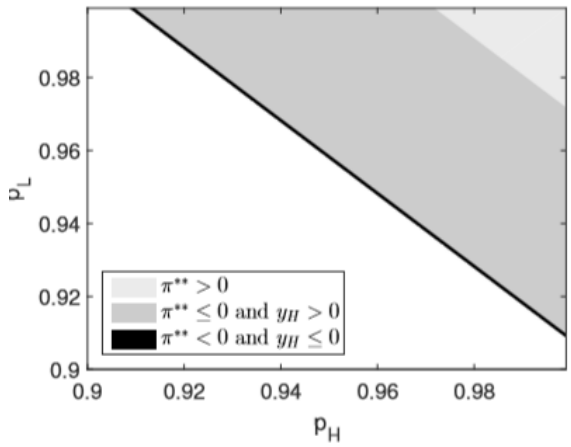
Model with sunspot shock

This graph shows what happen in a low-confidence state when the inflation target is raised. The *AD curve* is shifted upwards responding to an increase of the agents' desired consumption given higher expected inflation, while the *AS curve* shifts down answering to firms' desired increase in prices in response of the higher inflation.

The original equilibrium in point S has, at this point, to be shifted because of the excess demand. To get back to an equilibrium state, low-state inflation and output have to decline, getting us to the point *S'*.

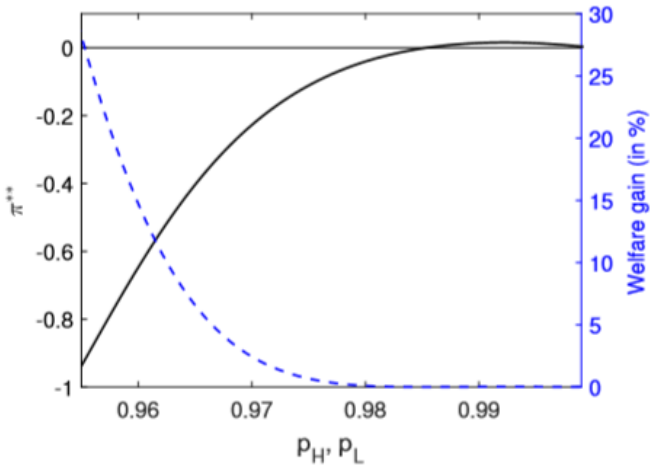
On the other side **in the absence of a sunspot shock**, the equilibrium would be in the point NS. The higher inflation target lowers the ex-ante real interest rate in the low-confidence state. This will be reflected by an increase in inflation at time t+1, leaving the output gap stable in the long run.

Nonetheless if we consider a situation different from the absorbing state one, the optimal inflation target for this model π** is function of the two states p_H and p_L persistence.



If the two confidence states are highly persistent, the optimal inflation target will be in the two shaded areas in the graph above. As much as they're both persistent the inflation target will get closer to the light grey shaded area. If instead the two state are less persistent the optimal inflation target will be in the black shaded area and the inflation target will be negative. The white shaded area represents the situation in which the two states are less persistent, in this region the sunspot equilibrium does not exists.

The optimal inflation target is then plotted in the following graph (black line) together with the welfare gain that derives from assessing the optimal target to the central bank (blue line).



With low values for p_H and p_L, the optimal inflation target is then negative and grows proportionally to the increase in the persistence of the two states.

If a situation of liquidity trap like the abovementioned is observed in the market, the Central Bank will be able to use, as only monetary policy tool, the possibility to steer short term interest rates to fulfil its objectives. Nonetheless, since the rates are already at very low level, the usual monetary policies will not be effective anymore. In this scenario, unconventional monetary policy could be desired and overcoming the zero lower bound could be a useful tool.

Interesting, now, is the assessment of factors that, in a usual monetary policy conduct, should be taken into account to avoid losing potentially useful information to the policy maker.

4.1. Asset Prices and Conduct of Monetary Policy

Looking at the most recognised models, a good starting point consist in talking about *backward-looking structural model.* In this kind of models, the optimal interest rate is function of current and

past inflation rates and current and past output gaps, assuming that inflation rates and output gaps are good proxies for future inflation rates and output gaps targeted by the central banks.

During the early 2000, the major consensus was towards the central banks required to respond to asset price movements if they would have been likely to influence future inflation and output gap (Bernanke and Gertler, 1999).

However, asset price movement are likely to influence other variables rather than just inflation and output gap. If we look at Modigliani, an easy outcome for this idea could be the following: a change in property price could affect consumer wealth which could lead to changes in their consumption plans.

Thus, as Goodhart and Hofmann suggest *"from a theoretical point of view seems to be a strong case also to consider property and share prices as determinants of aggregate demand, which would imply a direct reaction of monetary policy to movements in these asset prices"*. The authors try to get further with this idea suggesting a model that consists of *"backward-looking Phillips Curve relating CPI inflation to its own lags and lagged output gap and a backward looking IS Curve, relating the output gap to its own lags and las of the real interest rate, the real exchange rate, real property prices and real share prices"*[9].

Even if this model looks a simplistic approximation of the reality the idea of Goodhart and Hoffman was not to derive guidelines for the conduct of monetary policy, rather show how asset prices could give useful information about future demands conditions and the loss of information that could incur not taking them into consideration.

It's then presented the Phillips curve:

$$p_t = \sum_{i=1}^{n_1} b_{1i} p_{t-j} + \sum_{j=1}^{n_2} b_{2j} y_{t-j} + \sum_{k=0}^{n_3} b_{3k} dpo_{t-k} + e_t$$

Where *p* is the quarterly inflation, *y* is the percentage gap between real GDP and potential GDP and *dpo* is a proxy about the quarterly change in oil price.

While the IS curve has to take into account for the percent gap between the ex-post real short-term interest rate (*rir)*, the real effective exchange rate (*rex*), real residential property prices (*rhp*) and real

[9] Charles Goodhart and Boris Hofmann. *"Asset prices and the conduct of Monetary Policy"*. September 2002

share prices and their respective long run trend levels (*rsp*). What is more there is also a term that accounts for the lags in the OECD output gap (y^{oecd}).

$$y_t = \sum_{i=1}^{m_1} g_i y_{t-i} + \sum_{j=1}^{m_2} /_{1j}\, rir_{t-j} + \sum_{k=1}^{m_3} /_{3k}\, rex_{t-k} + \sum_{k=1}^{m_4} /_{4k}\, rhp_{t-k} + \sum_{k=1}^{m_5} /_{5k}\, rsp_{t-k} + \sum_{q=1}^{m_6} /_{1q}\, y^{oecd}{}_{t-q} + h_t$$

The optimal interest rate response to asset prices depends if the asset prices are **supply driven** or **demand driven**. If the asset prices are mainly driven by supply factors, the aggregate demand helps to equilibrate demand and supply. Instead when asset prices are influenced by demand factors, price movements tend to cause disequilibria in the goods markets that are to be adjusted with interest rate reactions.

Having said that, if movements of an asset price contain information about aggregate demand rather than supply conditions, we expect a positive ex-post correlation between the asset price and the output gap, if instead the other way around is true the output gap should not be significantly differ from zero or even negative.

These issues have been taken into account by the abovementioned scholars that opted for estimating separately the equations presented above using the OLS method.

For the Phillips Curve the output gap seems to be significant at least at the 5% level in all countries. Hence, an increase in asset prices lead to an increase in the inflation rate. Concerning the IS Curve, all of the four factors[10] characterizing the equation affect the output gap even if the timing of the impact differs.

At this point authors want to stress the idea of what will happen if the central bank ignores the effect of property prices and share prices on aggregate demand leaving the output influenced only by the interest rate and the exchange rate. The IS Curve, when dropping property and share prices, ends up with lower estimated coefficient for interest rate and exchange rate.

This result is explained as *"a positive correlation between real interest rates and properties and equity prices, which may arise if the central bank reacts to fluctuations in asset prices in order to stabilise the output gap"*.

[10] Real interest rate, real exchange rate, real house prices and real equity prices.

4.2. Differences in monetary policy conduct of European Central Bank and FED

In this section we are going to stress the view about monetary policy of ECB and FED observing the way they conduct monetary policy and the challenges posed during their activity period.

The ECB, has turned to its 22nd years of activity, gathering at inception 11 central banks, reaching nowadays 19. To assess the challenges of these years of activity we will review the working paper that ECB published for the 20th anniversary of its birth.

The main challenge ECB had to face was to reach **price stability** with the possibility of **steering short-term interest rates** in line with the decisions of the Governing Council.

As declared by the ECB itself, price stability was hard to achieve. It was addressed, anchoring prices to medium-term inflation having as mantra:

"*Price stability shall be defined as a year-on-year increase in the Harmonised Index of Consumer Prices (HICP) for the euro area below 2%. Price stability is to be maintained over the medium term".*

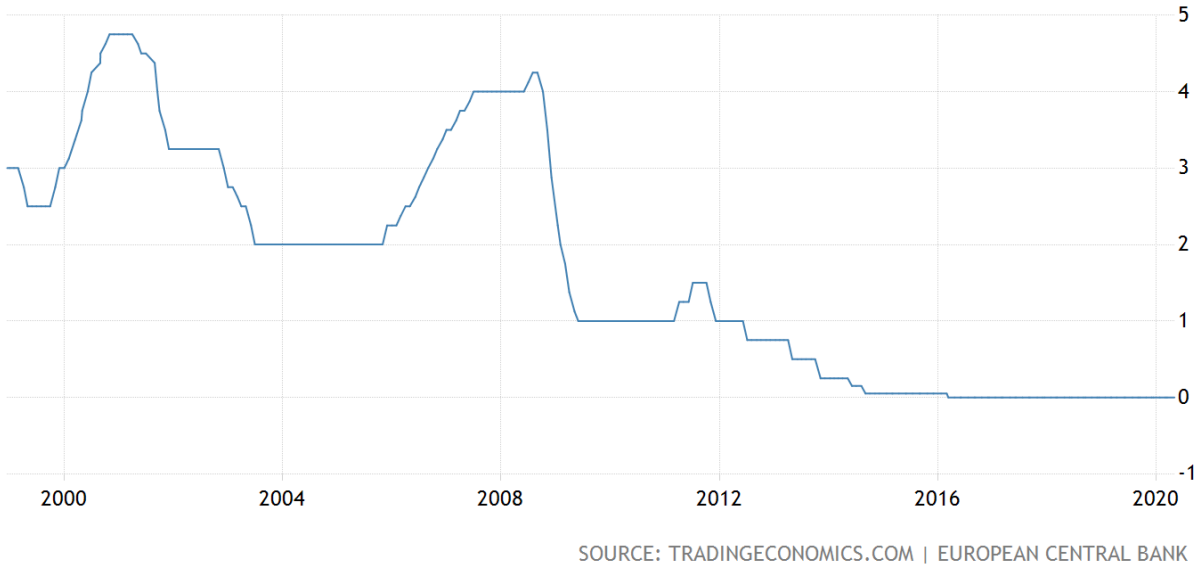
The medium-term orientation was an important feature of the ECB's strategy, not only anchoring on longer-term inflation expectation was perceived as a price stability measure, it could be deemed also as a credibility index. In fact, over the past two decades the average inflation has been approximately 1.7%. Likewise, this time orientation also helped avoiding excessive activism and unnecessary volatility into the real economy.

About the mentioned challenges, ECB dealt with them using three tools mainly:

- **Main-refinancing operations (MROs)**: to enhance liquidity on a weekly basis, they are mainly used to provide liquidity to the banking system. Sometimes the weekly maturity could vary depending on situations like bank holidays in Member States.
- **Longer-term refinancing operations (LTROs)**: to provide longer-term liquidity to the banking system. Usually these kinds of operations have a three-month maturity, but also operation with six-months or twelve-months maturity have been observed during the years. They are used to avoid that all liquidity in the money market has to be renewed on weekly basis, giving at the same time the opportunity to the counterparties to access longer-term refinancing.
- **Fine-tuning operations (FTOs)**: to provide ad-hoc open market liquidity-absorbing or liquidity-providing operations. In particular, FTOs seem helpful to keep steering interest rates, smoothing at the same time the effect of unexpected liquidity fluctuations in the market. These

operations have been executed throughout the years as reverse transactions, foreign exchange swaps or through the collection of fixed-term deposits.

The use of these tools lead to the following key interest rate for the Euro area.



Especially in the aftermath of the 2008 crisis, the ECB adopted fixed-rate/full-allotment tender procedure in all its monetary policy operations, at the same time they opted for expanding the list of eligible collateral (BBB or higher) and lengthened the average maturity of its outstanding operations. These measures led to an expansion of the ECB balance sheet.

Switching the discussion to the FED approach, as per statement, the goal of the American central bank is to have a stable price level, that involves a long-run **inflation goal** of the 2%, and a maximum **sustainable employment**.

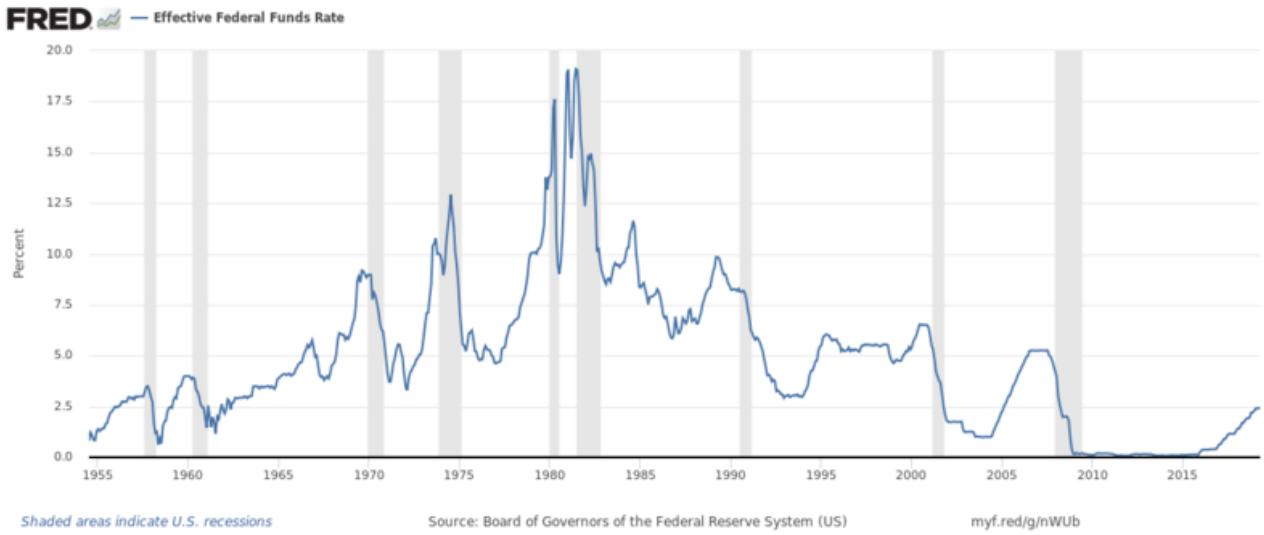
The Federal Reserve has three instruments to conduct the monetary policy and expand or contract money and credit:

- **Open market operations**, namely the FED buying existing U.S. Treasury securities using Federal Reserve Notes to expand the reserve base and increase at the same time, injecting liquidity in the market, the ability of financial institutions to broaden money and credit.
- **Change in reserve requirements**. Such a measure influences the available liquidity in the market, but it's used occasionally. Last time the reserve requirements were changed by the FED was during 1992.
- **Changing the interest rates they administer directly**. The FED allows depository institution to borrow from it on a temporary basis, and the discount rate offered to these institutions involves just a small mark-up over the federal funds. Modifying this discount

factor is a valuable way to expand liquidity in the market. In fact, if the FED wish to expand money and credit, this discount rate will be lowered to encourage more lending and activity, if on the other side the wish is to tighten money and credit, the discount rate will be raised. Such a tool is a relevant liquidity source especially during financial crises.

The rate we just talked about is known as **federal funds rate**. The federal funds rate is the interest rate at which banks and other depositary institutions lend money to each other overnight on an uncollateralized basis.

Before the subprime crisis, this rate had experienced a downward trend starting from 1982. However, some argues that exceptionally low rates are one of the 2006 crisis causes, many in fact affirm that short-term rates were kept too low for too long, causing an increase in demand for housing that lead to a price bubble.



The discussion about the monetary policy of FED and ECB will continue further in this work, to understand how the usual monetary policy conduct of these two is adapted in an economic downturn period.

5. Unconventional Monetary Policies

When conventional monetary policies reach their limit of effectiveness, central banks could opt for providing additional easing with unconventional monetary policies.
Over the past years, Quantitative Easing and more recently negative interest rates have been used by central banks to mitigate the adverse effect of global financial crisis.

5.1. Unconventional monetary policies major central banks adopted throughout the years

As introduced above, when a central bank comes to the choice of using unconventional monetary policies, the choices over the last years have been towards **quantitative easing** and **negative interest rates**. These measures have to be thought as temporary, however after the 2007-09 crisis they have been put in place for longer time horizons than it was expected, becoming part of the modern central bank's toolkit. In this section we will review these measures providing a general overview about them.

5.1.1. Quantitative Easing

Quantitative easing is an unconventional monetary policy, adopted to increase money supply in the economy to further increase lending by commercial banks and spending by consumers. The central bank infuses a pre-determined amount of money into the economy buying financial assets from commercial banks and private entities. This leads to an increase in banks' reserves. Quantitative Easing has been effective when lowering interest rates fail to work[11] and usual monetary policies reach the limit of effectiveness.

To unlock liquidity and help bank's lending activity, significative rounds of QE during last years were undertaken as per below:

- FED: Q1 2008, Q4 2010 and Q3 2012.
- ECB: Q1 2015 and Q2 2016.

The ultimate goal of quantitative easing is to flatten the yield curve and stimulate borrowing, investment, and spending, increasing the price of long-term debt through central bank purchases. Prices of assets indeed should rise, and their yields decline. Declining yield and rising asset prices will have as effect the easing of financial markets and the stimulation of the economic activity.

[11] Usually when a liquidity trap situation occurs in the market.

Investors will then be encouraged to rebalance their portfolios towards long-duration assets not included in the purchasing program of the central bank, and corporate bonds will then become more appealing to investors.

QE puts, as well, downward pressure on the exchange rate, providing impetus to aggregate demand through improved price competitiveness of domestic production.

Indeed, according to Harriet Jackson (2015) QE has not only lowered interest rates on purchased assed, but also helped lowering rate on some types of debt. QE, therefore, has been seen as a substitute for conventional monetary policy when policy rates approaches to the effective lower bound.

Nonetheless, QE decreases the availability of safe assets like long-term government bond, that are a safe environment for certain investors, just as institutional investors, and because of this, QE could be harmful for the market functioning. Even more, in a situation where central bank's asset holdings are a considerable share of outstanding supply, price discovery and liquidity premiums could be compromised.

5.1.2. Negative Interest Rates Policies

As mentioned in chapter 2, since 2012 several central banks pushed short term rates into a negative field trying to ease monetary conditions and support economic activity. At the time, at a global level, the tendency was towards a reduction in investments associated with an increase in savings and a diminishing interest in highly rated low-risk fixed income assets. Alongside previous unconventional monetary policies, several central banks tried to provide additional accommodation breaking through the zero-lower bound.

There are several reasons why Central Banks decided to opt for negative rates. The main motivation that stands for ECB, BOJ and Riksbank was to stabilize inflation expectations and growth. In March 2016, ECB when disclosing the adoption of this policy declared it was needed *"to further ease financing conditions, stimulate new credit provision and thereby reinforce the momentum of the euro area's economic recovery and accelerate the return of inflation to levels below, but close to, 2 percent"*

Under NIRP, market participants are required to pay interest on deposits, this way the central bank tries to penalize financial institutions and individuals for holding cash guiding them towards lending to businesses and investing in alternative assets boosting their prices.

The transmission channels of negative interest rates policy work similarly to those of conventional easing (Jackson 2015, Hannoun 2015), having as a main effect the downward shift of the yield curve at all maturities[12].

Indeed, following the rollout of negative rates, all floating-rate loans and mortgages should be more affordable, financing costs for firms and households reduced, encouraging an increase in borrowing. Aside from lowering borrowing costs for businesses, NIRP have been used also to achieve different goals. Bank of Japan used NIRP during 2016 to avoid a strengthening of the yen potentially harmful for an export-reliant economy like the Japanese one. A weaker currency will give to the country's export a competitive advantage. Furthermore, as much as the interest rates go down, the value of fixed-income securities goes up, leading to higher profits. Consequently, a decline in the level of interest rates can also push up net interest margins in the short run for the markets' participants.

The effectiveness of NIR in being able to boost economic growth and support inflation has still to be proven and several concerns have been highlighted regarding negative interest rates. As mentioned in chapter 2, the major concerns are for financial stability and investments. In particular, the impairment of the banking system and an increase of exposure towards risky assets, are a likely downside of this policy. We will try to assess the likelihood of these risks and how the portfolio rebalancing channel will deal with these threats.

5.2. Monetary transmission of negative interest rates

The motivation behind the implementation of NIRP varies from case to case, nevertheless the transmission channels are analogous to any rate cut even the ones leaving rates slightly positive. Negative rates, however, soften the expectations of markets that current and future short-term rates cannot be negative. By removing the perceived lower bound of central bank rates, NIRP facilitate the monetary accommodation to propagate through the entire yield curve.

Beginning with the **interest rate channel**, a rate cut, will enhance borrowing and lending condition market participant will face. Once the zero lower bound has been overcome, a rate cut will reduce the money market rates and the bond yields for shorter maturities.

These effects could face some constraints if the banks hesitate to impose negative rates for individual or corporate deposits to avoid losing their income associated with the deposits. This reluctance,

[12]QE shifts down primarily longer maturities.

together with efforts to maintain interest margins could potentially impact the pass-through on negative rates to lending rates.

Regarding the **credit channel**, negative central bank policy rates will discourage banks from holding excess reserves in favour of lending, pushing down even more market interest rates. Supposing confidence and the health[13] of banks, namely the absence of non-performing assets in the banks' balance sheet, the effect on lending will depend on the investment opportunities available and on the amount of money that are going to be lost if cash is held as a deposit.

Once again, it will depend also on the willingness of banks to pass through negative rates to protect their profits. What could happen according Heider, Saidi and Schepens (2016) is that banks, being afraid of losing their most relevant source of financing, may be careful about lowering interest rates on deposits below zero. Negative interest rates could then impair bank profitability leading to a contraction in lending.

Negative interest rates policies are expected to affect the available credit to households and firms, bringing as a side effect an adverse impact on *credit growth* if banks will charge higher lending rates to cover their lowered profitability and diminished capital base after an eventual introduction of NIRP.

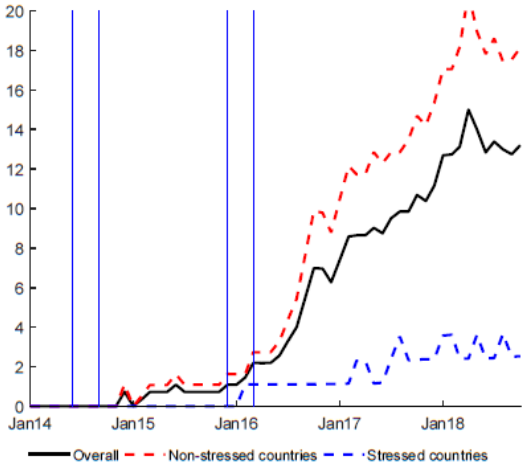
Same discussion has to be done about **consumption**, that will depend on the household's behaviour. If saving behaviour remains unchanged, after the implementation of negative rates, there will be an incentive towards borrowing and investing that won't be different from a rate cut happening in the positive field. But there are two concerns about the impact of negative rates policies on consumption.

First of all, if the majority of private public, after the introduction of NIR, decide to convert their deposits in cash there will be a reduction of the availability of loanable funds, pushing up borrowing costs and watering down the stimulatory effect of such an unconventional policy.
Secondly, the fear they will redirect their investments towards riskier assets. This threat has been already introduced and as we already said, there is not still any empirical support for the argument, but it is still a risk that should be taken into account when consumers are deprived of a safe haven for their cash holdings.

However, despite the fear of households withdrawing their cash, according ECB, **deposits**, that are the most important source of financing for the European monetary financial institutions, have been growing also during periods of negative interest rates. The following graph comes from a working

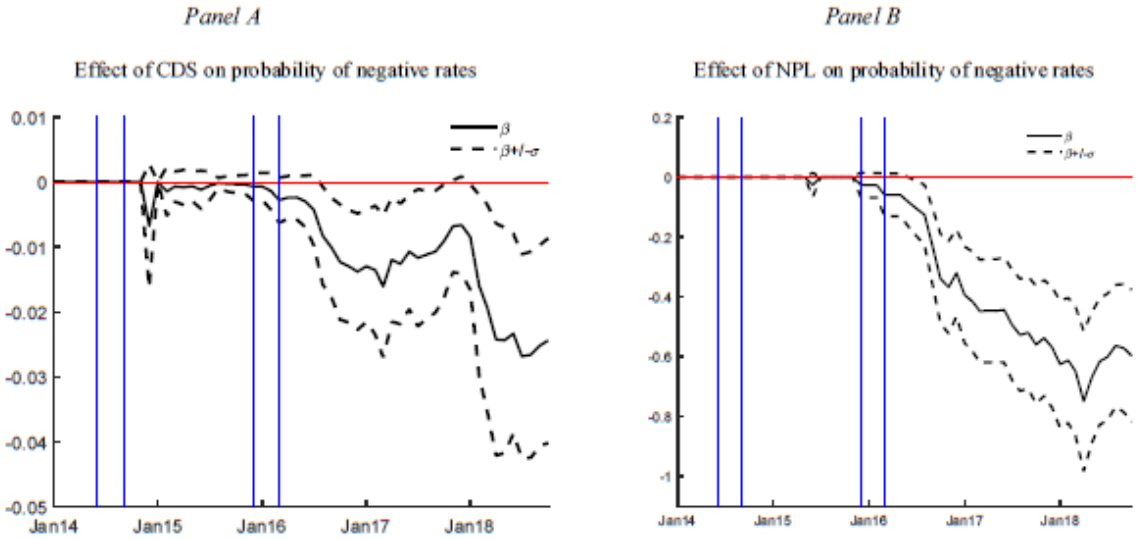
[13] Without which bank will be reluctant to lend and consumer to borrow.

paper of the ECB dated June 2019. It shows the percentage of banks adopting NIR over time in stressed[14] and non-stressed countries. Non-financial corporations' deposits with negative rates increase more in non-stressed countries rather than in stressed countries where they remain stable over time. Consequently, the first conclusion we can draw, is that bank health plays a significant role in the transmission of monetary policy when policy rates turn negative.



Only banks that are more solid, namely with less non-performing loans or with lower default risk, are able to offer NIR on deposit, even for deposit of financial corporations.

Secondly, looking at the following graphs, it is highlighted that the effects of the NIRP are gradual since no central bank has still set an effective lower bound, the effects become statistically significant after some month from the introduction of negative rates.



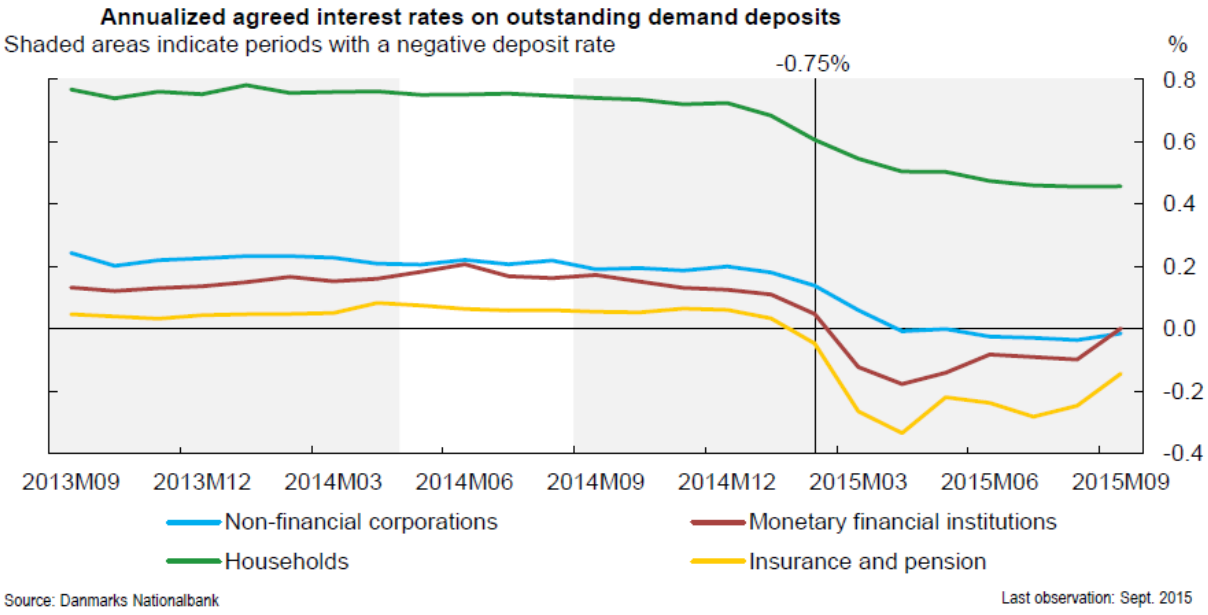
[14] Stressed countries are economies having problems dealing with their sovereign debt. The default risk of these ones will be considered by the investors in their investing decisions.

5.3. Examples of unconventional monetary policy

Switzerland, Denmark, Sweden and the Euro Area have introduced NIR since mid-2014, either charging negative interest rates on reserves deposited or in lowering the key policy rate target below zero (Sweden and Switzerland), in this section an overview about past experiences with NIR policy will be presented.

Denmark and Switzerland introduced NIR to shrink the capital inflow and appreciation pressures, the Euro Area because of the weak growth and inflation and Sweden because of the deep recession.

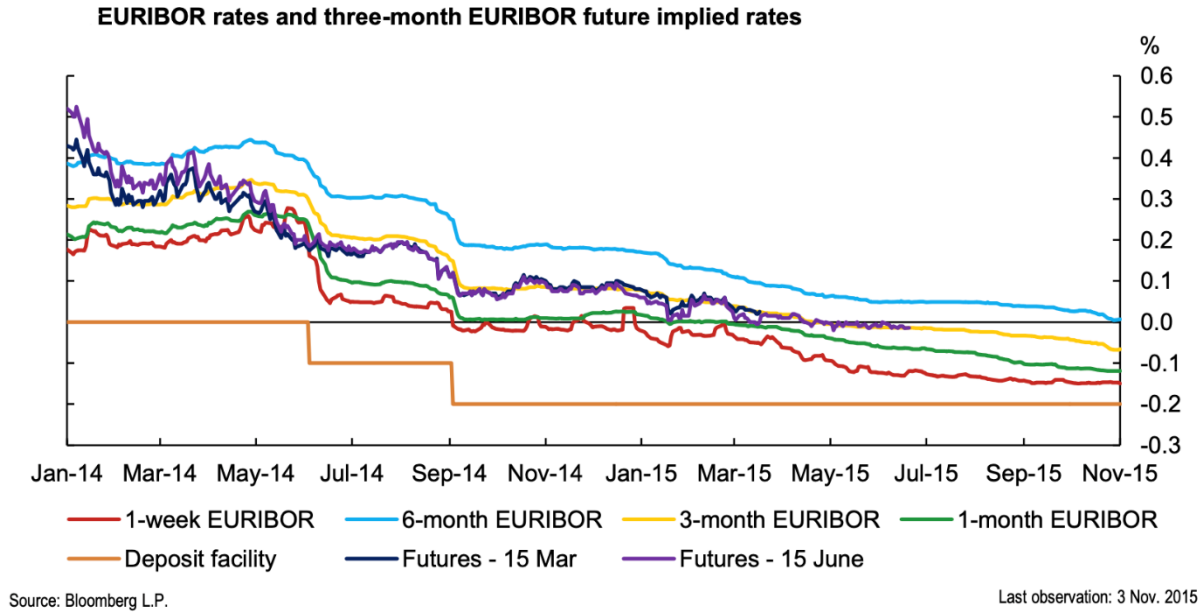
In Denmark the excess of liquidity was considerable. Treasury bills were already trading at negative yield before the introduction of negative interest rates policies. Yields on mortgage bonds also were falling. The Danish central bank lowered further rates on deposits to -0.75% in September 2014 in response to the onward pressure from capital inflows. At the same time, pressure on krone intensified, as a result Danish government suspended the issuance of Danish government bonds on January the 30th, 2015 trying to reduce the yields thereof. These measures drove further down negative rates, even for longer maturities.



Negative rates are usually associated to a likely squeeze out of bank earnings. However, in their assessment done at the end of Q3 2015, Danmarks Nationalbanks find out that negative rates have not passed on to bank-administered deposits and household lending rates, since several customers opted for a remortgage, but rather their effect influenced mostly deposits of firms and institutional investors.

This behaviour observable in the Danish pass through of negative rates worked out consistently, avoiding the presumably risk of households switching their deposits in cash undermining the bank's profitability.

About the Euro Area experience, NIRP were adopted to prevent the action of disinflationary forces in the aftermath of the global and sovereign debt crisis. The decision that took negative interest rate down, exceeding the zero-lower bound, seemed to work out in a solid way, probably in the best way between the countries that were applying NIRP at the time. Lower rates were well transmitted to money market rates in secured and unsecured markets. Liquidity and volatility remained unaltered, the policy action was transmitted to longer market rates, implying that the EURIBOR, the 3-months EURIBOR futures and yields on euro area Treasury Bills declined.



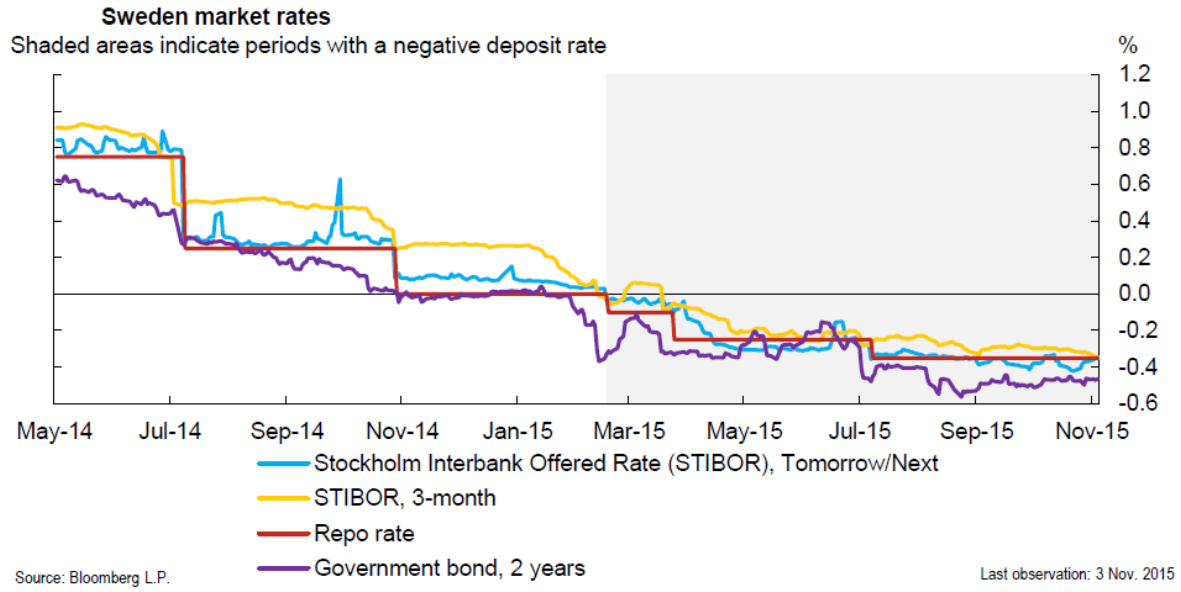
Moreover, during the 2014 experience, funding costs for euro area banks have been compressed trying to maintain the usual level of intermediation margins for banks. Even if the pass through of negative rates worked quite good in the Euro Area, there are some degree of downward rigidity in retail deposits rates, limiting further improvements in funding cost.

However, the overall experience seems fairly encouraging, since as ECB states "*as a result of NIRP, lending volumes have expanded and the creditworthiness of borrowers has improved, thereby mitigating the impact of lower interest rates on overall bank profitability"*[15].

[15] European Central Bank, *"Low interest rates and households net interest income*", ECB Economic Bulletin, Issue 4 / 2016, Box 3.

The Swedish national bank cut its repo rates to -0.35% expecting to stay negative till the end of 2016. Deposits were charged by -1.1%, market rates, including treasury bills, government and mortgage bonds, interest rates derivatives have been traded at negative rates (look at the chart below). The main aim of the NIRP for Sweden consisted in an attempt to bring up again the inflation at its target level of 2%. Swedish central bank achieved this result within a short time after the adoption of negative rates, but some argues that this result was not an effect of negative interest rates policies rather something achieved because of the general bullish trend of the European economies on which Sweden was highly correlated.

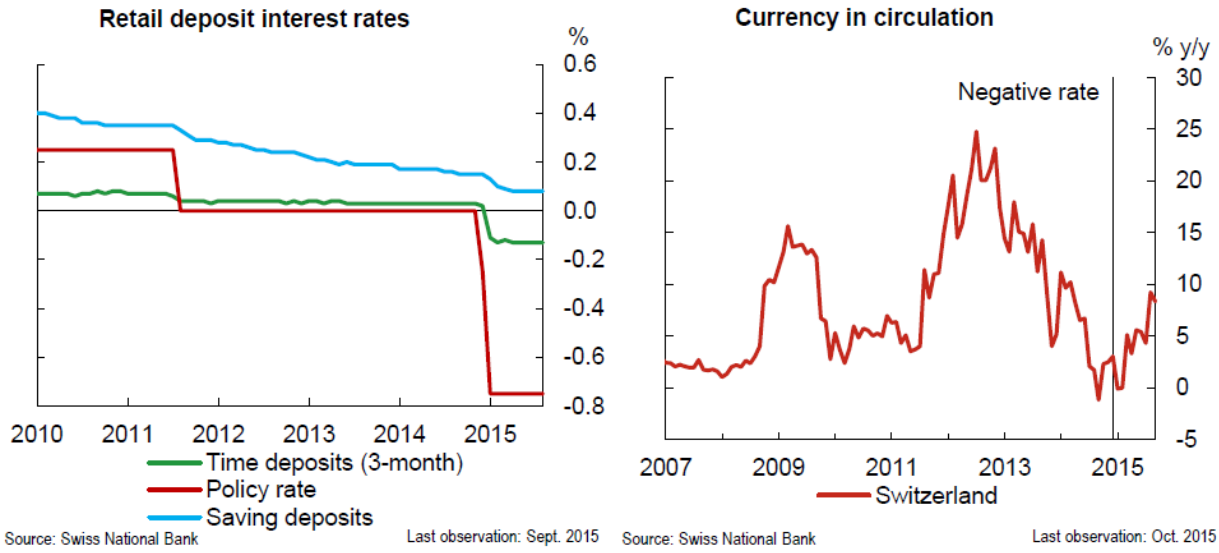
Nonetheless, some concerns were associated to a price bubble of the housing market together with the high degree of household indebtedness. Riksbank replied to these concerns declaring that further reduction in the repo rates would have been possible.



Lastly, as anticipated above, rates went negative in Switzerland to mitigate the huge capital inflow threat. Switzerland in fact, represents an almost safe haven for deposits and in absence of a negative interest rates policies the insurance against severe crises offered by the Swiss franc would be provided freely.

Negative rates were applied to the entire spectrum of money and capital markets interest rates and the market overall continued to work without compromise its general functioning. Rates in Switzerland

become negative on Swiss government bond. A general reduction of currency in circulation was gradually achieved.



Indeed, it is difficult to completely disentangle the effectiveness of NIR since several other measures were undertaken at the same period. According to the International Monetary fund the effect of these measures looks limited but still, it seems too early for a full assessment.

Banks profitability wasn't undermined during the Swiss experience, the NIRP consequences were mitigated by the fact that negative rates were charged only on a portion of the deposit bank account balance which exceed a certain threshold, that was set at 10 million CHF.

If a downside of this policy has to be assessed, it would be about currency circulation. It is true that during 2015 reached its lowest point since 2007, but still this process took time and several concerns are associated with the prolonged use of unconventional policies.

The outcome from the overall 2014 experience with negative rates appears positive. Once again according Jackson (2015), NIR didn't cause significant volatility, or impaired markets, but is also true that several banks have been reluctant to pass negative rates to individual depositors.

According to the Canadian economist, as long as "*there is a positive spread to encourage borrowing and lending, the absolute level of interest rates is not particularly important for intermediaries*"[16]. In

[16] Jackson, H. "*The international experience with negative policy rates*", Bank of Canada Staff Discussion Paper, No. 2015-13, November 2015.

fact, despite the negative rates, trading volumes during the period have generally been stable and the majority of unsecured transaction ran smoothly without any particular problem.

5.4. Where is the lower bound?

At this point the real challenge would involve understanding how much central banks can push down negative interest rates having a value at which agents in the market still prefer to hold cash over bank deposits earning a negative interest. Key determinants for assessing these issues are **cost of storage**, **insurance**, **safekeeping** and **transportation of cash**.

Starting with the cost of storage, safekeeping and transportation, according Keohane[17] (2015) they could be approximated in a range between 0.2% and 1%. These variables will be influenced by the size of the bills. For example, we could expect a lower storage, transportation and convenience cost for Swiss Francs with the largest denomination available at 1000 Francs (approximately 941[18] Euros) rather than for Euro where the largest denomination available is 500 Euros.

To the abovementioned values, should be added the **cost of convenience,** classified as the extra price consumers are willing to pay to make their lives easier**.** A fair approximation for the cost of convenience are the fees associated with credit and debit card interchange fees, estimated on average around 1-3% annually.

Gathering these data, could be suggested that NIR marginally below 2% are possible without shrinking the likelihood of the investor holding cash as a bank deposit despite the unconventional policy we are considering.

If from a theoretical standpoint a negative rate of 2% seems feasible, looking at the Euro market during the 2014 experience, the ECB declared in September 2014 that they reached the lower bound with -0.2% as deposit facility rate. However, President Mario Draghi, in October 2015 declared that a further lowering of deposit rates would have been likely, if additional easing was needed. Similar attitude has been associated to Denmark's NIR experience. Lars Rohde, governor of Danmarks Nationalbank, with a negative rate on deposit at the time of -0.75%, declared that they did not find the lower bound yet.

A further point to consider is the **duration of negative rates**. Bean (2013) claims that it is not possible to hold rates negative around -0.5% for more than a year or two without provoking a movement from

[17] Data about cost of storage, insurance, safekeeping and transportation of cash are from Keohane (2015).
[18] FX rate 1,06 as at March the 29th, 2020.

deposits to cash by the households, unless the convertibility of bank reserves into cash would have been restricted in some ways. The British economist argues that if NIRP are perceived as a permanent policy, banks will consider converting their reserves into cash to avoid charges and will impose significant charges for the managed bank accounts. Customers might prefer to increase their cash holding, shrinking banks' reserves and undermining the banks system ability to deliver basic banking functions of maturity transformation[19] and payments transfer.

Indeed, if NIRP become a common practice and agents' expect these as persistent, some scholars, like Cecchetti and Schoenholtz (2016), theorize the possibility to mitigate the effect of the duration of negative rates, with banks offering what the scholars call *"cash reserves accounts"*, namely a type of product backed by cash kept in a caveau allowing easy transfers that would act as substitutes for deposits.

In summary, an "economic lower bound" has not been agreed yet, but balanced decision would involve taking into account both positive and detrimental effect of negative rates. The idea is to bring interest rates into negative territory as soon as the simulative effect on lending and consumption, related to the implementation of NIRP, outweigh the detrimental effects on bank profitability. At that point, *"bank profitability will fall, reducing capital generation via retained earnings, which is an important source of capital accumulation, and thereby eventually restricting lending"*[20] potentially causing short term dislocation in financial markets.

Capital gains are in fact calculated as change in equity created by the changes in interest rates:

$$CG = E_0(i) - i$$

Where $E_0(i)$ are the expectations about the evolution of negative interest rates in zero, and i represents the interest rates observed in the market in zero.

If bank profitability is shrunk, there are no capital gains, namely CG = 0, the change in profits due to an interest rate cut exceeding the lower bound will be strictly negative. However, going very negative, requires other policy changes, like taxing cash or charging agents when converting deposits in cash. Under these conditions, which are however unlikely to happen, theoretically there is no limit to how far negative rates could go.

[19] Maturity transformation is when banks take short-term sources of finance, such as deposits form savers, and turn them into long-term borrowings, such as mortgages.
[20] Brunnemeier and Koby (2019).

5.5. How the asset valuation channel reacts to negative interest rates

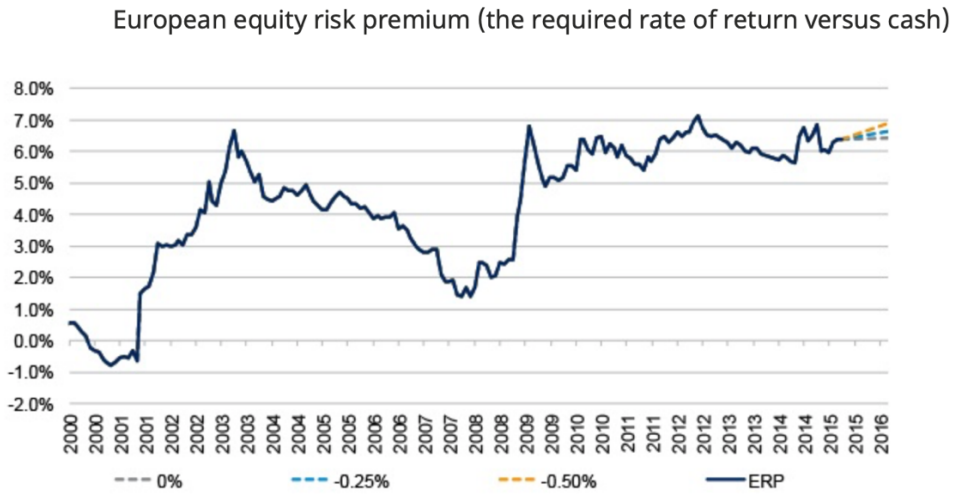
When considering the monetary transmission of negative interest rates, it is interesting to understand the impact they have on the asset valuation channel. A direct way to examine the impact of negative rates on assets and equities is through discounted cashflow models.
These models are helpful in estimating the intrinsic value of stock, assets, equities summing up the present value of the expected cashflows generated by the abovementioned, using an appropriate interest rate as discount factor. All other conditions being equal, a lower discount rate boosts the present value of the assets.

Even the values of fixed income securities will increase, leading to higher profits having as immediate effects of the new rates a boost in net interest margins in the short run.

This way, every model discounting the expected cash flows associated to an asset to calculate the price of such, will result in an increase of the abovementioned. Should however be considered that a negative interest rates environment could potentially distort the asset valuation channel in two ways:

- Increasing the risks of an asset price bubble, if such a measure will be used for a prolonged period, shifting market participants preference towards riskier assets.
- Loose monetary conditions are likely to raise expectation of the economy's recovery, letting people think that in the short future they will be able even more to gain higher revenues from the purchased assets.

The chart below in fact, shows the impact of negative interest rates on equity risk premium for Europe, disclosing the evolution of ERP (on the vertical axis) starting from the early 2000 until 2016.

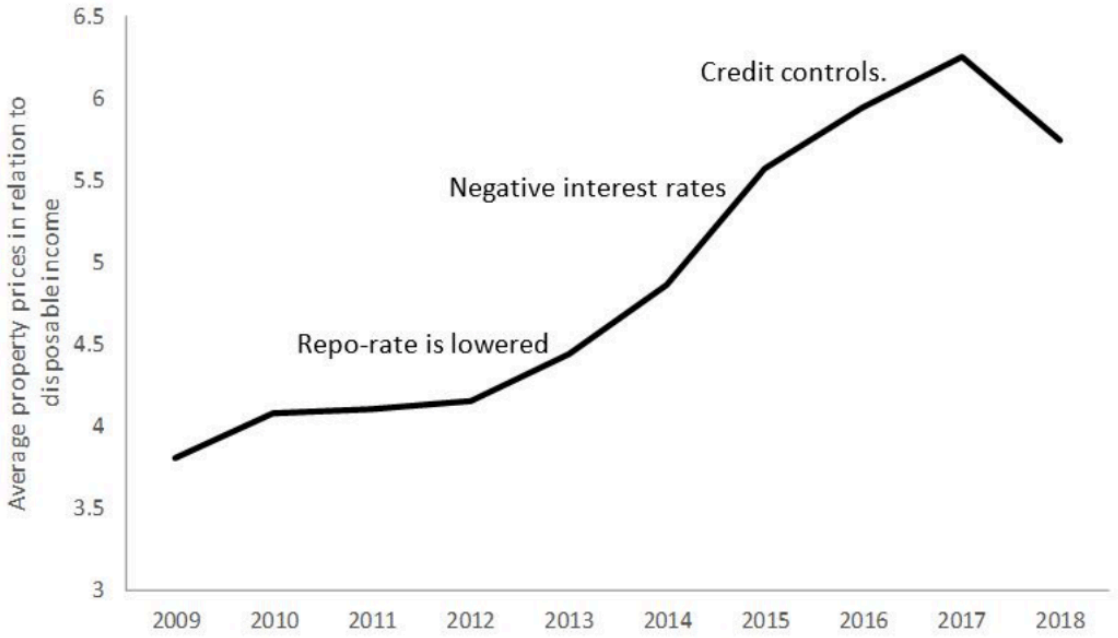


Source: Datastream.

An environment of negative yields forces investors to shift their asset preference towards riskier assets. The ERP should reflect the additional compensation to investors for the increased risk profile of their holdings, and if we look at the graph, this is the case. After the start of the subprime crises and especially after the implementation of unconventional monetary policies there has been a general bullish trend for ERP. Also, the expectations about future movements in the equity risk premium, showed as the area between the dotted lines, seems to respect such a trend.

Looking at the Swedish experience with NIRP, we can easily find out that the rates cut raised property prices in relation to disposable income of the market participants. Swedish financial supervisory authority tried to answer this problem imposing several credit controls on households like debt ceilings, however these measured were not effective. They not only had the effect of dampening real estate prices, but also contributed to growing inequalities on credit controls, which were binding mostly for younger households and other households without assets. Indeed, the credit controls didn't stop the bullish trend in real estate market.

Average property prices (flats) in relation to disposable income, 2009-2018.



Nonetheless, higher asset prices could induce wealth effects, and thanks to a higher valuation, this could eventually support investment and growth. Positive expectations about additional monetary policy easing form market participants and a "*feel-good"* effect generated from the implementation of NIRP in the short run, are likely to dampen this effect as well.

On the other side, the mentioned pros, for several insiders, seem not to be enough to counterbalance the negative effects. In fact, the most likely scenario to happen will involve portfolios being

rebalanced towards riskier assets with a higher concentration of small and medium-sized enterprises bonds which in this context are likely to generate higher returns but at the same time will bring a higher default risk to the investors' portfolios.

Yet, as stated in chapter 2, this behaviour didn't find any evidence in the controlled studies ran in the aftermath of the introduction of negative interest rates policies. On the other side it seems to worth sustain these risks, as soon as the "feel-good" effect and the positive outlook about the NIRP implementation mentioned early, are able to sustain an economy's recover.

5.6. ECB and FED general view about negative interest rates

As for the discussion about the usual monetary policy conduct of the European Central Bank and Federal Reserve, we will start the review related to these Central Banks perspective on NIRP, analysing the ECB point of view. To understand the view of ECB, we will analyse the ECB bulletin from 2016.

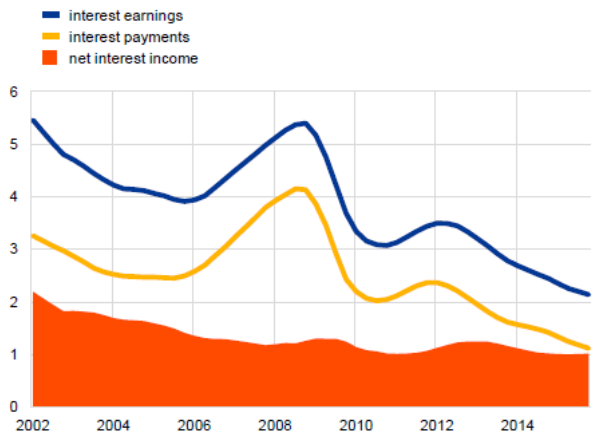
According their data, this accommodative monetary policy was effective in lowering borrowing costs for firms and households, but at the same time NIR had a detrimental effect on return on savings.

As the following graph shows, however, the reduction in return on savings seems to have been offset by a considerable decrease in interest payments.

Between Q4 2008 and Q4 2015 the interest payments fell by about 3% relative to disposable income. This drop has been assessed as comparable to the drop-in interest earnings, leaving the euro area household's net interest income almost unaffected.

Euro area households' interest payments/earnings

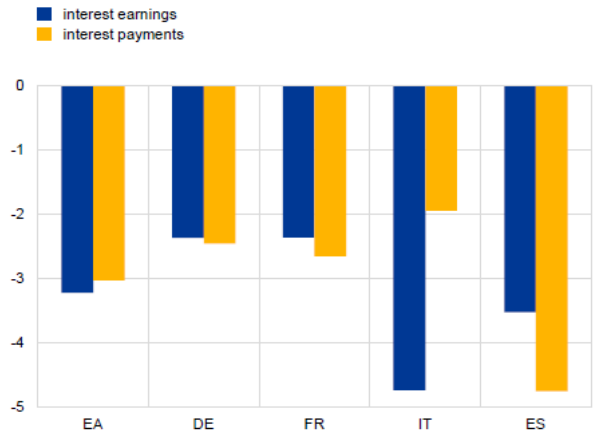
(percentage of gross disposable income)



Sources: ECB and Eurostat.
Notes: Interest payments/earnings after allocation of FISIM (financial intermediation services indirectly measured), based on four-quarter sums. The latest observation is for the fourth quarter of 2015.

Households' interest payments/earnings
Q3 2008-Q4 2015

(changes as a percentage of gross disposable income, percentage points)



Sources: ECB and Eurostat.
Note: Interest payments/earnings after allocation of FISIM (financial intermediation services indirectly measured), based on four-quarter sums.

The net interest income, as ECB states, remained stable especially in Germany and France, while NIRP did not have the desired effect in Italy and Spain. In particular, for the Italian case, the drop in households interest earnings were twice as large as the drop-in interest payments.
The rationale behind could be found in the fact that Italian households hold a large amount of interest-bearing assets while they are less indebted than peers in other European countries.

Overall, ECB has been pleased with the first experience with negative rates policies. NIRP have been useful not only in lowering borrowing costs but also in stimulating investment and consumptions, ECB is then comfortable in adding NIRP to the tools of monetary policies in situations where unconventional monetary policies are required.
Former president of the ECB Mario Draghi in his final speech at ECB, once again stood up for the effectiveness of negative interest rates and their role in holding the inflation target at 2%. About the concerns of several scholars he answers this way: *"The overall assessment has been clearly positive. The improvements in the real economy have more than offset any negative side-effect"*.

On the other side the U.S. Federal Reserve never adopted negative interest rates policies to provide additional ease to the American economy.
During 2014, while other central banks where exploiting this opportunity, Janet Yellen, Chair of the FED at the time, declared that NIR were something the FED could have considered later on, but at the same time she considered the benefits arising from the use of this policy fairly small.
In the early 2020, after the outbreak of Covid-19, BOJ and ECB immediately have opted for adopting a negative deposits facility rate to provide monetary ease, FED once again tried to avoid them even considering the current extreme liquidity strains.

Gavyn Davies[21] in an article published on the Financial Times in March 2020, argues that two factors mainly explain this:

- It's difficult for the US financial system to go negative. Money Market funds, accounting for $4tn in assets are sometimes treated like bank accounts, hence taxing them could end up in a tremendous pressure over their profitability.
- The experience with NIR in Japan and the eurozone doesn't provide enough information about the real value to boost confidence and economic activity. Since there isn't still enough confidence in the usefulness on negative rates policies, it could be a long shot sacrificing the profitability of the abovementioned Money Market funds to adopt such a measure.

[21] Gavyn Davies is a former Goldman Sachs partner and from 2001 to 2004 he was chairman of the BBC.

However, the debate is rather than closed. In early May 2020, President Donald Trump, through its social networks profiles declared *"as soon as other countries are receiving the benefits on Negative Rates, the USA should also accept the gift"*.
Federal Reserve Chairman Jerome Powell, on the other side threw it back *"I know there are fans of the policy, but for now it's not something that we're considering. We think we have a good toolkit and that's the one that we will be using."*

At the time of this statements, FED just launched a stimulus package of 3 trillion USD in loans and asset purchases. Only time will help to understand if this program will be useful for the US economy recover, or Federal Reserve will be forced a step back and embrace negative interest rates policies.

6. Optimal asset allocation with the presence of negative interest rates on the market

6.1. The portfolio rebalancing and risk-taking channel

When assessing a portfolio's risk-and-return characteristics, the major determinant to take into account is the portfolio asset allocation, namely the strategy of dividing the investment among different asset categories, such as stocks, bonds, real estate, cash, and cash alternatives. However, when talking about asset allocation, it is wise to consider that, over time, asset classes produce different returns, so the portfolio's asset allocation changes.

Rather than maximizing returns, the purpose of portfolio rebalancing is to minimize the risks associated to a target asset allocation. To achieve this purpose the portfolio rebalancing strategy should take into account each investor's risk tolerance, time horizon, and financial goals.

Over time, in fact, as the portfolio produces different returns, it will **drift**[22] from its original target allocation getting risk and return characteristics that may be inconsistent with the rebalancing strategy proposed. Therefore, the portfolio should be rebalanced periodically to achieve a reduction of the drift and of the risk exposure relative to the market movements.

In the next paragraph I will present an example of portfolio rebalancing involving the Vanguard's VVTHX index, but at the moment it is important to understand what would happen if a thoughtful rebalancing strategy is not developed.

The VVTHX index, is a portfolio developed by Vanguard for people that target their retirement around 2035. Such an index is composed by domestic stock, foreign stock and domestic bonds. This last voice is taken in order to ease the risk profile of the portfolio. Vanguard does not disclose its strategy of asset allocation, hence let's suppose the portfolio is composed in the following way:

- 40% domestic stocks (30% S&P500, 10% NASDAQ Composite)
- 25% foreign stocks (FTSE 100)
- 35% domestic bonds.

[22] **Portfolio drift** is the divergence of a fund from its investment style or objective. The drift can result naturally from capital appreciation in one asset relative to others in a portfolio. It can also occur from a change in the fund's management or a manager who begins to diverge from the portfolio's mandate.

If we look at the above portfolio during the first 6 months of 2020, because of the Covid-19 there would have been a considerable drift.

Building the portfolio as mentioned above at December 31st, 2019, supposing an initial investment of 100.000 USD, would let us face the following situation:

		Price 31/12/2019	Initial Investment	Initial Weight
^GSPC	Domestic Stock	$3,230.78	$25,000.00	**30%**
^IXIC		$8,972.60	$10,000.00	**10%**
^FTSE	Foreign Stock	$7,542.40	$20,000.00	**25%**
^TNX	US Treasury Yield 10yrs	$98.56	$35,000.00	**35%**
			$100,000.00	100%

Without any further adjustment, or any rebalancing strategy after only 6 months the asset allocation of our portfolio could be heavily impacted by the market evolution. Indeed, if we look at the same portfolio at June 29th, 2020, we would have the following:

		Price 29/06/2020	Return over the period	Current Balance	Current Weight
^GSPC	Domestic Stock	$3,053.24	-5.50%	$23,626.18	**27%**
^IXIC		$9,874.15	10.05%	$11,004.78	**13%**
^FTSE	Foreign Stock	$6,225.80	-17.46%	$16,508.80	**19%**
^TNX	US Treasury Yield 10yrs	$99.89	1.35%	$35,471.58	**41%**
				$86,611.34	100%

The trend observed since the end of 2019, in fact, involved Equity securities with a substantial decrease in their value, representing a smaller portion of the portfolio after the analyzed period, and defensive fixed income, like the US Treasury Yield at 10 years, increasing their value because of the reduced yield.

This is exactly what happened to the portfolio, when the impact of Covid-19 caused a seasonal minimum of stock exchanges all over the world. Since the portfolio has not been rebalanced, the significant dependence by domestic and foreign stocks lead to a loss over the period. A periodic rebalancing strategy would have hedged the investors from the mentioned stock exchange fall.

Looking at the above example, in only 6 months, the portfolio has lost almost 13.000 USD. To avoid this behavior, during the portfolio construction process the following should be formally addressed:

1. How frequently the portfolio should be monitored
2. How far an asset could deviate from its original target before being rebalanced
3. Whether periodic rebalancing should restore a portfolio to its original target or to a close approximation.

Furthermore, an **investment policy statement** (IPS) has to be developed, providing an asset allocation range for each asset class. As the portfolio drifts, and an asset class moves outside the range specified by the IPS, the portfolio will not match anymore its strategic intention, and a rebalancing of the abovementioned will be needed.

Should be considered that the current unprecedent times made the portfolio rebalancing exercises more challenging. Mercer, one of the world's largest outsourced asset manager, in the guidelines for investors published during March 2020, recommend just a rebalancing halfway to the target. The rationale behind this, lays in the fact that the current market situation should let investors take into account considerations different from the usual rebalancing process, making it a *"more portfolio-specific analysis than usual"*

Once the need of a rebalancing strategy has been clarified, it is necessary to give further information about the tool that will be used to rebalance the above portfolio, namely the **portfolio selection** theory by H. Markowitz.

Before the publication of the modern portfolio theory by Markowitz, investors' decisions were mainly focused on identifying securities with the highest possible return and the lowest possible risk. Markowitz approach is called diversification, because during the construction process, instead of looking at the risk profile of each individual stock, it suggests evaluating the overall portfolio risk and select the combination of assets that will result in the higher possible expected return with the minimum variance.

Markovitz's assumption is that the securities' return over a period of time are random variables, hence it is possible to calculate associated expected return and standard deviation.

The **expected return** of the portfolio is a linear combination of the expected return of the individual assets included in it:

$$r_t = \frac{P_t - P_{t-1}}{P_{t-1}}$$

$$\mu_i = E(r^i) = \frac{\sum_{t=1}^{m} r_t^i}{m}$$

With r_t^i as the return on asset i between $t = 1$ and m that represents the number of periods on which the return should be calculated.

The **standard deviation** is intended as measure of the portfolio's risk, the higher it is, the higher is the risk profile associated with the portfolio. It is calculated in the following way:

$$\sigma_i = \sqrt{\sigma_i^2} = \sqrt{\frac{\sum_{t=1}^{m}(r_t^i - \mu_i)^2}{m-1}}$$

Since the purpose of the portfolio theory is to evaluate the risk profile of the portfolios as a whole, the dimension of risks will be organized in a **return covariance matrix**. This matrix will have variances of the assets on the main diagonal and covariances between two assets of the portfolio as any other item:

$$\Omega_{nxn} = \begin{bmatrix} \sigma_1^2 & \cdots & \sigma_{1n} \\ \vdots & \ddots & \vdots \\ \sigma_{n1} & \cdots & \sigma_n^2 \end{bmatrix}$$

With:

$$\sigma_{ij} = Cov(r^i, r^j) = \frac{\sum_{t=1}^{m}(r_t^i - \mu_i)(r_t^j - \mu_j)}{m}$$

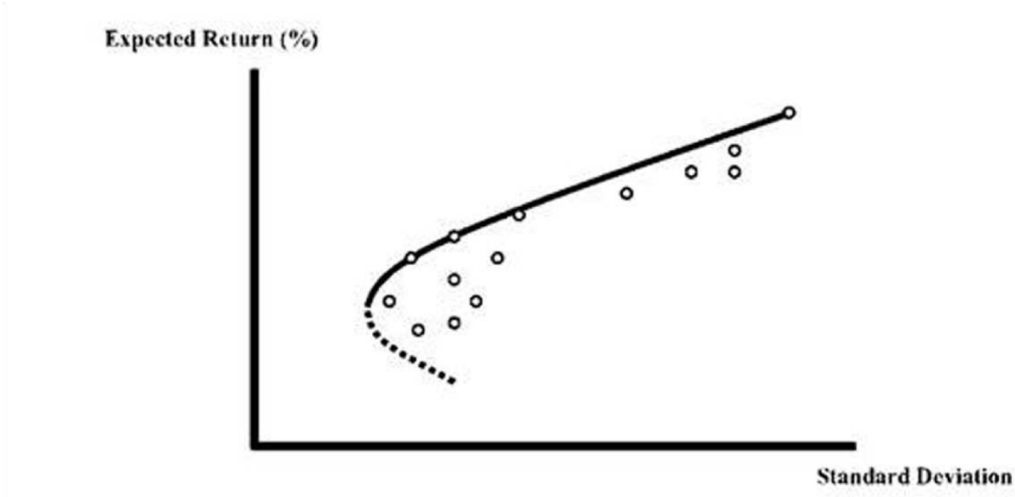
The risk of the portfolio will depend on the covariance between assets rather than on the risk profile of individual assets.

To identify the portfolio that will maximize the expected return and minimize the risk profile a parametric optimization problem has to be solved:

$$\max E(r_P) = max \sum_{i=1}^{n} \omega_i \mu_i$$
$$\min \sigma_P = \min \sqrt{\sum_{i=1}^{n} \sum_{j=1}^{n} \omega_i \omega_j \sigma_{ij}}$$

$$0 \leq \omega_i \leq 1,\ i = 1, \dots, n$$
$$\sum_{i=1}^{n} \omega_i = 1$$

Where ω_i is a percentage of capital that will be allocated in asset i. Every possible efficient combination of ω_i can be plotted in a graph with standard deviation on the $x - axis$ and expected return on the $y - axis$.



The black line represents the **portfolio efficient frontier**. All the combinations along this line will represent the set of portfolios for which the lowest risk profile can be achieved for a given level of return.

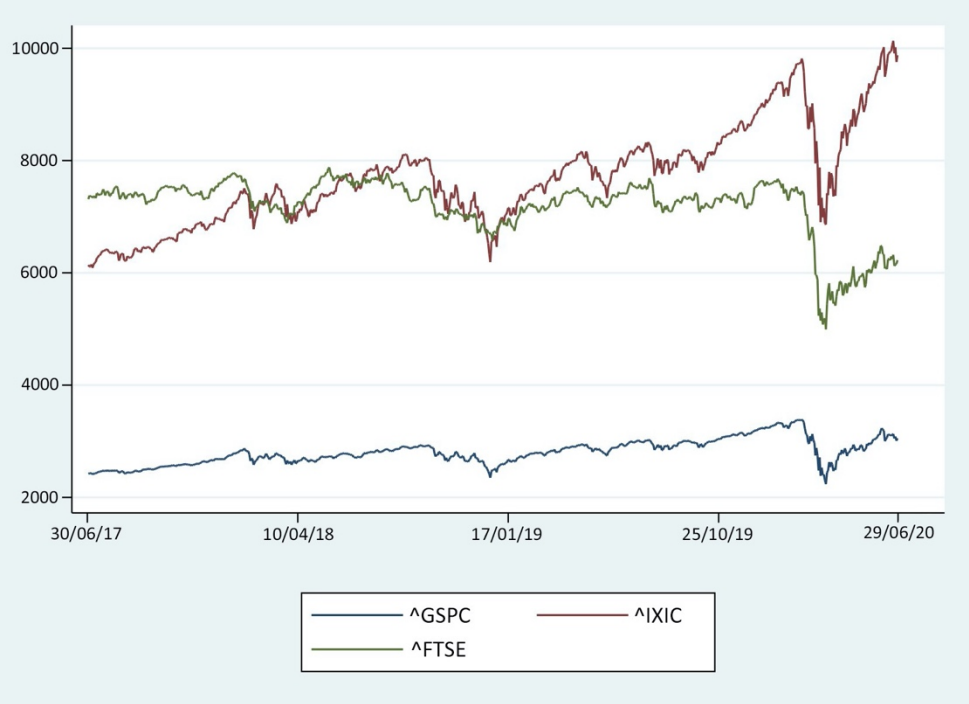
6.2. Asset allocation and portfolio rebalancing using Markovitz portfolio theory with negative interest rate on the market

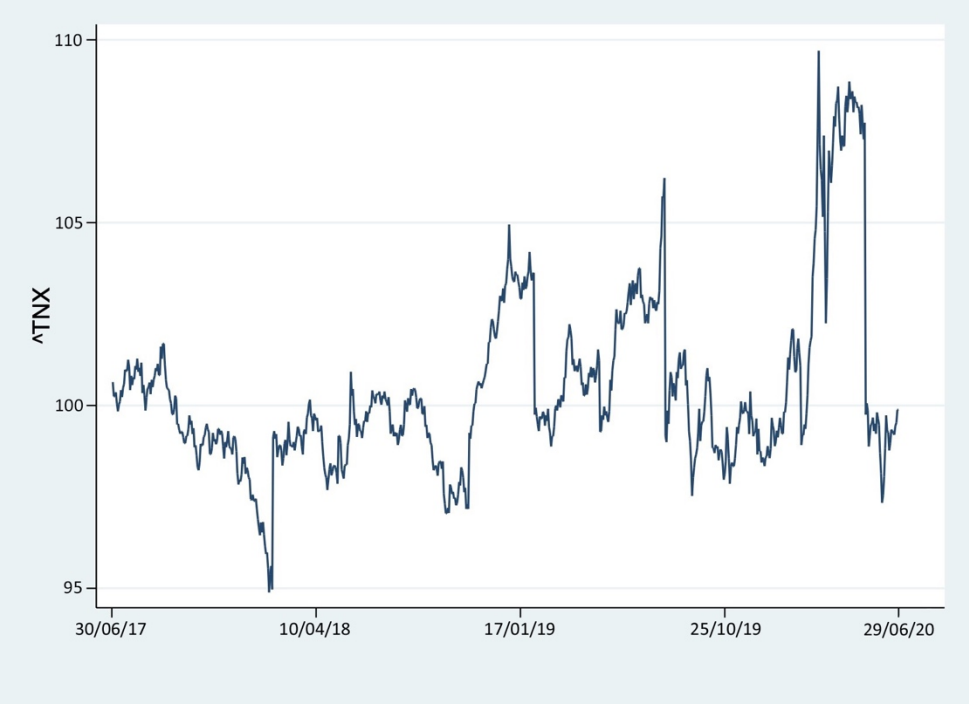
As introduced above, the analysis has been carried out with reference to the VVTHX index. This index has been chosen mainly for two reasons:

1. It includes only 4 asset classes. This makes easier to deal with the optimization problem included in the Markowitz model.
2. The portfolio is focused on a long-term horizon. Having a long-term horizon means that investors are not interested in a quest for absurd yields in the short-term, that would be unlikely in a period of economic downturn without extremely increasing the risk profile of the portfolio.

Indeed, the data used for this portfolio rebalancing exercise comes from the market observation of the last three years. Although three years may seem a short period of time for a realistic forecast using the portfolio selection method, the choice lays in the idea of cleaning the stocks returns from any effect arising from previous used unconventional monetary policies.

The last round of Quantitative Easing in the Euro Area, in fact, has been carried out during Q2 2016. Our data starts from Q2 2017, particularly from June the 30th, 2017, to June the 29th, 2020, displaying in the mentioned period the following behaviour.





On the $x - axis$ it has been displayed the days going from June the 30th 2017 to June the 29th 2020, while on the $y - axis$ the closing prices per day of the stocks (the prices are expressed in USD). S&P500 has been marked as ^GSPC, NASDAQ Composite as ^IXIC, FTSE 100 as ^FTSE and US Treasury Yield 10yrs as ^TNX.

Nonetheless, the exercise does not look for finding the best performing portfolio during the application of NIRP, rather, the purpose of this one is to show that a portfolio rebalancing strategy is needed to hedge investors from a market turmoil. Moreover, Vanguard has declared an achieved yearly yield of 2.49% at the end of May, we will try to understand if in order to have an expected return close to this value, a sensible increase of the portfolio's risk profile is needed.

As explained in the previous paragraph the portfolio is composed by the S&P500 index (30%), the NADSAQ Composite index (10%), the FTSE 100 index (25%) and US Treasury Yield with 10 years maturity (35%).

Even if FED has never exploited the possibility of using negative rates, the policy's effects will be visible looking at the FTSE 100 index. The Euro Area, in fact, was trading the deposit facility rate in the negative field immediately after the breakout of the Covid-19 emergency in early 2020.

Without any portfolio rebalancing strategy, the VVTHX as presented above, would produce the following expected returns over a three years period:

Expected simple returns (Geometric means):

	Exp ret
r_gspc	.000399
r_ixic	.000733
r_ftse	-.000142
r_tnx	8.45e-06

Observations to calculate expected simple returns: 770

The Variance-Covariance matrix would be the following:

The Variance-Covariance matrix is:

	r_gspc	r_ixic	r_ftse	r_tnx
r_gspc	.0001966			
r_ixic	.000203	.0002258		
r_ftse	.0001039	.0001003	.0001317	
r_tnx	-.0000244	-.0000242	-.0000147	.0000361

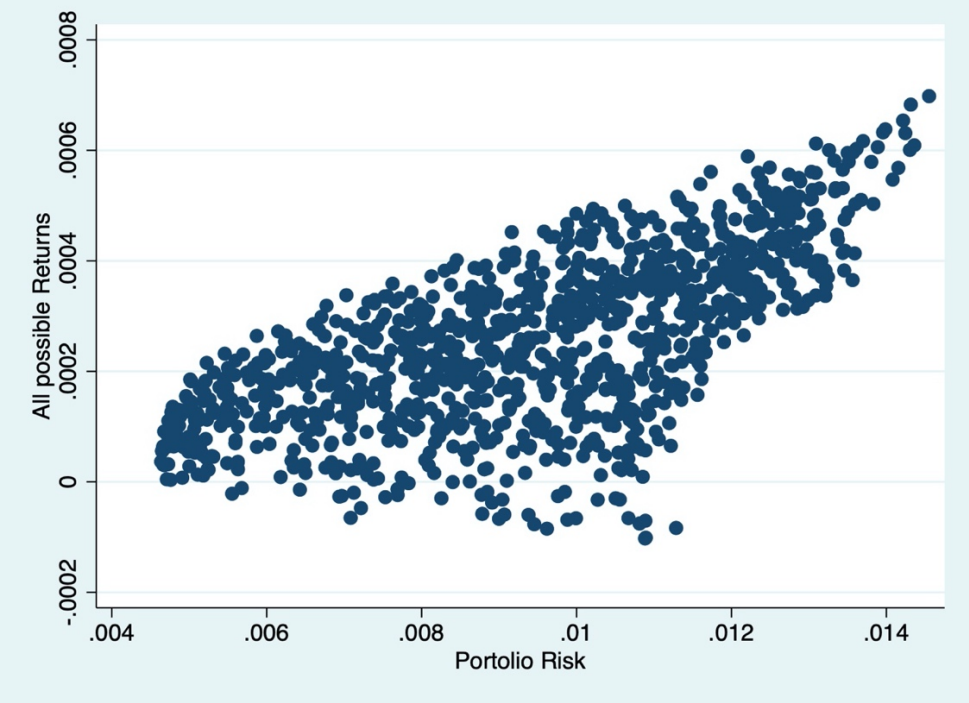
Observations to calculate the var-cov matrix: 770

And on a sample of 1000 different randomly generated portfolios the optimal one would be the following:

```
Random portfolios were generated with no negative weights.
Descriptive statistics of the set of portfolio returns are below:

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
           R |      1,128    .0002516    .0001512  -.0001024   .0006981
Random portfolio with the minimum variance had a return of: .0000366 and a stan
> dard deviation of .00463795
Weights of this random portfolio:
```

w1	w2	w3	w4
.0890832	.0291172	.1844365	.6973632



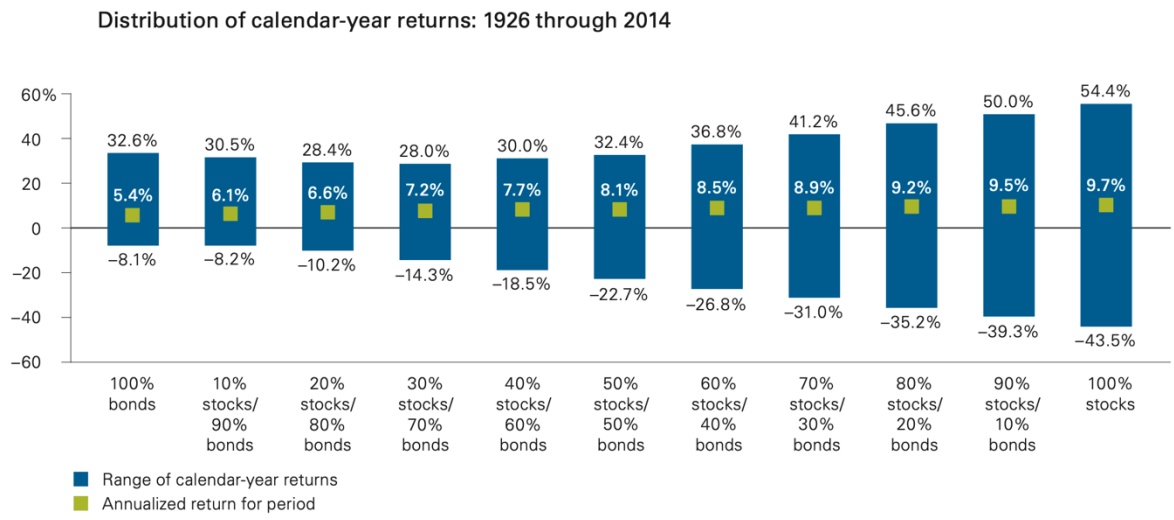
Hence, the optimal portfolio without any rebalancing during the last three years would be composed in the following way: The S&P500 would represent the 8.90% of the weight, the NASDAQ Composite the 2.91%, the FTSE100 the 18.44% and finally the US Treasury Yield the 69.73%. The expected return of the portfolio is sensibly below the target of 2.49% over these 3 years. Furthermore, the risk profile of the investment is higher than the one after the rebalancing strategy that will be showed later.

Having the expected return of 0.00036% over 3 years, it was not possible to rebalance the portfolio without adding riskier asset classes to get an expected return of 2.49% yearly.

To try getting closer to the declared return by Vanguard, the **MSCI World Daily Total Return Net Index** have been added to the portfolio.

The MSCI World Total Return (Net) Index is a free float-adjusted market capitalisation weighted index that is designed to measure the equity market performance of developed markets.

Adding such an index to the portfolio, means increasing its risk profile as we are adding equities to the portfolio. Equities during the last years have outperformed bonds, but it is also true that there is a higher associated volatility as the following graph shows.



Sources: Vanguard calculations, based on data from FactSet.
Past performance is no guarantee of future returns.

The portfolio will be rebalanced at the end of the analyzed period looking at what happened on March the 23rd, 2020, day in which, as explained before, because of the effect of the Covid-19 breakout, several stock exchanges all over the world had their seasonal minimum. The rebalanced portfolio would then produce the followings expected returns:

Expected simple returns (Geometric means):

	Exp ret
r_gspc_an	.0048766
r_ixic_an	.0056438
r_ftse_an	.0035061
r_tnx_an	-.0009569
r msci an	.004652

Observations to calculate expected simple returns: 770

The Variance-Covariance matrix will be the following:

The Variance-Covariance matrix is:

	r_gspc_an	r_ixic_an	r_ftse_an	r_tnx_an	r_msci_an
r_gspc_an	.0005832				
r_ixic_an	.0005325	.000524			
r_ftse_an	.0003978	.0003391	.0005147		
r_tnx_an	-.0000245	-.0000175	-.0000357	.0001004	
r msci an	.0004638	.0004135	.0003733	-.0000248	.0003958

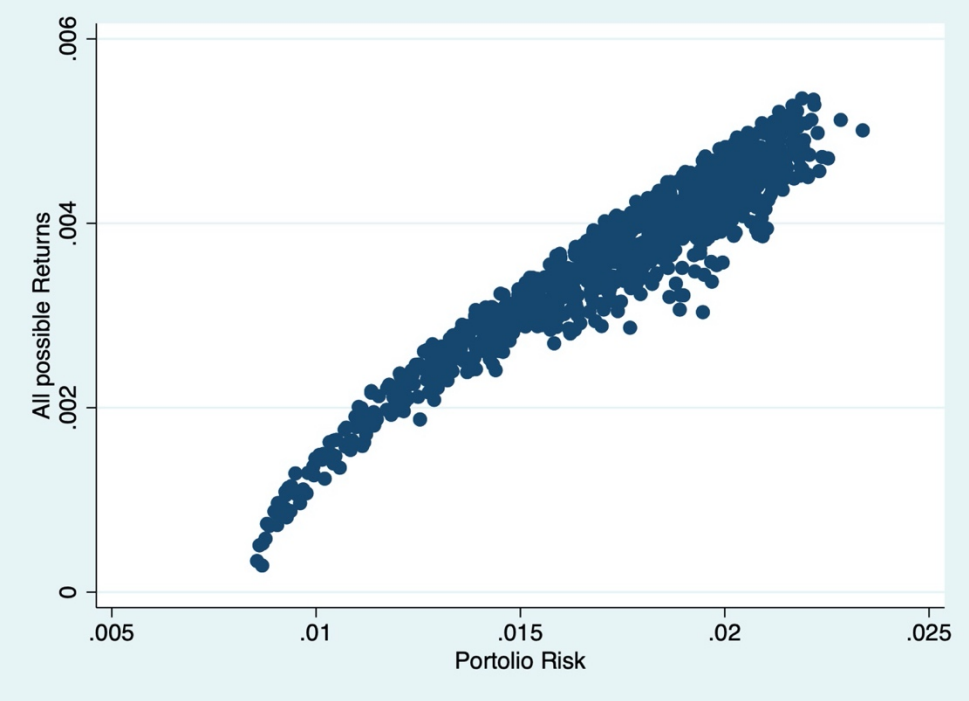
Observations to calculate the var-cov matrix: 770

Looking again for the efficient portfolio over 1000 randomly generated portfolios, the expected return and the risk profile of the new VVTHX would be the following:

```
Random portfolios were generated with no negative weights.
Descriptive statistics of the set of portfolio returns are below:

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
           R |      1,029    .0035852    .0009487    .0002891    .0053541
Random portfolio with the minimum variance had a return of: .0003385 and a standard deviation of .00855394
Weights of this random portfolio:
```

w1	w2	w3	w4	w5
.0316835	.0113143	.1730033	.736972	.047027



In this case, the minimum variance portfolio will have a return of 0.0033% over approximately two months[23], that converted on a yearly rate would involve an average yearly return of 0.0203%, that is definitely closer to the target, even if it still does not match with the value declared by Vanguard.

This optimal portfolio in this case will be composed as follows:

- S&P500 3.16%
- NASDAQ Composite 11.31%
- FTSE 100 17.30%

[23] From March 23rd, 2020, to May 29th, 2020.

- US Treasury Yield 10yrs 73.69%
- MSCI World Total Return (Net) Index 4.72%

To get the yearly return declared by Vanguard, it has been allowed the short sale of the previous asset classes composing the portfolio.

Portfolio weights of the portfolio:

	Weights
r_gspc_an	**-2.295863**
r_ixic_an	**1.204031**
r_ftse_an	**-.2776428**
r_tnx_an	**.2671967**
r_msci_an	**2.102278**

Number of observations used to calculate expected returns and var-covariance matrix : 770
Required return of the Portfolio: .00415
Minimum standard deviation of the portfolio (Allowing for short sales): .01194947

Not surprisingly, to get to this return in a period of global recession the weight of the portfolio previously allocated to S&P500 and FTSE 100 have been shorted and a huge portion of the portfolio has been allocated to the riskier asset, namely the MSCI Index.

However, coming back to the optimal portfolio yielding 0.0203% yearly, something else that deserves the spotlight is the greater presence in the portfolio of the FTSE index rather that the S&P500 or NASDAQ Composite. It looks like that the stimulus created by the ECB over the Euro Area, through Quantitative Easing and Negative Interest Rate Policy had an immediate effect, being able to ease the Italian Market.

With regards to the US Market, there has been a general bullish trend because of the huge stimulus package developed by the Federal Reserve, however there has been a higher volatility associated to this market that reduced the presence of S&P500 and NASDAQ Composite in the above portfolio.

Even if the US Treasury Yield has not broken down the zero-lower bound, it has been held really close to zero and the associated yield has declined during the first months of 2020. Nonetheless, this asset class, is the one that contain the volatility and the risk profile of the portfolio, this is why after the introduction of the MSCI index and the rebalancing exercise its weight has grown.

Looking instead at the portfolio matching the return declared by Vanguard, it displayed a huge presence of the MSCI index at the expense of S&P500 and FTSE 100. This points out that a period of Negative Interest Rates Policy drives the investors to assume a higher risk profile in their investments. Investors, in fact, to get a satisfactory return are likely to increase the presence of riskier equities in their portfolios.

7. Conclusion

The study achieved its target of giving an overview about negative interest rates policy, how they work and how they influence the investors' behavior and risk profile. However, negative rates are associated with several pros and cons due to the fact that their usage is something extremely new and this is why several doubts have arisen.

Nonetheless, from the early assessment of the 2014 experience, the findings seem encouraging. No country or area applying negative rates have seen its bank system corrupted, still no evidence has been found about investors increasing their risk-tolerance profile in an absurd search for yield nor any other extremely worrying factor has been highlighted. NIRP, have been useful in monitoring inflation, especially in the Euro Area in the aftermath of 2008 crises, and in controlling excessive situations of capital inflows. Moreover, the monetary transmission mechanisms, have been working out in a consistent way, like any other rate cut not breaking the lower bound.

On the other side, the possibility of distortion of the asset valuation channel and the fear about any massive switch in the investors' risk tolerance profile are still the major critics moved to such a measure. As showed in the previous chapters, in fact, seems straightforward that in order to achieve the desired yield during current times, the introduction of several riskier assets to investors' portfolios is needed. Similarly, it seems straightforward that also the impact of negative rates on valuations done using discounted cash flows-based models could lead to an overestimation of the considered assets.

A longer observation period will be needed to draw a final conclusion about NIRP. It will be interesting understand if the regions that still do not adopt them will have a positive or negative impact at the first introduction. It will be interesting, for example, to understand if the United Stated of America, will decide to adopt negative rates and if this experience will be a positive or a negative one.

What this analysis suggests is that negative rates are a good addiction for a central bank monetary policy toolset when further ease in needed, especially in extraordinary situation. Of course, this measure, must be thought as **temporary**. If this will be the case, the Negative Interest Rates Policy does not seem potentially harmful for a government economy.

Of course, even if in the past decades there have been few experiences with negative rates, 2014 represents the turning point for such a measure. It was the first time, several governments needed at once, to go beyond the use of Quantitative Easing, and negative rates were seen as the most reliable and effective alternative. Further experiences will be needed to have a better general overview about

their effectiveness, and especially to understand the most likely downside effect associated with its use.

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LUISS

Department of *Business and Management*

Master's degree in *Corporate Finance*

Course of *International Financial Economics*

Negative Interest Rates Policy and Investment Trends (Summary)

Prof. Guido Traficante

SUPERVISOR

Prof. Ugo Zannini

CO-SUPERVISOR

Valentino Mazzariello
ID No.714031

CANDIDATE

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1. Introduction

For decades, the idea of breaking the zero-lower bound, charging depositors with a negative rate was perceived as something unfeasible. After the breakout of the subprime mortgage crisis, however, this perception changed.

In 2014, indeed, several central banks, to mitigate the effects of the 2008 crisis decided to break the zero lower bound and apply a negative deposit facility rate. Throughout this study it has been described the rationale behind the implementation of such a measure, how it is supposed to work, but especially the downside effects associated with its application and how the investors' risk-taking profile react to this new threat.

Negative interest rates policy, hence, is something extremely new, that have become part of the central banks' monetary policy toolkit recently. Nonetheless, the academic debate about negative interest rates and their effectiveness has its roots in the late 19th century, but the heart of the debate was during 1930s. During this period the great depression lead to an investigation for alternative solutions to give stimulus to the economy.

Silvio Gesell, autodidactic economist and social activist, commonly recognized as the founder of NIRP, was the first to propose a system of stamped money in order to accelerate monetary circulation. Gesell points out that there is no charge associated with holding money. On the other side, goods are subject to a natural deterioration and depreciation, hence their holders incur in considerable costs. Consequently, if there is an economic downturn, money holders may withhold their money from circulation to avoid losing value, while producers, merchants and goods' holders cannot. Gesell's idea to prevent this, consists in money exposed to natural decay, like goods, via taxation. If money will be taxed, money holders will not be driven anymore to hoard money since the currency will involve some carrying charges.

Gesell's simple idea is something extremely different from the modern theorization of Negative Interest Rates Policy, and at the time he did not receive any interest from his peers. Keynes, in fact, about the Gesell's idea states that it is simply unfeasible.

2. Assessing the implication of negative interest rates on government bonds, financial stability, and investments

Negative interest rates are a useful tool to provide additional easing to an economic system when usual monetary policies seem to not work out anymore, however the prolonged use of such measures could have several implications on the abovementioned system that in this section we will try to highlight.

About *financial stability*, some argue that NIRP are useful to complete the tools of expansionary measures a central bank can use. Some others are more concerned about the risks associated with NIRP like the reduction in banks' willingness to lend and yet the fact that monetary policies become ineffective below the zero-lower bound. Market participants could prefer to hold cash and banks could not be able anymore to lower interest rates on deposits, potentially losing one of their main sources of financing. Also, central banks might be heavily affected. Once reached the zero-lower bound in fact they would not be able anymore to stimulate lending by lowering short term interest rates.

Nevertheless, those most affected should be **institutional investors**, like pension funds and insurance companies, that often hold significant position in government bonds. Under low or even negative yielding bonds, they could struggle to generate significant positive returns. For this type of investors, a range of products, like *fixed rate annuity*, might become less attractive. Similar issues could be drawn for **money market funds**. These kinds of funds make investments in highly liquid near-term instruments such as cash and cash equivalent securities. Because of the effect of short-term rates cuts they could face challenges even working with very low but still positive rates. Moreover, these funds earn from investors a management fee, that will impact further their overall return, the diminished return is then likely to be counterbalanced investing in riskier assets.

Lastly, several scholars argue that a general effect of the unconventional monetary policies is the rise of misallocation of resources, some others have concerns regarding the fact that unconventional policies will impact central bank credibility if these measures will be used for a long period. This very last point indeed is the most agreed, if NIRP are going to be used for a prolonged period and the rates will go substantially below zero, the erosion of banks' and other financial intermediaries' profitability will not be a possible scenario, but rather the reality. By the way, the experience with negative rates, doesn't give a change yet to understand which

is the ultimate lower bound or which is the maximum time horizon to keep using this tool wisely. On the contrary, the 2014 experience of the Euro Area suggests that negative rates are a valuable policy when extraordinary downturn periods, like the 2008 sub-prime crisis, happen.

Looking instead at the *implication on government bonds*, negative interest rates are associated with a downward shit in the yield curve at all maturities. During the 2014 experience several factors can explain what was happening at the time, like a very low inflation rate, and an increasing preference towards savings by the households or towards fixed yield instruments for most investors. Or even, the effect of Quantitative Easing, with central banks buying bonds, with an increase in the demand for these assets that contributed to a reduction of their yields. Taking into account these factors associated with declining growth expectations, and a diminishing interest in highly rated low-risk investments, the impact of NIR on bond yield seems to reflect the downward shift in central banks' credibility about future paths of policy rates.

Moving the discussion to the *implication on investments*, what could be expected from a negative rates environment consists in agents that will prefer to withdraw their deposits, to avoid losing money that they will be likely to spend or to invest in riskier assets like corporate bonds. Following this idea, agents would behave like in a **prospect theory**[1] framework, preferring the possibility of losing money with the hope of a higher return rather than allocate their resources in a low risk environment that involves a reduction in their wealth. However, a behaviour like this one has still to be observed during the short experience scholars have in real life. Actually, in a working paper by Anat Bracha dated November 2017, this idea is completely disrupted. In a series of controlled experiments, random participants were asked to invest their money in two available portfolios, both of them with possible rates of returns and probability of a certain event to happen displayed in advance. No evidence was found reflecting the prospect theory, no evidence of excessive investment in the riskier portfolio was found and participants exhibited risk-neutrality suggesting no loss-aversion, maximizing the expected return and yet, in the loss domain[2] there is some evidence of risk-aversion.

[1] Prospect theory is an economics theory developed by Daniel Kahneman based on results from controlled studies, it describes how individuals assess in an asymmetric manner their loss and gain perspectives.
[2] Participants that ended up with a negative return on their portfolios.

3. Unconventional Monetary Policies

Over the past years, Quantitative Easing and more recently Negative Interest Rates have been used by central banks to mitigate the adverse effect of global financial crisis.

While *Quantitative Easing* is adopted by the government to increase money supply in the economy in order to further increase lending by commercial banks and spending by consumers, under *Negative Interest Rates*, market participants are required to pay interest on deposits, this way the central bank tries to penalize financial institutions and individuals for holding cash guiding them towards lending to businesses and investing in alternative assets boosting their prices.

The transmission channels of negative interest rates policy work similarly to those of conventional easing (Jackson 2015, Hannoun 2015), having as a main effect the downward shift of the yield curve at all maturities[3]. Indeed, following the rollout of negative rates, all floating-rate loans and mortgages should be more affordable, financing costs for firms and households reduced, encouraging an increase in borrowing. Aside from lowering borrowing costs for businesses, NIRP have been used also to achieve different goals. Bank of Japan used NIRP during 2016 to avoid a strengthening of the yen potentially harmful for an export-reliant economy like the Japanese one. Furthermore, as much as the interest rates go down, the value of fixed-income securities goes up, leading to higher profits. Consequently, a decline in the level of interest rates can also push up net interest margins in the short run for the markets' participants.

The effectiveness of negative interest rates in being able to boost economic growth and support inflation has still to be proven and several concerns have been highlighted regarding negative interest rates. As mentioned previously, the major concerns are for financial stability and investments. In particular, the impairment of the banking system and an increase of exposure towards risky assets, are a likely downside of this policy.

3.1. Monetary transmission of negative interest rates

The rationale behind the implementation of NIRP varies from case to case, nevertheless the transmission channels are analogous to any rate cut even the ones leaving rates slightly positive.

[3]QE shifts down primarily longer maturities.

Talking about the monetary transmission of negative rates, should be analysed the impact on *interest rate channel, credit channel and consumption*.

About the *interest rate channel*, a rate cut, will enhance borrowing and lending condition market participant will face. Once the zero lower bound has been overcome, a rate cut will reduce the money market rates and the bond yields for shorter maturities. These effects could face some constraints if the banks hesitate to impose negative rates for individual or corporate deposits to avoid losing their income associated with the deposits. This reluctance, together with efforts to maintain interest margins could potentially impact the pass-through on negative rates to lending rates.

Regarding the *credit channel*, negative central bank policy rates will discourage banks from holding excess reserves in favour of lending, pushing down even more market interest rates. Supposing confidence and the health[4] of banks, namely the absence of non-performing assets in the banks' balance sheet, the effect on lending will depend on the investment opportunities available and on the amount of money that are going to be lost if cash is held as a deposit. Negative interest rates policies are expected to affect the available credit to households and firms, bringing as a side effect an adverse impact on *credit growth* if banks will charge higher lending rates to cover their lowered profitability and diminished capital base after an eventual introduction of NIRP.

Lastly, about the *consumption channel*, if saving behaviours remain unchanged, after the implementation of negative rates, there will be an incentive towards borrowing and investing that won't be different from a rate cut happening in the positive field. But there are two concerns about the impact of negative rates policies on consumption. First of all, if the majority of private public, after the introduction of NIR, decide to convert their deposits in cash there will be a reduction of the availability of loanable funds, pushing up borrowing costs and watering down the stimulatory effect of such an unconventional policy.
Secondly, the fear that the public will redirect their investments towards riskier assets. This threat has been already introduced and as we already said, there is not still any empirical support for the argument, but it is still a risk that should be taken into account when consumers are deprived of a safe haven for their cash holdings.

[4] Without which bank will be reluctant to lend and consumer to borrow.

3.2. Where is the lower bound?

The real challenge when talking about negative rates involves understanding how much central banks can push down negative interest rates having a value at which agents in the market still prefer to hold cash over bank deposits earning a negative interest. Key determinants for assessing these issues are **cost of storage**, **safekeeping** and **transportation of cash**.

Starting with the *cost of storage*, *safekeeping and transportation*, according Keohane[5] (2015) they could be approximated in a range between 0.2% and 1%. These variables will be influenced by factors like the size of the bills. For example, we could expect a lower storage, transportation and convenience cost for Swiss Francs with the largest denomination available at 1000 Francs (approximately 941[6] Euros) rather than for Euro where the largest denomination available is 500 Euros. To the abovementioned values, should be added the **cost of convenience,** classified as the extra price consumers are willing to pay to make their lives easier**.** A fair approximation for the cost of convenience are the fees associated with credit and debit card interchange fees, estimated on average around 1-3% annually.

Gathering these data, could be suggested that NIR marginally below 2% are possible without shrinking the likelihood of the investor holding cash as a bank deposit despite the negative deposit facility rate. Even if an "economic lower bound" has not been agreed yet, a balanced decision would then involve taking into account both positive and detrimental effect of negative rates. The idea is to bring interest rates into negative territory as soon as the simulative effect on lending and consumption, related to the implementation of NIRP, outweigh the detrimental effects on bank profitability. At that point, *"bank profitability will fall, reducing capital generation via retained earnings, which is an important source of capital accumulation, and thereby eventually restricting lending"*[7] potentially causing short term dislocation in financial markets.

3.3. How the asset valuation channel reacts to negative interest rates

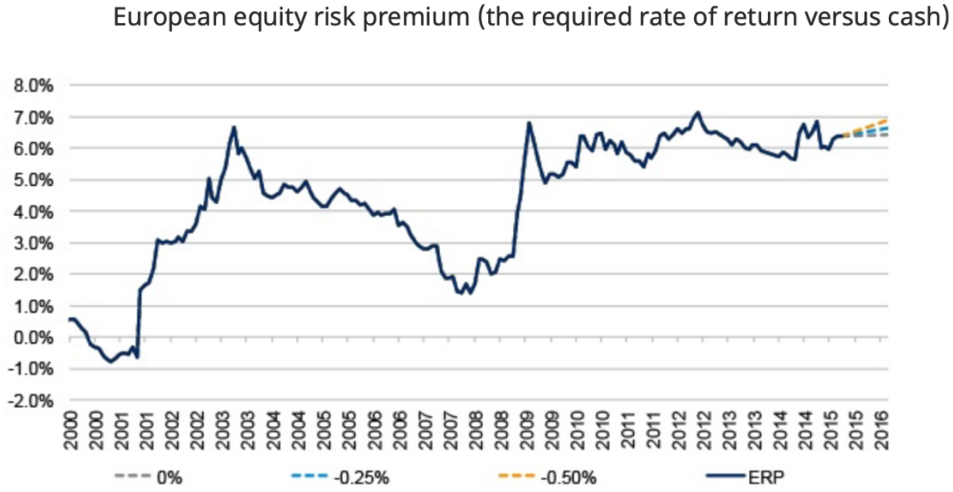
A direct way to examine the impact of negative rates on assets and equities is through discounted cashflow models. These models are helpful in estimating the intrinsic value of

[5] Data about cost of storage, insurance, safekeeping and transportation of cash are from Keohane (2015).
[6] FX rate 1,06 as at March the 29th, 2020.
[7] Brunnemeier and Koby (2019).

stock, assets, equities summing up the present value of the expected cashflows generated by the abovementioned, using an appropriate interest rate as discount factor. All other conditions being equal, a lower discount rate boosts the present value of the assets. Should however be taken into account that a negative interest rates environment could potentially distort the asset valuation channel in two ways:

- Increasing the risks of an asset price bubble, if such a measure will be used for a prolonged period, shifting market participants preference towards riskier assets.
- Loose monetary conditions are likely to raise expectation of the economy's recovery, letting people think that in the short future they will be able even more to gain higher revenues from the purchased assets.

The chart below in fact, shows the impact of negative interest rates on equity risk premium for Europe, disclosing the evolution of ERP (on the vertical axis) starting from the early 2000 until 2016.



Source: Datastream.

An environment of negative yields induces investors to shift their asset preference towards riskier assets. The ERP should reflect the additional compensation to investors for the increased risk profile of their holdings, and looking at the graph, this is the case. After the start of the subprime crises and especially after the implementation of unconventional monetary policies there has been a general bullish trend for ERP. Also, the expectations about future movements in the equity risk premium, showed as the area between the dotted lines, seems to respect such a trend. Indeed, in the portfolio rebalancing exercise of the last chapter it will be showed whether to achieve a satisfactory return, during the

implementation of negative rates, the massive presence of riskier assets is needed in investors' portfolios.

3.4. ECB and FED general view about negative interest rates

To assess the experience of the European Central Bank with negative rates, it seems proper to check the data from the ECB bulletin of 2016. According this early assessment, Negative Interest Rates Policy was effective in lowering borrowing costs for firms and households, but at the same time NIR had a detrimental effect on return on savings. However, the reduction in return on savings seems to have been offset by a considerable decrease in interest payments.
Between Q4 2008 and Q4 2015 the interest payments fell by about 3% relative to disposable income. This drop has been assessed as comparable to the drop in interest earnings, leaving the euro area household's net interest income almost unaffected.
Overall, ECB has been pleased with the first experience with negative rates policies. NIRP has been useful not only in lowering borrowing costs but also in stimulating investment and consumptions, ECB is then comfortable in adding NIRP to the tools of monetary policies in situations where unconventional monetary policies are required.

On the other side the U.S. Federal Reserve never adopted negative interest rates policies to provide additional ease to the American economy. Gavyn Davies[8] in an article published on the Financial Times in March 2020, argues that two factors mainly explain this:

- It's difficult for the US financial system to go negative. Money Market funds, accounting for $4tn in assets are sometimes treated like bank accounts, hence taxing them could end up in a tremendous pressure over their profitability.
- The experience with NIR in Japan and the eurozone doesn't provide enough information about the real value to boost confidence and economic activity. Since there is not still enough confidence in the usefulness on negative rates policies, it could be a long shot sacrificing the profitability of the abovementioned Money Market funds to adopt such a measure.

[8] Gavyn Davies is a former Goldman Sachs partner and from 2001 to 2004 he was chairman of the BBC.

4. Optimal asset allocation with the presence of negative interest rates on the market

When assessing a portfolio's risk-and-return characteristics, the major determinant to take into account is the portfolio asset allocation, namely the strategy of dividing the investment among different asset categories, such as stocks, bonds, real estate, cash, and cash alternatives. However, when talking about asset allocation, it is wise to consider that, over time, asset classes produce different returns, so the portfolio's asset allocation changes.

Rather than maximizing returns, the purpose of portfolio rebalancing is to minimize the risks associated to a target asset allocation. To achieve this purpose the portfolio rebalancing strategy should take into account each investor's risk tolerance, time horizon, and financial goals.

Over time, in fact, as the portfolio produces different returns, it will **drift**[9] from its original target allocation getting risk and return characteristics that may be inconsistent with the rebalancing strategy proposed. Therefore, the portfolio should be rebalanced periodically to achieve a reduction of the drift and of the risk exposure relative to the market movements.

Looking at the following portfolio rebalancing example, it is important to understand what happens if a thoughtful rebalancing strategy is not developed, especially in an economic downturn period like the one analysed. The index under consideration is the VVTHX index developed by Vanguard, it is a portfolio for people that target their retirement around 2035 and it is composed by domestic stock, foreign stock and domestic bonds. Vanguard does not disclose its strategy of asset allocation, but they declare a yearly return on May 2020 of 2.49%.

Let's suppose the portfolio is composed in the following way:

- 40% domestic stocks (30% S&P500, 10% NASDAQ Composite)
- 25% foreign stocks (FTSE 100)
- 35% domestic bonds.

[9] **Portfolio drift** is the divergence of a fund from its investment style or objective. The drift can result naturally from capital appreciation in one asset relative to others in a portfolio. It can also occur from a change in the fund's management or a manager who begins to diverge from the portfolio's mandate.

Building the portfolio as mentioned above at December 31st, 2019, supposing an initial investment of 100.000 USD, would let us face the following situation:

		Price 31/12/2019	Initial Investment	Initial Weight
^GSPC	Domestic Stock	$3,230.78	$25,000.00	**30%**
^IXIC		$8,972.60	$10,000.00	**10%**
^FTSE	Foreign Stock	$7,542.40	$20,000.00	**25%**
^TNX	US Treasury Yield 10yrs	$98.56	$35,000.00	**35%**
			$100,000.00	100%

Without any further adjustment, or any rebalancing strategy after only 6 months the asset allocation of our portfolio could be heavily impacted by the market evolution. Indeed, if we look at the same portfolio at June 29th, 2020, we would have the following:

		Price 29/06/2020	Return over the period	Current Balance	Current Weight
^GSPC	Domestic Stock	$3,053.24	-5.50%	$23,626.18	**27%**
^IXIC		$9,874.15	10.05%	$11,004.78	**13%**
^FTSE	Foreign Stock	$6,225.80	-17.46%	$16,508.80	**19%**
^TNX	US Treasury Yield 10yrs	$99.89	1.35%	$35,471.58	**41%**
				$86,611.34	100%

The trend observed since the end of 2019, in fact, involved Equity securities with a substantial decrease in their value, representing a smaller portion of the portfolio after the analyzed period, and defensive fixed income, like the US Treasury Yield at 10 years, increasing their value because of the reduced yield. Looking at the above example, in only 6 months, the portfolio lost almost 13.000 USD. To avoid this behavior, during the portfolio construction process the following should be formally addressed:

1. How frequently the portfolio should be monitored.
2. How far an asset could deviate from its original target before being rebalanced.
3. Whether periodic rebalancing should restore a portfolio to its original target or to a close approximation.

Furthermore, an **investment policy statement** (IPS) has to be developed, providing an asset allocation range for each asset class. As the portfolio drifts, and an asset class moves outside the range specified by the IPS, the portfolio will not match anymore its strategic intention, and a rebalancing of the abovementioned will be needed.
Once the need of a rebalancing strategy has been clarified, it is necessary to give further information about the tool that will be used to rebalance the above portfolio, namely the **portfolio selection** theory by H. Markowitz. Markowitz approach instead of looking at the risk profile of each individual stock, suggests evaluating the overall portfolio risk and select the combination of assets that will result in the higher possible expected return with the minimum variance.

As introduced above, the analysis has been carried out with reference to the VVTHX index. This index has been chosen mainly for two reasons:

1. It includes only 4 asset classes. This makes easier to deal with the optimization problem included in the Markowitz model.
2. The portfolio is focused on a long-term horizon. Having a long-term horizon means that investors are not interested in a quest for absurd yields in the short-term, that would be unlikely in a period of economic downturn without extremely increasing the risk profile of the portfolio.

Indeed, the data used for this portfolio rebalancing exercise comes from the market observation of the last three years. Although three years may seem a short period of time for a realistic forecast using the portfolio selection method, the choice lays in the idea of cleaning the stocks returns from any effect arising from previous used unconventional monetary policies.

As explained, the portfolio is composed by the S&P500 index (30%), the NADSAQ Composite index (10%), the FTSE 100 index (25%) and US Treasury Yield with 10 years maturity (35%).

Even if FED has never exploited the possibility of using negative rates, the Negative Interest Rates Policy's effects will be visible looking at the FTSE 100 index. The Euro Area, in fact, was trading the deposit facility rate in the negative field immediately after the breakout of the Covid-19 emergency in early 2020.

Without any portfolio rebalancing strategy, the VVTHX as presented above, would produce the following expected returns over a three years period:

Expected simple returns (Geometric means):

	Exp ret
r_gspc	.000399
r_ixic	.000733
r_ftse	-.000142
r_tnx	8.45e-06

Observations to calculate expected simple returns: 770

The Variance-Covariance matrix would be the following:

The Variance-Covariance matrix is:

	r_gspc	r_ixic	r_ftse	r_tnx
r_gspc	.0001966			
r_ixic	.000203	.0002258		
r_ftse	.0001039	.0001003	.0001317	
r_tnx	-.0000244	-.0000242	-.0000147	.0000361

Observations to calculate the var-cov matrix: 770

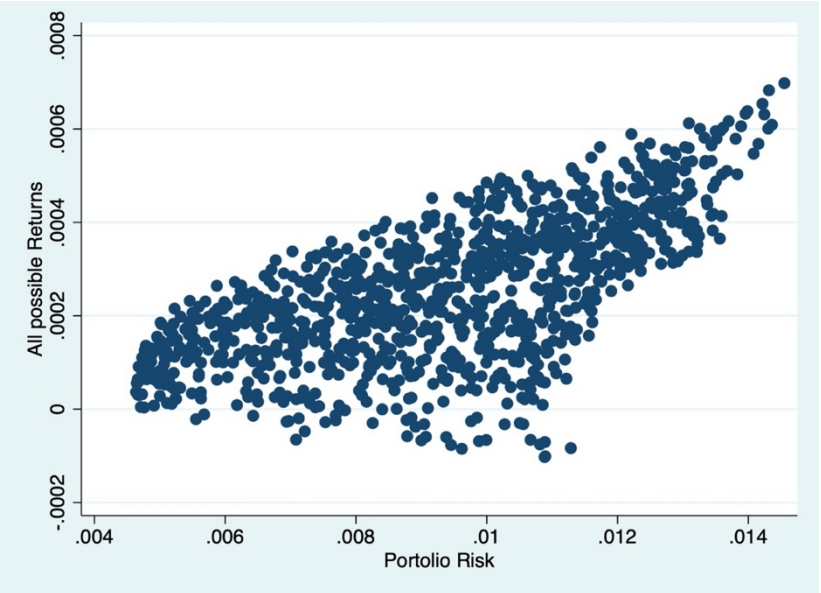
And on a sample of 1000 different randomly generated portfolios the optimal one would be the following:

Random portfolios were generated with no negative weights.
Descriptive statistics of the set of portfolio returns are below:

Variable	Obs	Mean	Std. Dev.	Min	Max
R	1,128	.0002516	.0001512	-.0001024	.0006981

Random portfolio with the minimum variance had a return of: .0000366 and a stan
> dard deviation of .00463795
Weights of this randomportfolio:

w1	w2	w3	w4
.0890832	.0291172	.1844365	.6973632



Hence, the optimal portfolio without any rebalancing during the last three years would be composed in the following way: S&P500 would represent the 8.90% of the weight, NASDAQ Composite the 2.91%, FTSE100 the 18.44% and US Treasury Yield the 69.73%. The expected return of the portfolio is sensibly below the target of 2.49% over these 3 years. Furthermore, the risk profile of the investment is higher than the one after the rebalancing strategy that will be showed later. Having the expected return of 0.00036% over 3 years, it was not possible to rebalance the portfolio without adding riskier asset classes to get an expected return of 2.49% yearly.

To try getting closer to the declared return by Vanguard, the **MSCI World Daily Total Return Net Index** have been added to the portfolio. The MSCI World Total Return (Net) Index is a free float-adjusted market capitalisation weighted index that is designed to measure the equity market performance of developed markets. The portfolio will be rebalanced at the end of the analyzed period looking at what happened on March the 23rd, 2020, day in which, because of the effect of the Covid-19 breakout, several stock exchanges all over the world had their seasonal minimum. The rebalanced portfolio would then produce the followings expected returns:

Expected simple returns (Geometric means):

	Exp ret
r_gspc_an	.0048766
r_ixic_an	.0056438
r_ftse_an	.0035061
r_tnx_an	-.0009569
r msci an	.004652

Observations to calculate expected simple returns: 770

The Variance-Covariance matrix will be the following:

The Variance-Covariance matrix is:

	r_gspc_an	r_ixic_an	r_ftse_an	r_tnx_an	r_msci_an
r_gspc_an	.0005832				
r_ixic_an	.0005325	.000524			
r_ftse_an	.0003978	.0003391	.0005147		
r_tnx_an	-.0000245	-.0000175	-.0000357	.0001004	
r msci an	.0004638	.0004135	.0003733	-.0000248	.0003958

Observations to calculate the var-cov matrix: 770

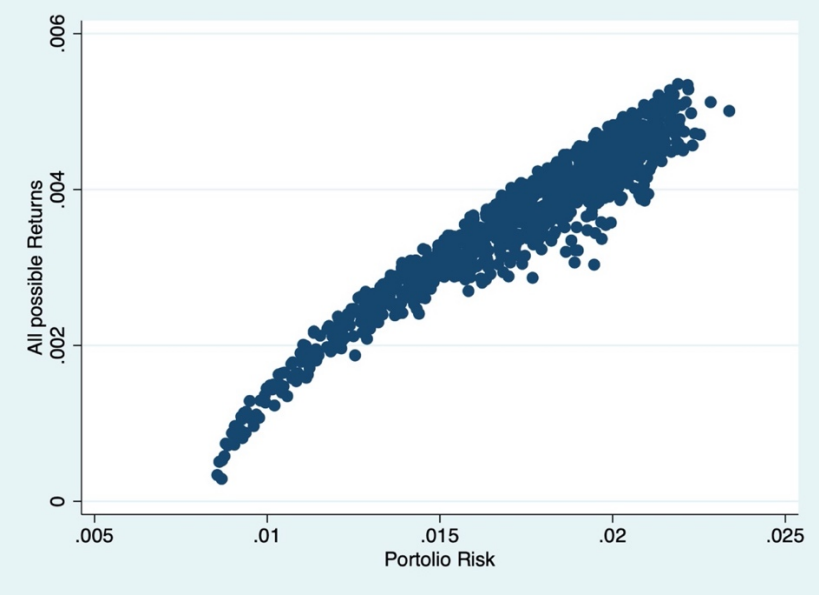
Looking again for the efficient portfolio over 1000 randomly generated portfolios, the expected return and the risk profile of the new VVTHX would be the following:

Random portfolios were generated with no negative weights.
Descriptive statistics of the set of portfolio returns are below:

Variable	Obs	Mean	Std. Dev.	Min	Max
R	1,029	.0035852	.0009487	.0002891	.0053541

Random portfolio with the minimum variance had a return of: .0003385 and a standard deviation of .00855394
Weights of this random portfolio:

w1	w2	w3	w4	w5
.0316835	.0113143	.1730033	.736972	.047027



In this case, the minimum variance portfolio will have a return of 0.0033% over approximately two months[10], that converted on a yearly rate would involve an average yearly return of 0.0203%, that is definitely closer to the target, even if it still does not match the value declared by Vanguard.

This optimal portfolio in this case will be composed as follows: S&P500 3.16%, NASDAQ Composite 11.31%, FTSE 100 17.30%, US Treasury Yield 10yrs 73.69%, MSCI World Total Return (Net) Index 4.72%

However, to get the yearly return declared by Vanguard, it has been allowed the short sale of the previous asset classes composing the portfolio.

[10] From March 23rd, 2020, to May 29th, 2020.

Portfolio weights of the portfolio:

	Weights
r_gspc_an	**-2.295863**
r_ixic_an	**1.204031**
r_ftse_an	**-.2776428**
r_tnx_an	**.2671967**
r_msci_an	**2.102278**

Number of observations used to calculate expected returns and var-covariance matrix : 770
Required return of the Portfolio: .00415
Minimum standard deviation of the portfolio (Allowing for short sales): .01194947

Not surprisingly, to get to this return in a period of global recession the weight of the portfolio previously allocated to S&P500 and FTSE 100 have been shorted and a huge portion of the portfolio has been allocated to the riskier asset, namely the MSCI Index.

Coming back to the optimal portfolio yielding 0.0203% yearly, something that deserves the spotlight is the greater presence in the portfolio of the FTSE index rather that the S&P500 or NASDAQ Composite. It looks like that the stimulus created by the ECB over the Euro Area, through Quantitative Easing and Negative Interest Rate Policy had an immediate effect, being able to ease the Italian Market.

To conclude, the portfolio asset allocation matching the return declared by Vanguard, displayed a huge presence of the MSCI index at the expense of S&P500 and FTSE 100. This points out that a period of Negative Interest Rates Policy drives the investors to assume a higher risk profile in their investments. Investors, in fact, to get a satisfactory return are likely to increase the presence of riskier assets in their portfolios.

A longer observation period will be needed to draw a final conclusion about NIRP. What this analysis suggests is that negative rates are a good addiction for a central bank monetary policy toolset when further ease in needed, especially in extraordinary situation. Of course, this measure, must be thought as **temporary**. If this will be the case, the Negative Interest Rates Policy does not seem potentially harmful for a government economy.