

# IPO Underpricing, Is It Interest(ing)?

Evaluating the impact of interest rate policy on the size of IPO underpricing



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## **Abstract**

Given the recent changes in how central banks use the tools they have at hand to control inflation and money supply this study aims to evaluate the effect that interest rate policy has had on IPO underpricing. More specifically, the effect that negative interest rate policies and quantitative easing has had on the size of the underpricing premium. To test these effects, we collected IPO data from 22 different countries, during seventeen years and calculated a quarterly average underpricing of these IPOs for every country. We then regressed interest rate and deviations from the Taylor rule as the main explanatory variables on the average IPO underpricing. The results showed that mainly deviations from the Taylor rule is a good explainer of the average underpricing, where a positive deviation indicates that the average IPO underpricing premium increases. The Taylor rule deviations explanatory power also showed to be stronger during the time period 2009-2017. As a result we conclude that, while interest rates to some degree can explain average underpricing, it seems not to capture as much information as the deviations from the Taylor rule. The results of the paper widens the knowledge of the impact that the recent phenomenon of quantitative easing has had on financial markets in general and on IPO underpricing in particular.

**Keywords:** IPO underpricing, Quantitative easing, Interest rate policy

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# 1. Introduction

Since the banking crisis of 2008 a more or less new phenomena has started to evolve on the world market. Modern well developed economies have introduced historically low interest rates, zero percent or less, as well as initiated different kinds of large scale purchases on their own government bonds. The phenomenons are in literature referred to as *Negative interest rate policies (NIRP)* and *Quantitative easing (QE)* and the idea behind these modernities is to boost the nation's investments in an attempt to raise inflation, although the effectivity of this has been debated (Arteta et al., 2018) (Bordo & Landon-Lane, 2013).

What has also been debated lately is the impact these policies and purchases has on different financial markets. Recently *Pacific Economic Review* gave out an entire issue dedicated to this subject only. Articles targeting everything from exchange rates to equity returns were presented (Arteta et al., 2018). Evidence has been found that the negative interest rate policies has had an impact on financial markets, such that equity prices rise on announcement and that financial stability is reduced (Arteta et al., 2018). Earlier research has also proven that NIRP and QE leads to a booming stock market (Bordo & Landon-Lane, 2013) as well as increases in lending volumes from banks (Jobst & Lin, 2016, p19). However as far as we know, no research has yet been conducted on NIRP and QE effect on IPOs and IPO underpricing which is what we will do in this paper.

Looking at existing literature regarding underpricing it becomes obvious that underpricing is an established stylised fact of IPOs. Historically there has been a number of theories presented in order to explain this. The theories can be categorized into mainly two groups, asymmetric information and institutional models. Asymmetric information models refers to theories that assume that there is a difference in how much different investors know about the company being listed and its profitability. Institutional theories try to explain underpricing as a consequence of the structure of the market, for example that firms tend to underprice because of fear of lawsuits

from investors, or that the underwriter of the IPO buys stock at a certain price making the stock receive a lower price limit (Ljungqvist, 2007).

In an attempt to progress the research on NIRP and QE, as well as theories regarding IPO underpricing, we in this paper hypothesize that the size of the IPO underpricing premia depends on the interest rate and deviation from the Taylor rule. Further on, we also test if there are any direct effects of NIRP and QE on the underpricing premium. We argue that interest rates, Taylor deviations, NIRP and QE affects the amount of cash available to the market and therefore affect firms preferred and possible capital structure, which in its turn should affect the number of 'bad' firms that are able to go public. According to existing underpricing theory the number of bad IPOs affects the underpricing premium and as a result underpricing should change under NIRP and QE.

In order to evaluate this effect we will look at the first day returns of IPOs on 22 different geographical markets during the period 2001-2017. The markets chosen span all over the world and includes both countries that have introduced NIRP and QE, as well as markets that still have a fairly high interest rates and deploy no asset purchases. We then compare the average quarterly first day returns to the interest rate of the corresponding market, as well as to deviation from the Taylor rule. In a final attempt to evaluate the specific effect of NIRP and QE we create dummy variables for when these policies have been applied. We find that both interest rate and Taylor deviations have a significant positive impact on IPO underpricing. Moreover, QE might hold a significant negative effect on IPO underpricing, while we find no clear correlation between underpricing and NIRP. We also conclude that the reason interest rates and Taylor deviation affects underpricing is probably due there impact on capital supply to the market.

There are some limitations to our study that we are aware of, mainly the study only focuses on short term underpricing and that long term underpricing might differ a lot in relation to this. In addition the country sample is mostly limited to OECD countries and thus limits the study in some ways.

The rest of the paper is disposed as follows. Part two will be a brief literature review about IPO underpricing as well as the effects of NIRP and QE on different financial markets and products. Part three will describe the methodology of the paper, starting with a short description of the general execution of the experiment, followed up by a description of the data selected and statistical analysis used. Part four will be our presentation and analysis of the result rendered to us and finally part five will discuss and conclude our findings.

## **2. Literature review**

In this chapter previous research within IPO underpricing will be presented. Firstly we will present the empirical findings of the existence of IPO underpricing. Then theories of why IPOs tend to be underpriced will be reviewed after which some brief literature about negative interest rate policies (NIRP) and quantitative easing (QE) as well as their impact on the financial markets will be discussed. On a final note earlier findings will be connected to the question at hand.

### **2.1 Empirical Findings of IPO Underpricing**

The empirical research regarding initial price offerings (IPO) has shown that firms that go public tend to have abnormally large returns on the first day of trading. Since the 1960s the average first day returns in the United States have been 19% (Ljungqvist, 2007). This observed anomaly of the percentual difference between the offered price of shares and the price at which they are then traded is what is in the literature referred to as IPO underpricing.

One of the first researchers to observe the phenomenon of IPO underpricing was Ibbotson (1975) in the US market. In his research he found that the average initial performance of a newly issued stock on the New York stock exchange in the 1960s was 11.4%. The stylized fact of underpricing in the American IPO market has since then been tested and proven repeatedly. For example Ritter proves underpricing in the 1980s (Ritter, 1984) and again in 2002, where he together with Loughran discusses the increased underpricing found on the US market from 1980 to 2000 (Loughran & Ritter, 2002).



We see the same pattern in other well developed and liquid financial markets. In 1981 Buckland et al. investigate new equity issues in the UK market and find positive average returns for the period of 1965-1975 (Buckland, Herbert & Yeaomans, 1981). In 1994 Loughran et al. concludes that underpricing exist in all 25 countries they investigate, although the amount of underpricing varies a lot between different economies (Loughran, Ritter & Rydqvist, 1994). According to a more recent study by Ljungqvist (2007) the average underpricing between 1960 and 2004 has been 19%.

All in all, the stylised fact of underpricing has been tested and proven not only in the leading financial market (US) but also throughout the different financial markets around the world. However, one can also conclude two other empirical finding of IPOs and underpricing, that the size of the underpricing tends to cluster over time, i.e. there are periods when underpricing is larger and periods when they are lower and that it varies between countries.

Regarding the reason to the substantial variation in underpricing found between markets Loughran et al. (1994) contributes this mainly to three different things, different selling mechanisms, differences in firms going public and institutional differences. As a result, there is a significant difference between well and less developed markets but also between highly regulated and non-regulated markets. For example Sweden's high degree of underpricing can be explained as a result of high marginal tax and the possibility of tax avoidance by share allocation to employees (Loughran et al., 1994). Although, a lot of other possible explanations has been given towards the reason as to why the amount of underpricing varies between both markets and time periods.

For example, the fact that there are time periods when underpricing is larger has been tried to be explained by Loughran and Ritters (2004). They argue that one of the reasons that increases underpricing is the so called changing issuer objective function hypothesis. This means that issuing firms become less worried about underpricing when they focus more on hiring a lead underwriter with a highly ranked analyst to cover the issue. According to Loughran and Ritters this hypothesis can partly explain why IPOs were as underpriced as they were during the 1990s. They mean that the higher valuations of new issues in the 1990s compared with the 1980s led to

analyst coverage being a more important factor for the firms. During the 1980s they mean that the asymmetric information was the main reason that IPOs were underpriced. Something to note is that the size of underpricing could also be explained by the difference in what type of companies are being listed. During the 1990s there was a significant shift towards IPOs within the technology sector as well as companies with negative profit. Loughran and Ritters also conclude that the difference in underpricing between time periods can to a certain degree be explained by the riskiness of the firms being issued.

Ritter (2018) on the other hand has showed that the average first day return of newly issued stock depends on the sales of the company being listed prior to the offering date, where smaller sales usually indicated that the average underpricing was higher. This relationship has showed to hold for the period 1980-1998 but has since weakened. From 1999-2000 this relationship was reversed, during this period the average underpricing was also abnormally large (64.6%).

In this paper we have a different approach and instead argue that one of the reasons to these fluctuations can be central bank policies and their impact on money market rates. We argue that since central bank interest rates affects the amount of cash available to the market, which affect overall investment in the market, it should affect IPO investments as well. But more on this later. To instead conclude something regarding the fact that underpricing varies both over time and between markets we can say that it has been proven repeatedly, although the reason as to why this is happening varies between authors, and possibly have different explanations. In the end almost all literature indicates that underpricing is a proven stylised fact of IPOs in more or less all developed and liquid financial markets. The very reason to this underpricing is however heavily debated and is most commonly divided into two different explanation models. Asymmetric models and institutional models, which is done for example in Ljungqvist (2007). Asymmetric models explains underpricing as a function of the asymmetric information between investors and the issuing company or between institutional and non-institutional investors. Institutional models on the other hand derive underpricing as a function of different institutional factors, such as legislation or tax regulation (Ljungqvist, 2007), resembling the logic between Loughran et al (1994) explanation to variation in size of underpricing. The different types of

models will now be further explained and linked towards interest rate to see how interest rates could affect underpricing in accordance with established theories.

## 2.2 Asymmetrical models

The models that are referred to as asymmetrical build on the assumption that some investors, mainly institutional investors, are more informed than others. One of the more prominent models within the asymmetric information framework is the winner's curse model presented by Rock (1986). The model assumes that there are two type of investors; informed and uninformed. The informed investors know which new issues that will be profitable. The uninformed do not. This leads to the informed investors only subscribing to the IPOs that will be profitable and the uninformed investors to subscribe to all new issues since they can not differentiate between the IPOs that will be profitable and the IPOs that will be unprofitable. The uninformed investors will then receive the entire amount of stocks in the low-quality IPOs. In the high-quality IPOs the uninformed investors will only be allocated a part of their requested amount of stocks since these IPOs will be oversubscribed as a consequence of both group of investors demanding the stock. In order for the uninformed investors to be willing to take part in the market they therefore require that they on average make at least zero profit. Since uninformed investors get fully subscribed in the bad IPOs, and are only allocated a fraction of their requested amount in the good IPOs there has to be underpricing in order for the uninformed investors to break even (Rock, 1986).

The winner's curse hypothesis has been tested by Levis (1990) on new issues in the United Kingdom, the results show that the winner's curse can not be ignored as an explanation of IPO underpricing. The model has also been tested on the Singaporean market during the period 1973-1987. In the singaporean market the allocation of shares is decided by a lottery, making it a perfect market to test Rock's hypothesis. The results show that the average first day return on the singaporean market during this time period was 27%, but when taken into account for allocation the results show that the average return for an uninformed investor is roughly 1% (Koh & Walters, 1989). This supports Rock's hypothesis since even if the average stock gives a high positive return, the uninformed investor will not receive a risk adjusted positive return.

Another asymmetric explanation to underpricing is called information revealing and is based on Rocks (1986) theory of investors with different information levels. The argument goes that underwriters usually set the price of IPOs through bookbuilding where the price is set based on what prices investors indicate that they are willing to pay and has learned that some investors have more information than others. As a result underwriters want these well informed investors to reveal true information regardless of the price is set too low or too high. However, since there are economic incentives for the well informed investors not to share true information when prices are too low, underwriters have to reward knowledgeable investors who share true information about high value firms. As a result underwriters reward aggressive, i.e. investors that say they are willing to pay a high price for the IPO, investors during the bookbuilding with a higher allocation in the IPO. In order for this reward to be worth something the IPO has to be underpriced, which makes information revealing lead to underpricing. (Benveniste & Wilhelm, 1990) (Ljungqvist, 2007)

The information revealing hypothesis has been tested by Cornelli & Goldreich (2001) as well as by Jenkinson and Jones (2004). Both surveys are based on information from European bookbuilding process but the results contradict each other. While Cornelli & Goldreich find evidence of underwriters premiering high bids, Jenkinson and Jones do not, leaving an unclear conclusion of the hypothesis. The hypothesis weakens even more since the data of these processes often are kept secret and the hypothesis has therefore never been proved outside the European market (Ljungqvist, 2007).

A somewhat similar hypothesis is that firms have been suggested to signal high quality by underpricing their offering. The logic goes that the issuing firm best knows the true value of itself. If the firms raise capital in two rounds, once via the IPO and later via a second offering, the high-quality firms can afford to underprice their stock in the first offering and later on raise more capital at their value indicated by the market price. The low quality firms can not do this since they risk not being able to recoup the cost of selling their stock at a discount (Ljungqvist, 2007). The evidence of this hypothesis has been mixed. Francis et al. (2010) concludes that research has not found unambiguous proof of the relationship being true. However they show

that when looking at financially segmented markets, instead of integrated markets, the hypothesis has a strong degree of support. They find that firms from these type of markets that are heavily underpriced are more likely to issue a seasoned offering, likely to raise a large amount of capital in their seasoned offering, and less likely to experience a price drop after the announcement of a seasoned offering.

### 2.3 Institutional models

Moving on to institutional models of underpricing we can firstly conclude, as said before, that institutional models of underpricing derives underpricing from institutional factors in different markets, and are thus the prime explanation to differences in IPO underpricing between geographical markets. One of the earliest institutional approaches is the legal insurance hypothesis that heritages from the litigation risk in the US. The legal insurance hypothesis argues that underpricing is a consequence of a firm's likelihood of being sued for withholding information in connection with the IPO (Ljungqvist, 2007). Hughes and Thakor argues in their article from 1992 that litigation risk has a clear impact on underpricing. If a company is exposed to a potential lawsuit that will affect the after price of the IPO, underpricing increases as a hedge towards the potential litigation. Although, they also concluded that this effect is dependent on the legal environment in the market since IPO underpricing occurs in countries where litigation risk is not a factor (Hughes & Thakor, 1992).

Another institutional explanation to underpricing is tax regulation. The argumentation is fairly simple, if there is a difference in the taxation levels of income and capital gains an incentive is created for paying employees in appreciating assets instead of salary. One of the most common appreciating assets that can be used for this purpose is underpriced stock, which preferably is allocated to the employees at the IPO (Ljungqvist, 2007). In 1997 Rydqvist argued he had found substantial proof for that underpricing in Sweden was directly linked with tax benefits. With a massive decrease in underpricing in Sweden, from 41% to 8% in average, in connection with a regulatory change that made capital gains taxed with roughly the same amount as income,

Rydqvist claimed that underpricing in Sweden had been directly linked to tax avoidance (Rydqvist, 1997).

Further on research has shown a connection between underpricing and interest rates. A study by Tran and Jeon (2011) on the US market between 1970 and 2005, has shown that the amount of proceeds raised by IPOs has a positive correlation with federal interest rate. Another study by Fung and Che (2009) has shown that underpricing and interest rates have a positive correlation on the Hong Kong market. Rendering in a conclusion that interest rate increases the amount of IPOs as well as the underpricing of IPOs, although this is somewhat debated.

Although proof has been provided for institutional explanation to underpricing the idea is also fairly criticized. The legal insurance hypothesis has received critique for being limited almost exclusively to the US, which Hughes and Thakor also admits (Hughes & Thakor, 1992), but has also been found not to hold even in the American market (Ljungqvist, 2007). The tax avoidance theory may hold some merit but can never alone explain the whole concept of underpricing. However, as concluded above, both by Loughran et al. (1994) and Rydqvist (1997), it might hold the solution to regional market alterations in amount of underpricing.

In this paper we claim that interest rates could indeed count as an institutional explanation to underpricing although it is probably not, even though it definitely should affect underpricing. We also hypothesize that Taylor deviation could be included as an institutional factor.

## 2.4 Negative interest rate policies & Quantitative easing

Regarding the fairly new phenomena of NIRP as well as QE, some words need to be said. The phenomena has occurred a couple of times throughout history but has during the last 5-6 years for the first time been systematically used by different central banks around the world in efforts to raise different targeted measurements, mainly inflation. The major banks that have implemented NIRP is Bank of Japan, The European central bank, the Swedish Riksbank, the Danish Nationalbank and the Swiss National Bank (Arteta et al., 2018). While QE has been more broadly used, for example by both Bank of England and the Federal Reserve.

Notable, however, for all these countries is that these efforts have continued even after their economies have recovered from recession and entered good economical climates (growing GNP etc), since the targeted measurement refused to go up. As a result, NIRP and QE have been proved to deviate positively from the Taylor rule and thus the capital injection from these policies actually renders a booming market with even more capital to spend, rendering the effect on financial markets questionable as well as their effectiveness (Nikolsko-Rzhevskyy & Papell, 2013).

As a result, a lot of research has been done on the effects of NIRP and QE on financial markets even though the phenomena is quite new. To begin with it has been proved that QE and NIRP have increased bank loan issuance rates. In a paper from 2017 Darmouni and Rodnyansky proved that QE had increased loan issuance by banks to non-financial institutions on the american market (Darmouni & Rodnyansky, 2017) and in the same year Jobst and Lin argued that NIRP have increased banks lending volumes (Jobst & Lin, 2016, p19). Moreover in an extensive paper from 2013 Bordo and Landon-Lane concludes that NIRP and QE have lead to a booming stock market (Bordo & Landon-Lane, 2013).

Regarding further impact on the financial market Arteta et al. (2018) listed a number of effects that negative interest rates has on different financial markets. Amongst other things it affects interbank rates negatively and equity as well as CDS spreads variously (Arteta et al., 2018). It has also been concluded that the extremely low rates can affect banks risk taking. This increased risk taking within banks also increases the risk for different types of asset bubbles, which can be very damaging for the economy (Claessens, Kose, & Terrones, 2012).

Further on Hameed & Rose has investigated the NIRP effect on exchange rates. They conclude that the negative interest rates have had an impact on exchange rates although a bit reluctantly, since they correctly state that the amount of data available is daunting (Hameed & Rose, 2018). All in all researchers have tended to find results of NIRPs impacting the financial markets, even though the data sets are too small to draw any wide conclusions. However, it seems pretty evident that NIRP and QE have increased the amount of capital available to investors as well as

created a boom on the market. Any direct studies done on the impact of IPOs and underpricing has as far as we know not been done.

## 2.5 Question at hand

In conclusion of our literature review we can see that underpricing is described as either an effect of information asymmetry between institutional investors and regular investors, or as a result of institutional factors (Ljungqvist, 2007). As a result interest rates and Taylor deviations will affect underpricing, since they reflect institutional changes, but also possible alters the conditions for the asymmetric models.

NIRP and QE on the other hand will affect underpricing if they change any institutional factors, or changes the conditions for the information asymmetry between investors. From previous literature we know that NIRP and QE affect financial markets in different ways, for example it creates a booming stock market (Bordo & Landon-Lane, 2013) and increases banks lending volumes, making more capital available to the market (Jobst & Lin, 2016, p19). As a consequence we argue that both NIRP and QE should affect IPO underpricing since both increased capital to the market and a booming market should affect the conditions for the information asymmetry between investors.

The idea is that the increased supply of capital to the market created by these policies could increase overall investments and thus it should improve the conditions for firms to go public by enabling more capital to investors. As a result of this the number of IPOs in the market should increase, since there is now more capital that can be spent on IPOs, enabling firms to go public that before had a hard time finding investor capital for their IPOs. Arguing that firms possibility to attract capital is strongly connected to their profitability this would mean that the increase in IPOs created by QE and NIRP would mainly be by less profitable or even unprofitable firms. Assuming that profitability in firms and their ability to render investor with positive returns are highly correlated, QE and NIRP leads to an increase in firms with low chance to give positive return to their investors. Since the definition of a bad IPO in most asymmetric models is simply one that does not generate positive return to their investors (Ljungqvist , 2007), we can conclude



that the amount of bad IPOs in the market could increase as a result of QE and NIRP, which could affect underpricing in two different ways.

Firstly, it could affect underpricing negatively. An increase in bad IPOs without anything to offset it will result in a decrease in underpricing simply due to the fact that a bad IPO by definition does not render any return and therefore cannot carry any underpricing premium. An overall increase in bad IPOs will therefore increase the amount of firms with zero or negative underpricing in the market. Another way to look at this is with the signaling hypothesis, an increased amount of bad firms would render the market with a lower ratio that could afford underpricing as a signaling effect and thus the underpricing should decrease (Ljungqvist, 2007).

On the other hand it could also increase underpricing as a result of either the winner's curse or the information revealing hypothesis. Because, according to the winner's curse an increase in non-profitable IPOs that investors buy have to be compensated, in theory, by an increase in underpricing in the profitable ones, otherwise the market for IPOs would collapse. In the information revealing hypothesis, underwriters need to at least uphold the underpricing premia, otherwise they can't price IPOs accordingly. So depending on the efficiency of the market it could also mean an increased underpricing premium as a compensation for more unprofitable firms going public (Rock, 1986) (Benveniste & Wilhelm, 1990).

A totally different way to view the impacts of QE and NIRP is as a discount of debt to firms, resulting in firms reaching for debt financed, instead of equity financed, solutions. This would mean that firms rely more heavily on debt than on equity to finance their business, rendering the market with less firms going public. Following the same argumentation as above, but with debt being the increasing way of financing for firms, we see that this can also render us with a higher or lower underpricing premium, since the amount of bad IPOs could decrease as a result of them finding cheap capital in debt solutions. Same as above this could either increase or decrease underpricing, depending of the correctness of the different asymmetry models.

A more institutional explanation of changes in underpricing due to QE and NIRP can be that even though previous research has found a positive connection between underpricing and interest

rates (Fung & Che, 2009) there are other factors indicating that QE and NIRP should increase underpricing. For example, underpricing is notoriously known to be pro-cyclist and these policies have been proven to create a business boom on the financial markets. As a result the impact of low interest rates are debatable and could both increase or decrease the underpricing when low, regardless of old proven relationships between interest rates (Bordo & Landon-Lane, 2013).

In conclusion, we argue that NIRP and QE will affect underpricing through alterations in capital supply to the market. These alterations will lead to a change in bad firms going public which will adjust the underpricing premia in either way depending on which asymmetric underpricing model that holds most merit. An alternative explanation is that interest rates and Taylor deviations are institutional variables for underpricing, for example dictating the demand of return, and that NIRP and QE impact underpricing indirectly through these, since they might be assumed to have a high correlation.

### 3. Methodology

In this chapter we will initially give a brief explanation of the execution of the paper, in order to then more thoroughly describe the data set used. The final part is a summarization of the regression models used and a variable specification.

#### 3.1 General execution of the paper

The idea of this paper, as already stated multiple times, is to investigate if and how QE and NIRP have had any impact on IPO underpricing. As presented above the idea is that NIRP and QE affects the number of bad IPOs listed, which can have different effects on the underpricing mechanism.

In order to test this we have collected data on 22030 IPOs in 22 different countries spanning the time period 2001-2017. We have also collected quarterly data for short term money market interest rates for these 22 countries during the same time period. These rates are assumed to work as proxies for the repo rates effect on the market of the countries and thus works as indicators on

NIRP. Regarding data for QE we have chosen to use deviation from the Taylor rule as a proxy for QE, since QE has been proved to deviate positively from the Taylor rule historically (Nikolsko-Rzhevskyy & Papell, 2013). We have also collected data from different macro and control variables in order to see if the model improves by reducing the amount of variance entering the residuals.

All in all this render us with sporadic daily data, whenever an IPO has occurred in one of the countries, and continuous quarterly data for interest rates and Taylor deviation, spanning between 2001-01-01 until 2017-12-31. From this data we calculate an average underpricing for each country in each quarter. This data is then used to investigate how interest rates as well as NIRP and QE impact underpricing through different types of panel regression and statistical analysis.. We will also introduce other types of macro variables in order to see if they can strengthen our model further and limit the size of the variance in our residuals. Finally we also calculate weighted underpricing on the amount of IPOs in each country quarter and run the same regressions on these for robustness reasons.

## 3.2 Data selection

### *3.2.1 Countries*

The 22 selected countries are chosen in order to have a good diversity in our sample, both regarding geographical position and financial markets as well as interest rate levels. Countries such as US, UK, Japan and various EU countries are there as well developed financial markets with low interest rates, while countries such as Indonesia, South Africa and China represent less developed markets. All in all the sample is selected in order to capture the effect of interest rates, Taylor deviation, NIRP and QE on underpricing in different markets. However, the country selection is somewhat limited due to data availability.

For example, to even have a functional IPO market a country's financial market has to be quite well developed. As a result the phrasing “less developed market” can be somewhat misleading. What we here mean when we talk about less developed markets is relatively speaking towards the other countries in our sample, not towards the world as a whole. However, the selection of

only fairly well developed financial markets can be used as a foundation for critique of biased selection in our paper. We also actively tried to find countries that were implementing NIRP and QE, for obvious reasons, and the selection can as a result be somewhat biased for this reason as well. On a final note it was very hard to find data on potential output for countries outside OECD, which limited our data sample even further. Although this can be seen as a problem, the results are still pretty robust since the data still span over multiple countries and continents. The data is collected from OECD.stat

### 3.2.2 IPO Data

Regarding the IPOs themselves there are a couple of important things to mention. To begin with we need to define IPO underpricing. We will use the classical definition, the difference between initial offering price, i. e. what you buy the IPO for before it starts trade and the closing price of the stock on the first day.

#### *Equation 1: Underpricing*

$$(P_1 - P_0) / P_0 = U$$

$$P_1 = \text{Price at day end}$$

$$P_0 = \text{Initial Price}$$

$$U = \text{Underpricing in \%}$$

We are fully aware that looking on underpricing in a longer time period could better show the negative effect bad listings has on the underpricing effect. However, since we want to look at the effects NIRP and QE has in the light of the classical underpricing theories, which has mainly been proven on this definition of underpricing, this definition has been chosen.

The reason we decided to use a quarterly measurement of underpricing instead of daily has to do with the random nature of occurrence of IPOs. Since IPOs get listed without any specific model or pattern, we decided to calculate an average underpricing measurement for each quarter in every country in order to decrease the amount of missing observations in our panel data. The mean calculated is a simple arithmetic mean:

*Equation 2: Average underpricing equally weighted*

$$1/N * \sum_{i=1}^N U_i = U_i^*$$

$U_i$  = Single IPO underpricing observation.

$N$  = Number of U observed in quarter.

$U_i^*$  = Average underpricing in quarter.

Further on, we have also decided to weight the underpricing observations equally when calculating the average underpricing per quarter. Of course other weighting techniques could be used, for example to weight the underpricing according to the offer size of the IPO. However, equal weighting is an appropriate technique from the perspective of an investor. Additionally, since only first day returns are observed there is no need to weight the portfolio according to market value, which would be more appropriate when looking at investments on a longer investment horizon. In addition this is also the most common way to weight IPOs in earlier research, making this weighting technique better for comparing our results with the results already found by others. However, in order to test for robustness we also run our regressions with weights accounting for number of observations in the quarter for each country, to adjust for quarters with single extreme values, i.e quarters with more observations gets heavier weights.

*Equation 3: Average underpricing weighted with number of IPOs in country quarter*

$$n_i/N_i * U_i^* = U_i^w$$

$n_i$  = Number of IPOs in a country quarterly

$N_i$  = Number of IPOs in total for a country

$U_i^*$  = Average underpricing in quarter.

$U_i^w$  = Weighted average

Finally we have also decided to limit our data to IPOs with an offer size greater than 3 million dollars in order to exclude some of the most extreme values of initial return. We know that this limits our selection and data set, however smaller IPOs tend to differ quite a lot in how they

behave and might dilute our data even though including them increases the number of observations. The data is collected from Bloomberg.

### *3.2.3 Interest rates*

The interest rates collected for each country are not repo rates of each country but instead money market or treasury bill rates for short term (3 months) interest rates in each country. The reason for this is partly that they work as a good proxy for institutional rates and their market impact, since they are very closely correlated, but also since actual money market rates represent the price of capital in the market better, which is desirable since we argue that the price and supply of capital is impacting the level of bad IPOs. The data is collected from OECD.stat.

### *3.2.4 Taylor rule*

The selection of deviation from the Taylor rule as a proxy of QE is based on previous studies finding periods which have implemented these strategies to clearly deviate positively from the Taylor rule. We are indeed aware of that this is a quite broad generalisation. However, it is a simplification that needs to be done since there are no other good ways to easy capture QE for our countries (Nikolsko-Rzhevskyy & Papell, 2013).

The Taylor rule interest rate was developed by Taylor (1993) and is based on econometric research on interest rate policies. The rule is based on the output (GDP) and inflation of a country. Taylor has showed that his rule very closely mirrors the interest rate of the United States federal funds rate for the period 1987-1992.

In order to estimate the Taylor rule interest rate, data has been collected for the inflation as well as the GDP-gap in each country. The data for inflation has been collected quarterly from OECD.stat. For data on GDP-gap we have only been able to collect annual data, we have also been unable to find data on GDP-gap for non-OECD countries which means that we were only able to approximate the Taylor rule for 18 of the total 22 countries in our dataset. The non-OECD countries that therefore have not received a Taylor approximated interest rate are; China, Indonesia, South Africa, and Russia. We are aware of that this more or less disables us from drawing conclusions regarding any other market then well developed markets, which of

course damages our results. However, we still think our result will be fairly robust since we can compare what differences NIRP and QE make in our sample, which still covers a large sample of the world's well developed economies. Enabling us to draw conclusions on at least the world's leading financial markets, which are the prime markets for IPOs.

The Taylor rule interest rate has then been calculated with the following equation:

*Equation 4: Taylor rule interest rate*

$$i_t = p_t + r_t^* + a_p(p_t - p_t^*) + a_y(y_t - \widehat{y}_t)$$

$i_t$  = Interest rate

$p_t$  = Inflation

$r_t^*$  = Assumed equilibrium interest rate

$p_t^*$  = Inflation goal

$y_t$  = Logarithm of Real GDP

$\widehat{y}_t$  = Logarithm of potential output

In our calculation we have assumed an equilibrium interest rate of 2% and an inflation target of 2% for all countries. We have also assumed that  $a_p = a_y = 0.5$ . These assumptions are in line with the assumptions originally proposed by Taylor (1993). We have also set an arbitrary lower limit of deviation in order for us to call it QE at 3%. The reason to do so was to exclude noise from other factors, not setting any limit would render more or less our whole sample to be affected of QE efforts. Setting a minimum deviation level also rhymes well with QE being associated with abnormal deviation from the Taylor rule.

### *3.2.5 Other macro and other control variables*

The other macro and control variables we have selected are GDP growth, inflation, the global stock index S&P Global 1200 and average IPO size in the quarter. The selection is done in order

to capture other effects that might affect underpricing. GDP growth is selected to capture eventual cyclical underpricing mechanisms. Inflation is there to correct for inflation so that the underpricing measurement does not get artificially high due to high inflation. Size is selected as one of the previous prime explanations of IPO underpricing and will capture standard reasons for underpricing, such as risk etc. Finally S&P Global 1200 was chosen to capture market movement and eventual effect on underpricing. The data is collected from OECD.stat, BLOOMBERG and Datastream and exist for almost the whole sample, although there are some gaps in the data for GDP growth in China.

### *3.2.6 Time period*

The time period of the study is set to seventeen years, between 2001-2017. The sample time can be considered random and unnecessarily lengthy but we wanted to have data from years with high interest rates in all countries, especially those that now exhibit NIRP and QE. This was desirable since we assume there will be country specific effects that even if we adjust for these cannot be totally erased. Single countries with both high rates and NIRP during the sample time will allow us to study the impact of these better.

## 3.3 Regression analysis

Since we will be running panel regression analysis of our dataset a short description of panel data and analysis might be in its place. Panel data is the same data collected for a number of entities over time. In our case the entities will be countries and the data underpricing, however since the data for underpricing is a calculated average our data is rather what is called pseudo panel data then pure panel data. Irrespectively, panel data has a number of advantages, not least that it increases our number of observations but also enables us to test for time and cross sectional heterogeneity. This means that we can test our data to see if the residuals of the model are dependent of time or entity specific factors (Brooks, 2014).

Depending on the result of this we will run different types of regressions allowing for heterogeneity, both in time and entity. This will be done by both so called fixed and random effects in order to see what fits our data best. Fixed effects means that we will assume that each



country and/or time period have a fixed impact on underpricing in each period. One can think of this as a simple OLS regression but adding a dummy for both the time and country parameters. Random effects on the other hand is entity or time specific effects that are randomly distributed. In other words it is basically the same as fixed effects but are allowed to vary within the same entity or time period (Brooks, 2014).

As a result of this we will start by just running a pooled regression on our data including only interest rate as an explanatory variable, treating it like a simple cross-sectional data sample and estimating the effect of interest rates on IPO underpricing by a simple OLS estimation. We will run the same estimations for the deviation from the Taylor rule to see if there is any difference.

In accordance with panel regression theory (Brooks, 2014) we will also test the data for fixed and random effects in entity and time. If this improves our model, which it should since we know that both institutional (country) factors and cyclical (time) impacts IPO underpricing (Ljungqvist, 2007) we will adjust our model by also performing a Hausman test to see whether we should use fixed or random effects. The Hausman test detects eventual endogeneity in the models, i.e. correlation with the error term and the regressors and then compares the two different models residuals, i.e. with fixed and random effects, against each other with the help of a chi-square test.  $H_0$  of the test is that the differences in the coefficients are not systematic while  $H_1$  is that the effects are systematic. If the effects are systematic we have to use fixed effects. Notable is that the test prefers random effects for their efficiency through the  $H_0$  since it has to be rejected in order for us to use fixed effects.

When this is done we will run regression on different time sub-samples of our data, checking the robustness of the result. The two different sub-samples used are before and after 2009, set in an attempt to catch effect before and after the financial crisis. After this we will introduce more and more explanatory variables in the same model in order to see how it improves. The two different models will be merged, then dummy variables for NIRP and QE, set as interest rates below zero and positive Taylor deviation above 3 %, will be added. In a final effort to improve the model we will introduce other different macro variables in order to see if we can capture more of the residuals and give us a better result. The Macro variables used will, as said, be GDP growth,

Inflation, the global stock index S&P Global 1200 and average IPO underpricing size. The complete specification will look like this.

*Equation 5: Complete specification for regression*

$$\text{Underpricing}_{i,t}^* = \alpha + \text{Interest}_{i,t} + \text{TaylorDev}_{i,t} + \text{Country}_i + \text{Time}_t + \text{NIRP}_{i,t} + \text{QE}_{i,t} + \text{GDP}_{i,t} + \text{Inflation}_{i,t} + \text{S\&P Global}_t + \text{Size}_{i,t} + \varepsilon$$

$\text{Underpricing}_{i,t}^*$  = Amount of underpricing

$\alpha$  = Constant

$\text{Interest}_{i,t}$  = Interest rate

$\text{TaylorDev}_{i,t}$  = Deviation from the Taylor rule

$\text{Country}_i$  = Country specific effect

$\text{Time}_t$  = Time specific effect

$\text{NIRP}_{i,t}$  = Dummy variable = 1 when NIRP has been used

$\text{QE}_{i,t}$  = Dummy variable = 1 when QE has been used

$\text{GDP}_{i,t}$  = GDP growth

$\text{Inflation}_{i,t}$  = Inflation

$\text{S\&P Global}_t$  = S & P Global 1200

$\text{Size}_{i,t}$  = Average size of the IPO in the quarter

$\varepsilon$  = Error term

And have the hypothesis

$$H_0 = \text{Interest}_{i,t}, \text{TaylorDev}_{i,t}, \text{NIRP}_{i,t} \ \& \ \text{QE}_{i,t} \geq 0$$

$$H_1 = \text{Interest}_{i,t}, \text{TaylorDev}_{i,t}, \text{NIRP}_{i,t} \ \& \ \text{QE}_{i,t} < 0 .$$

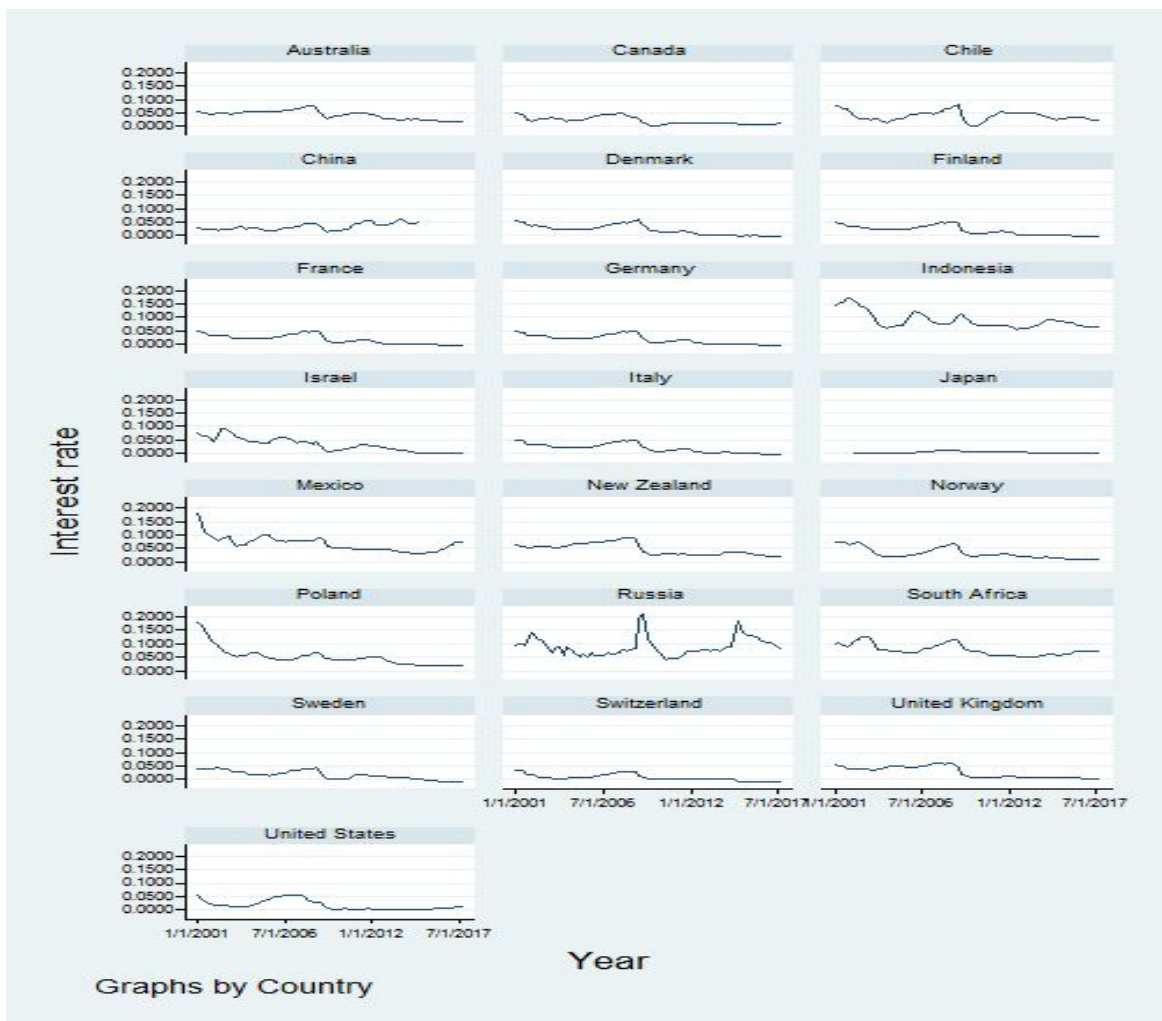
## 4. Results:

The overview of our results start with some basic descriptive statistics of our data set. This is then followed by the result of our different regressions, which finalises in our final model of underpricing as a function of NIRP and QE as well as other macro factors.

### 4.1 Descriptive statistics

To begin with we can just briefly look at the interest rates of our different countries.

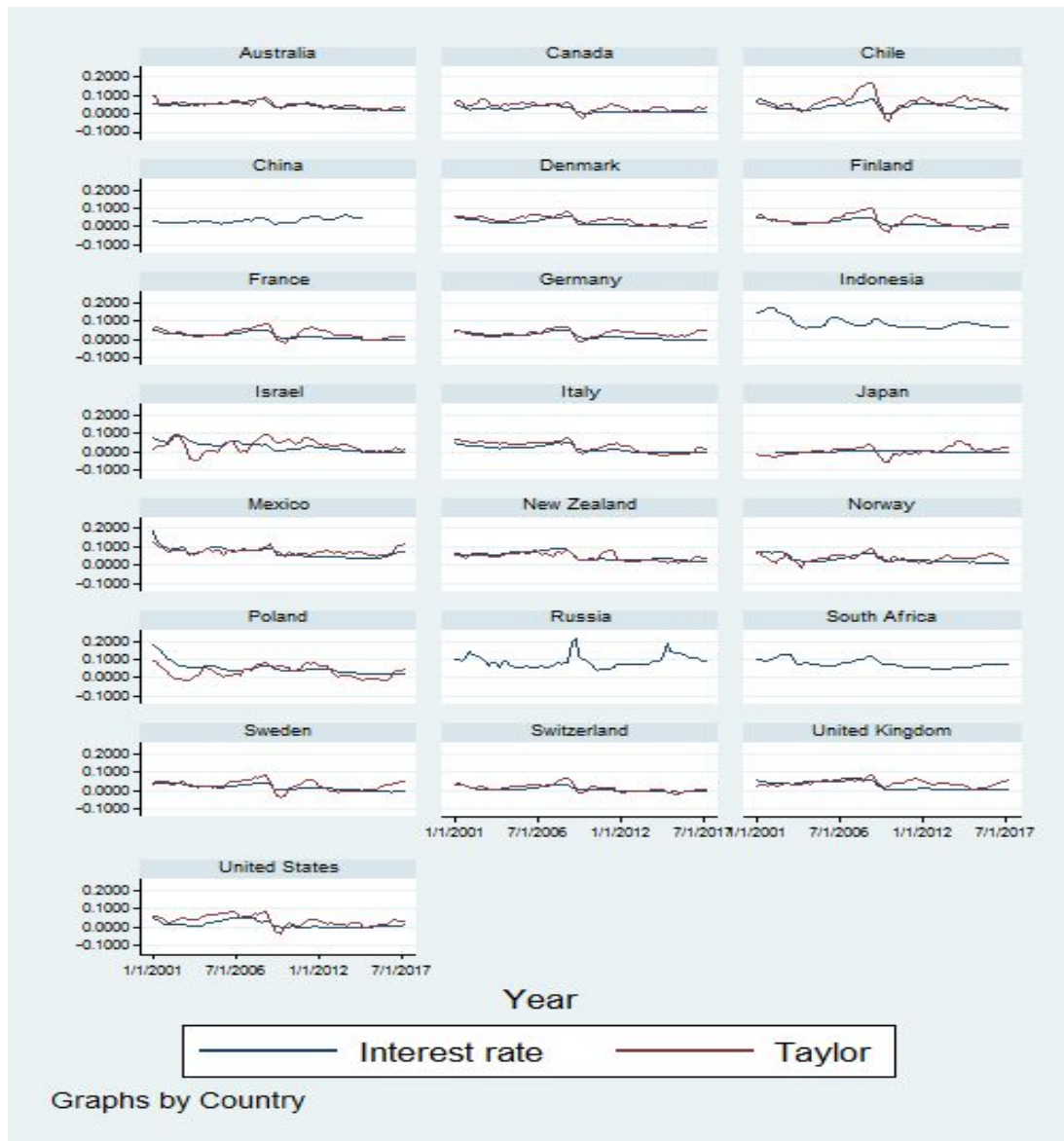
*Graph 1: National short term interest rates over time*



Nothing very particular stands out here, except maybe that more well developed countries have a lower interest rate, which is not very surprising since less developed countries need a higher interest rate in order to attract capital, as they need to cover the higher risk they carry. We can however note that the countries that have used NIRP are the countries already mentioned; Sweden, Germany and other ECB countries, Denmark and Switzerland, with one exception Japan. This might be due to money market rates not being as closely related to the policy rate in Japan.

Changing the focus towards QE instead of NIRP we start by plotting the suggested Taylor rate and the actual interest rates.

Graph 2: National interest rates & Taylor rates over time

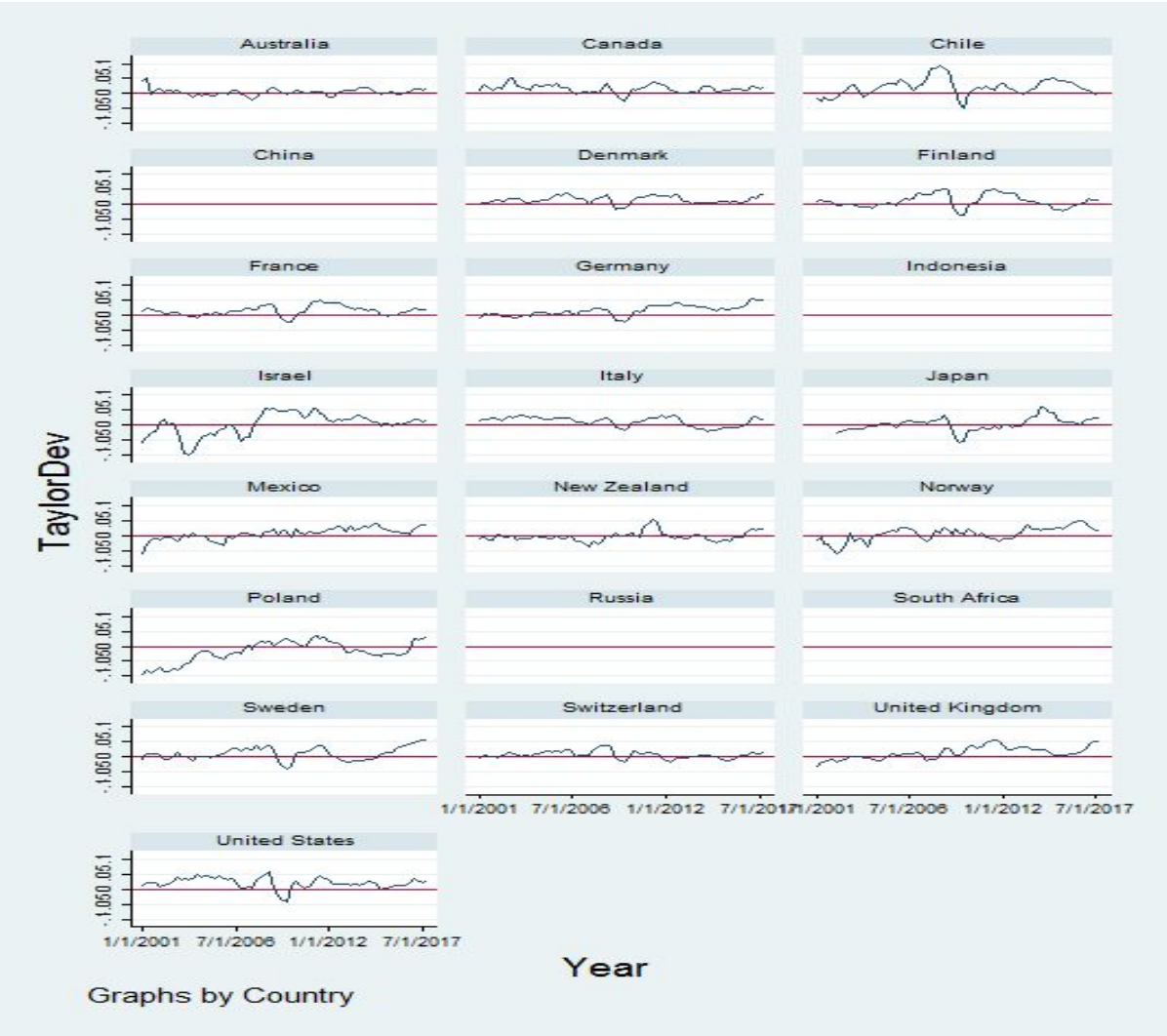


The graphs show the countries short term interest rate and the rate suggested by the Taylor rule. They can be interpreted as when the Taylor rate is above the interest rate, the government is keeping an interest rate that is lower than what is optimal, i.e they feed the market with more cash than what is indicated necessary by the Taylor rule. As said this has been found to be inherently connected to QE and as a result positive deviation from the Taylor Rule interest rate

can be assumed to proxy applied QE fairly well (Nikolsko-Rzhevskyy & Papell, 2013). As seen it is mainly occurring in the last 3 years with some exceptions.

In our regression later this is measured by a measurement for deviation from the Taylor rule, where a negative deviation indicates a too high rate and positive deviation a too low rate. In other words, when we have a significant positive Taylor deviation we have QE. This is visualised below.

Graph 3: National Taylor deviations



To begin with we can conclude that most countries has been using QE at some point and to some degree. We also see that, as already said, the positive deviation mainly occurs in the last three

years and that it is larger for countries applying both NIRP and QE. We also see that, as mentioned, the data is missing for some countries. For China, Indonesia, Russia and South Africa we could not manage to find adequate data to calculate the Taylor interest rate and deviation and as a result it is missing.

As described above we also decided to set a minimum requirement on the amount of deviation in order for us to call it QE. As said we set that limit to 3 % positive deviation which resulted in the following distribution of QE among our countries.

*Table 1: Number of quarters with observed QE for each country in the sample*

<b>Presence of Quantitative Easing</b>			
<b>Country</b>	<b>Freq.</b>	<b>Percent</b>	<b>Cum.</b>
Australia	2	1.16	1.16
Canada	8	4.62	5.78
Chile	17	9.83	15.61
Denmark	7	4.05	19.65
Finland	16	9.25	28.90
France	10	5.78	34.68
Germany	13	7.51	42.20
Israel	15	8.67	50.87
Italy	3	1.73	52.60
Japan	5	2.89	55.49
Mexico	8	4.62	60.12
New Zealand	4	2.31	62.43
Norway	7	4.05	66.47

Poland	3	1.73	68.21
Sweden	13	7.51	75.72
Switzerland	4	2.31	78.03
United Kingdom	16	9.25	87.28
United States	22	12.72	100.00
Total	173	100.00	

Table 1 shows how many quarters with quantitative easing that each country has had over the sample. The total number of quarters observed for each country is 68. Looking at the table we can see that we have a total of 173 observations with QE and that the countries that have also implemented NIRP in most cases also have a lot of observations with QE. Additionally we also see that UK and US have used QE quite frequently.

Moving on to a simple comparison we will compare the mean average underpricing for the different country-quarters, both when negative interest rate has been present and when it has not.

*Table 2: Mean of average underpricing for the part of the sample where interest rate has been positive*

<b>Positive interest rate</b>				
Mean estimation	Number of observations:			1,415
	Mean	Std. Err.	95% Conf. Interval	
Average Underpricing	.1191766	.0208753	.0782268	.1601265



*Table 3: Mean of average underpricing for the part of the sample where NIRP has been applied*

<b>Zero or negative interest rate</b>				
Mean estimation	Number of observations:			81
	Mean	Std. Err.	95% Conf. Interval	
Average Underpricing	.0419642	.0077238	.0265933	.0573351

As we can see we have 1415 observations with positive interest rate and only 81 with negative rate. This is due to the fact the NIRP has not been systematically used until recently and that our sample period is fairly long. As already mentioned the sample period is set in order to collect data from different stages in the business cycles for all countries and to get data for countries that have applied NIRP where they have normal interest rates. Nonetheless, this can of course be seen as a limitation of the study, but no more data is available at this point so it will have to do.

Regardless of this however, we see that in our sample the average underpricing differs significantly (see confidence intervals) and is significantly lower for the observations where we have negative interest rate. This could be seen as an indication that NIRP actually are decreasing underpricing in the market. However, it can also depend on a lot of other different factors, such as institutional differences between countries that have adopted NIRP and countries that have not.

Doing a similar comparison between observations with and without quantitative easing give us the following result.

*Table 4: Mean of average underpricing for the part of the sample where QE is present*

<b>With Quantitative Easing</b>				
Mean estimation	Number of observations:			173
	Mean	Std. Err.	95% Conf. Interval	

Average Underpricing	.0469534	.0112829	.0246827	.0692241
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*Table 5: Mean of average underpricing for the part of the sample where QE is not present*

<b>Without Quantitative Easing</b>				
Mean estimation	Number of observations:			1,034
	Mean	Std. Err.	95% Conf. Interval	
Average Underpricing	.0713423	.0064365	.0587122	.0839723

As said before we have set the minimum size of the deviation to count as QE to 3 %, smaller deviations than that are treated as noise and excluded. This renders us with 173 observations of QE. The mean underpricing of these observations is roughly 4,7 %, while the underpricing for the 1034 other observations is higher, around 7,1 %, but not significantly so. As a result no clear conclusions can be drawn from this.

To get a better overview we can finally also look at the mean underpricing in each country over the whole sample.

*Table 6: Mean of average underpricing for each country*

<b>Summary of Average Underpricing</b>			
Country	Mean	Std. Dev.	Freq.
Australia	.08682427	.09686085	68
Canada	.0109476	.03315977	68
Chile	.03038267	.1438376	68

China	.6030424	.58425119	68
Denmark	.02036813	.08212614	68
Finland	.01560407	.04816019	68
France	.03426934	.09062681	68
Germany	.01799699	.10251403	68
Indonesia	.21114209	.20445218	68
Israel	-.03523999	.19874166	68
Italy	.05834313	.11014969	68
Japan	.61164773	.41184952	68
Mexico	.01890928	.06141881	68
New Zealand	.02855033	.08877047	68
Norway	.03512079	.17998026	68
Poland	.08792638	.14190243	68
Russia	.41919381	3.3927026	68
South Africa	.05846339	.11319724	68
Sweden	.01268847	.06353612	68
Switzerland	.03637463	.06656464	68
United Kingdom	.11707079	.20273601	68
United States	.05028609	.03620016	68

As we can see here the underpricing is very low for countries that have adopted any type of NIRP or QE, maybe with the exception of UK whom have an average underpricing of 11.7%. Countries with higher interest rates such as China or Indonesia have higher underpricing premiums, which is exactly what we expect to find in accordance to existing literature. We also

note that Israel stands out as the only country with a negative mean underpricing. Regarding countries who have used NIRP and QE we see no real clear pattern.

## 4.2 Results of regressions

As mentioned in the method we run a number of regressions to evaluate the effect of NIRP and QE on IPO underpricing. The first regression is the regression where interest rate is the only explanatory variable for IPO underpricing.

*Regression table 1: Interest rates as only explanatory variable*

	(1)	(2)	(3)	(4)
	Reg1	Reg2	Reg3	Reg4
VARIABLES	Average return	Average return	Average return	Average return
Interest rate	0.491 (0.920)	-4.913** (2.037)	-1.126 (4.258)	0.0275 (0.654)
Constant	0.142*** (0.0409)	0.534* (0.292)	0.283 (0.484)	-0.0369 (0.0558)
Observations	1,048	1,048	472	576
R-squared	0.000	0.058	0.051	0.073
Number of Countries		22	22	22

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Regression      Explanation

model

- 1 OLS with Interest rate as explanatory variable
- 2 Fixed effects model with interest rate as explanatory variable
- 3 Fixed effects model using only sub-sample from 2001 to 2009
- 4 Fixed effects model using only sub-sample from 2009 to 2017

As we can see in regression 1 the coefficient for interest rate is slightly positive however the p-value of the coefficient is not very significant and the R-squared is zero, meaning that we explain basically nothing with the ordinary OLS model. However, it is not unreasonable, rather the opposite, to assume that the data experiences fixed and/or random effects. Therefore we performed a diagnostic test of the data, a Hausman test, which showed that the regression should be run with fixed effects both for entity and time and therefore rerun the regression with these effects taken into account.

The fixed effect model controlling for year and country specific effects renders us an estimation with a negative coefficient for the interest rate, see regression 2, which is rather remarkable and does not mirror previous research. The p-value of this regression is significant at the five percent level and naturally also a lot lower than the p-value from the regular OLS-regression. We also note that the R-square of this regression is a lot higher than in the regular OLS-regression.

In order to check the robustness of the result we also ran similar regressions as the one above on two different time samples, where the breaking point between the two samples is set to the 1st of January 2009, creating an estimation of the effect of interest rate on underpricing pre and post the banking crisis.

As we can see in regression 3 and 4 interest rate is insignificant for both subsamples and has a low r-square. This is the same as for the whole sample with the difference that the coefficient is

not significant and slightly lower r-square in the early period and slightly higher r-square in the later period. It is somewhat discouraging that the significance of the variable decreases that much by only dividing the sample up into two sub samples, since it indicates a somewhat spurious regression.

As a comparison we will also list mirroring regressions to those of the interest rate but with the Taylor deviation as the explanatory variable.

*Regression table 2: Taylor deviation as only explanatory variable*

	(5)	(6)	(7)	(8)
	Reg5	Reg6	Reg7	Reg8
VARIABLES	Average return	Average return	Average return	Average return
Taylor deviation	-0.351 (0.377)	0.961*** (0.353)	0.207 (0.703)	2.744*** (0.464)
Constant	0.0974*** (0.00861)	0.0763 (0.0513)	0.0725 (0.0586)	0.000822 (0.0593)
Observations	866	866	383	483
R-squared	0.001	0.116	0.135	0.138

Number of Countries	18	18	18
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Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Regression model	Explanation
5	OLS with Taylor deviation as explanatory variable
6	Fixed effects model with Taylor deviation as explanatory variable
7	Fixed effects model using only sub-sample from 2001 to 2009
8	Fixed effects model using only sub-sample from 2009 to 2017

The initial pooled regression of the Taylor deviation (regression 5) is quite similar to the interest rate pooled regression and leaves us without any significant results. Similarly, the model with fixed effects (regression 6) also resulted in somewhat better results, although considerably stronger than for the interest rate. The coefficient is positive and significant at the 1% level, meaning that an increased deviation leads to an increased underpricing. The r-squared is now also above 10%, which is starting to become decent for financial data.

Moving on to the two different time subsamples. Here we see that the results are actually significantly different between the two sub samples. When looking at only the sample period from 2009 and forward (regression 8) we notice that the coefficient value for Taylor deviation is a lot higher than for the whole sample. We can also note that the coefficient is more significant

and that the R-square is higher. For the sample period before 2009 (regression 7) we can note that the coefficient value is still positive but a lot lower and less significant than for the time period after 2009. This means that Taylor deviation holds some merit in explaining IPO underpricing after 2009 but not before. Since QE was implemented for systematic use for the first time in 2009, it is possible to argue that this is what actually affects underpricing, although it is not certain.

Moving on to the result of the regression on the more complete model where effects of both interest rate and deviations from the Taylor rule are accounted for improves our results even further. Here we also will introduce the macro and control variables.

*Regression table 3: Complete models, including control variables*

	(9)	(10)	(11)	(12)
	Reg9	Reg10	Reg11	Reg12
VARIABLES	Average return	Average return	Average return	Average return
Interest rate	1.560** (0.617)	1.697*** (0.620)	2.017** (0.880)	3.252** (1.439)
Taylor deviation	1.291*** (0.376)	1.760*** (0.452)	1.905*** (0.736)	3.970*** (1.061)
QE		-0.0416* (0.0227)	-0.0415* (0.0233)	-0.0229 (0.0275)
NIRP		0.0195 (0.0297)	0.0176 (0.0300)	-0.0281 (0.0292)
GDP growth			1.587	0.384



			(0.996)	(1.107)
S&P Global			0.842	0.188
			(0.742)	(0.298)
Inflation			-1.53e-05	-7.98e-05
			(6.13e-05)	(8.30e-05)
Size			6.07e-06	2.53e-06
			(1.93e-05)	(2.10e-05)
Constant	-0.0328	-0.0336	-0.000966	0.0189
	(0.0669)	(0.0668)	(0.0433)	(0.0403)
Observations	866	866	866	483
R-squared	0.123	0.127	0.130	0.156
Number of Countries	18	18	18	18

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Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Regression model	Explanation
9	Fixed effects model
10	Fixed effect model with dummy variables for negative interest rate and quantitative easing
11	Fixed effects with control variables
12	Fixed effects with control variables using only sub-sample from 2009 to 2017

As we can see the first specification (regression 9) it gives us a positive coefficient, instead of a negative, for the interest rate, which is inline with previous research. We also see that the coefficient for the Taylor deviation is positive and significant. This means that when interest rates are decreasing IPO underpricing is decreasing as well, but it also means that when central banks deviate positively from the Taylor rule the underpricing premium is also increasing. This is a somewhat surprising result, but could possibly be considered a consequence of an efficient market and different asymmetric underpricing models. Notable is also that the R-squared is not increasing a lot from the specification with only Taylor deviation, implying that both variables catches roughly the same variance in the sample. As a result it can be both unnecessary and misleading to include both factors in the same specification, although it is done in the rest of the regression above anyway.

To see whether or not NIRP or QE actually affects underpricing in itself we included a dummy for when interest rates are below zero and one for when we have a positive Taylor deviation larger than 3 %. As seen in regression 10, QE reduces the average underpricing while NIRP seems to increase it. However, the p-value for QE is significant at the 10 % level, which can be considered weakly significant, while the p-value of NIRP is far from significant. As a result we can conclude that QE has an effect on underpricing, while NIRP seems to not. This result also holds when running the regressions with one of the dummies included at a time, rendering us to conclude that while QE seems to have an impact on its own, NIRP captures the same variance in underpricing as the interest rates.

In order to enhance the model further we included different macro control variables. As we can see in regression 11 nothing really changes from the previous regression, interest rates and Taylor deviation are still significant under the 5 % level and QE is significant at the 10 % level. We can also conclude that none of the added variables have a significant coefficient, although this is not very relevant since they are only there for control. However, what is really surprising is that the size variable is not significant, which it should be in accordance to previous research. This can be due to the fact that we are using pseudo-panel data and that the strong correlation

between size and underpricing is therefore reduced, since a lot of the variance disappears due to the usage of average calculations of underpricing and not firm specific.

The last regression is the same as the previous one but only for the later time-period sub-sample. As we can see there are some differences here. The r-squared increases while the QE variable becomes insignificant, rendering us to conclude what we already know, that Taylor deviations have a stronger impact on the later sub-sample than on the previous one.

As said we also run our regression on underpricing weighted with the number of IPOs in each country quarter. The results follows below:

*Regression table 4: Complete models including control variable regressed on number of IPO adjusted underpricing*

	(13)	(14)	(15)	(16)
	Reg13	Reg14	Reg15	Reg16
VARIABLES	Weighted return	Weighted return	Weighted return	Weighted return
Interest rate	-0.00105 (0.0174)	0.00443 (0.0175)	0.00123 (0.0248)	0.0650** (0.0302)
Taylor deviation	0.0209** (0.0106)	0.0380*** (0.0127)	0.0326 (0.0207)	0.0629*** (0.0223)
QE		-0.00146** (0.000638)	-0.00154** (0.000656)	-0.000584 (0.000576)
NIRP		0.00156* (0.000838)	0.00156* (0.000845)	0.000153 (0.000613)
GDP growth			0.0267	0.0179

			(0.0281)	(0.0232)
S&P Global			-0.00783	0.00353
			(0.0209)	(0.00626)
Inflation			5.83e-07	-1.07e-06
			(1.73e-06)	(1.74e-06)
Size			-1.01e-07	-5.11e-08
			(5.43e-07)	(4.40e-07)
Constant	0.00111	0.00106	0.000254	-0.000339
	(0.00189)	(0.00188)	(0.00122)	(0.000846)
Observations	866	866	866	483
R-squared	0.132	0.141	0.142	0.140
Number of Countries	18	18	18	18

---

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Regression model	Explanation
13	Fixed effects model
14	Fixed effect model with dummy variables for negative interest rate and quantitative easing
15	Fixed effects with control variables
16	Fixed effects with control variables using only sub-sample from 2009 to 2017

As we can see the results does not differ a lot compared to our previous results, except from that Taylor deviations actually becomes insignificant in the regression for the whole sample that includes all the control variables. We also see that the r-square is fairly stable, both here and in the model with equally weighted underpricing, rendering us to conclude that including all our explanatory variables is fairly unnecessary and that the model could be suffering from multicollinearity. We therefore check for correlation within our explanatory variables, excluding the control variables.

*Table 7: Correlation matrix between explanatory variables*

	Taylor deviation	QE	Interest rate	NIRP
Taylor deviation	1.0000			
QE	0.5888	1.0000		
Interest rate	-0.3054	-0.0829	1.0000	
NIRP	0.0576	0.0131	-0.3283	1.0000

The table shows the correlation between our different explanatory variables, excluding control variables. As we see here only Taylor deviation and QE actually exhibits semi-strong correlation with each other and there is therefore a possibility that it would be unwise to use them in the same specification, since it could then suffer from multicollinearity.

*Regression table 5: Complete models without either Taylor deviation or QE*

	(17)	(18)
VARIABLES	Reg13	Reg14
	Average return	Average return

Interest rate	0.411	2.124**
	(0.627)	(0.880)
Taylor deviation		1.690**
		(0.727)
QE	-0.0316	
	(0.0230)	
NIRP	0.0135	0.0129
	(0.0300)	(0.0299)
GDP growth	1.752*	1.479
	(0.997)	(0.995)
S&P Global	0.792	0.909
	(0.744)	(0.742)
Inflation	0.000110***	-3.86e-05
	(3.78e-05)	(6.00e-05)
Size	6.16e-06	8.26e-06
	(1.93e-05)	(1.92e-05)
Constant	-0.00212	0.00649
	(0.0435)	(0.0432)
Observations	866	866
R-squared	0.123	0.127
Number of Countries	18	18

---

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Regression model	Explanation
17	Fixed effects with control variables (Taylor Deviation excluded)
18	Fixed effects with control variables (QE excluded)

As we see on the regression above Taylor deviation is significant without QE but the opposite is not true. This renders us to conclude that the significance of the Taylor deviation is robust but QE significance could be a result of multicollinearity.

## 5. Discussion

### 5.1 Interest rates & NIRP

Although the results from our research is a bit inconclusive there are some interesting results. Firstly we can conclude what previous research has already established. We see a clear positive correlation between interest rate and underpricing (see regression 3). This can be due to one out of two different reasons. Firstly, higher interest rates might create an expectation on higher return for other assets as well, as has been argued before (Fung and Che, 2009). Secondly, lower interest rates enables less profitable firms to find capital for their IPOs since it increases the capital supply to the market. As we have argued before in this paper we think that there might exist such a relationship, and the fact that lower interest rates leads to lower underpricing somewhat strengthens this argumentation even though there exists another explanation. Irrespective of the reason as to why interest rates affects underpricing we can state that it is a factor that affects the underpricing premium of IPOs.

Unfortunately the same cannot be said regarding NIRP. Through all the different models we tested we only twiced managed to see a significant result of NIRP impact on underpricing. This in the regression where underpricing is weighted against the number of observed IPOs in the quarter. However, since interest rates here loses its significance it can be assumed that this is

instead captured by the NIRP variable (see regression 4). Therefore we cannot conclude that NIRP has any specific effect on IPO underpricing, regardless of if it is due to a lack of observations, 81 observations are quite few, or if there truly is no effect. However, since we have proved that interest rates are positively correlated with underpricing we can say that a lower interest rate automatically leads to a lower degree of IPO underpricing. As a result NIRP in itself might not affect underpricing but they do so indirectly, as lower interest rates means lower underpricing.

It is therefore possible to argue that interest rates and NIRP indeed affects underpricing negatively and therefore also have an impact on the whole IPO market. Depending on the reason as to why interest rates and underpricing is correlated the impact may be in different ways. Firstly, if the decreased underpricing is due to a decreased demand for return due to lower rates, i.e. interest rates shifts underpricing by affecting investors expectation on return, nothing particular will happen to the IPO market, since it is only a market adjustment.

However, if the decreased underpricing is due to an increased number of bad IPOs on the market, due to increased capital supply to the market, the profitability of the IPO market has decreased. If this is true and the arguments behind the winner's curse underpricing model holds some merit, uninformed investors would start losing money on average when investing in IPOs. This is of course not sustainable and left unchecked it could severely harm the whole IPO market. Less informed investors will stop buying IPOs and thus less capital will be available to the market. Another negative impact of decreased underpricing due to an increased amount of bad IPOs would be worse conditions for underwriters to collect reliable information in accordance to the information revealing theory, since rewarding firms with underpricing will be harder for the underwriters. However, since we cannot be sure on what drives the decrease in underpricing we do not know if anything bad has happened.

## 5.2 Taylor deviation & QE

The picture becomes a bit clearer if we take the results from the specification regarding Taylor deviation and QE into account. As we can see from our regressions underpricing is positively



correlated with Taylor deviation and the correlation is also significantly stronger during the later part of our sample(see regression 6,7,8 and 11). Comparing Taylor deviation and interest rates as an explanatory variable for underpricing, we actually see that Taylor deviation holds more merit than the interest rate in explaining underpricing. In other words, models with only Taylor deviations explains more of the variation in underpricing than models with only interest rate. In fact Taylor deviation on its own holds a higher degree of explaining underpricing after 2009 than the combined model has for the whole sample. This may be because Taylor deviation captures the abnormal rates that render the market with a surplus or shortage of cash, while interest rates does not make this distinction. Another way to look at this is that Taylor deviation, in contrast to interest rates, also captures the state of the economy. Meaning for example that when interest rates are low even though economic outlooks are good Taylor deviations captures this and the underpricing increases.

This is an interesting result indicating that interest rates on their own don't have the most significant impact on underpricing, but when the net effect of interest rates and other economic circumstances are considered, the effect of interest rates on underpricing becomes more decipherable. In addition, since the r-squared does not improve a lot from when underpricing is only explained through Taylor deviation compared to a combined model we concluded that the different variables captures roughly the same variation in underpricing (see regression 2 & 3).

As a result it seems like deviation from optimal capital injections in the market (Taylor deviations), rather than interest rate returns, are the factor affecting underpricing. As far as we know this is a new discovery. No one has before proved a relationship between deviations from the Taylor rule and underpricing and it is thus an important step forward in understanding what drives underpricing. In addition, since it captures roughly the same variation in underpricing as interest rates it seems likely that interest rates is mainly affecting underpricing by capital injections in the market and not by creating differences in demand for return, which has previously been argued. Consequently, interest rates is not a direct institutional factor that affects underpricing, it is rather affecting the underlying conditions of the asymmetric models by capital injections, since the amount of capital available can be argued to determine the amount of bad

IPOs. In accordance with the argumentation above regarding interest rates and NIRPs effect on underpricing we can also see that NIRP can be harmful for the IPO market.

Moving onwards we also need to explain the positive correlation between Taylor deviation and underpricing. There are a number of different possible explanations to this. Firstly the positive, or negative, difference from optimal central bank capital stimulus that the deviation entitles affects the capital supply in the overall market by increasing (decreasing) lending volumes (Darmouni & Rodnyansky, 2017). An increase or decrease in capital to the market can as already argued affect the number of bad IPOs and thus change the conditions for the asymmetric underpricing hypotheses. Following the argumentation done before in this paper, taken in consideration that Taylor deviations are positively correlated with underpricing, we can see that the alteration in asymmetry conditions works in one out of two ways.

The first would be that more capital indeed increases the amount of bad firms on the market. However, if the market is efficient it would immediately incorporate this information and the stakeholder would adjust the underpricing premium on the firms that are able to afford this upwards, as a compensation for the greater risk of ending up with a bad IPO (Rock, 1986). It is also possible that in accordance with the signaling hypothesis profitable firms increases their underpricing in order to signal that they are good investment in a market where bad investments increases. As a result the average underpricing premium would increase when a country experiences a positive deviation from the Taylor rule and vice versa.

Secondly, the increased lending volumes could instead of creating an overall greater and cheaper capital supply only create a decrease in lending costs, not enabling more capital to all kinds of investors. This would create a shift from equity to debt as the preferred way of raising capital for firms. In turn, this would decrease the amount of firms going public, since they would instead finance themselves through debt. This is of course dependent on the reason for going public, the most common reason being to raise capital but it could also be the case that the decision to go public is based on initial investors wanting to take home their investment/return. Anyway, arguing similar as we did above, but in the other direction, this would mean a decrease in amount of bad IPOs. Assuming that the market is not truly efficient this would render the market with an

increase in underpricing premia, since underwriters in an inefficient market would take time to adjust to the new conditions. Meaning that in accordance to the winner's curse underwriters would not lower the amount of underpricing swiftly enough to compensate for the decrease in bad firms and a similar argument can be made for the signaling hypothesis.

As a result one could argue that the alteration in the asymmetry conditions has two possible explanations and in order to distinguish the most plausible one, a market efficiency test could be done. Although this falls outside the scope of this paper, but would be interesting as a continuing experiment, we nonetheless dare to argue that the most plausible explanation is the second one, since a fully efficient market is very unlikely. Therefore we argue that underpricing is increasing with an increased Taylor deviation as a result of a market inefficiency in the asymmetric underpricing models.

This also goes in hand with what we find when checking the results for how quantitative easing is affecting the underpricing premia, since we see that QE has a reversed connection towards underpricing compared to the Taylor deviation. This is fairly interesting since we use large positive Taylor deviation as a proxy for QE and thus it should logically have the same sign as the Taylor deviation, especially since we could suspect it to be suffering of multicollinearity. A possible reason to this could be that as the positive deviation gets bigger the capital injections to the market also increases. If the increase in capital is large enough the effect might start to spill over from only debt subsidization to an overall decrease in financing costs. This would start reversing the effect of the initial impact of the Taylor deviation and render equity a more tempting way of raising capital again. As argued before, this would enable less profitable firms to raise capital through IPOs, since more capital in the sector means less cautious investors. This is similar to the results of Claessens, Kose, and Terrones (2012) who showed that the risk taking of banks has increased with NIRP and QE.

Following similar argumentations as has been conducted before in this paper this would lead to an increase in bad IPOs and therefore a decrease in underpricing since underwriters will not incorporate the information efficiently. As a result QE can have the opposite sign of Taylor deviation and still be significant. In conclusion we can see that Taylor deviations are positively

correlated with IPO underpricing, while large positive deviations, i.e QE, are negatively correlated, due to their different impact on capital flow to investors, although not to big conclusion should be drawn here since the significance of QE could be a result of multicollinearity.

Especially since there are also other possible explanation as to the positive correlation between Taylor deviation and underpricing. For example NIRP and QE has been proved to lead to a booming stock market, i.e. that the returns on stock markets has increased, by Bordo and Landon-Lane (2013). In regard to the stylised fact that underpricing is pro-cyclical (Rydqvist, 2007) this means that the positive correlation between underpricing and QE can simply be a result of this. The different QE policies adopted by central banks booms the stock market which in its turn has been proven to create higher underpricing. As a result we consider it to be possible that the Taylor deviation has not only affected the returns of the stock market in general but also the first day return of initial public offerings.

This argumentation is somewhat flawed by the fact that it lacks a logical explanation as to why large positive deviations, i.e QE, decreases underpricing instead of increasing it. There is no evidence implying that the boom on the stock market should be decreasing with larger degrees of QE. Nor has it been argued that the cyclical effect on underpricing should be diminishing in larger market booms. As a result, underpricing should keep increasing even under large Taylor deviations for this to be true, which it seems to do not, rendering the whole explanation faulty. Although, this yet again depends on if QE significance is solely a result of multicollinearity or not.

Another interesting result we found is that the relationship between average underpricing and the deviation from the Taylor rule mostly holds for the period after 2009. Why this relationship is so much stronger after the financial crisis is something that would be interesting to evaluate further. A hypothesis to why this relationship has changed is that after the financial crisis the financial market faced a lot of regulatory changes. These regulatory changes might have affected how capital flows through the market and what types of investments investors seek. Another explanation could be that central banks to a large degree have changed the way they make their

policies. Quantitative easing simply hasn't had the type of presence before as it does now. The case could also be that the market has learned more about itself after the financial crisis and has simply changed the way it interprets, and reacts to, monetary policy.

What is troublesome with these findings are that they indicate that the correlation between underpricing and Taylor deviations have become stronger after QE has been implemented. This is somewhat confusing since we have found that QE has the opposite effect on underpricing and should therefore dilute the correlation. As a result we have either used a poor proxy for QE, large positive deviation might exclude more actions of actual QE than we thought, multicollinearity might create confusing results or other event with stronger counter effects have occurred. Both are fairly plausible and are of course an impairment to our research, since it either means we are missing some large structural change or are measuring the effects of QE poorly. Nonetheless we can for certain claim that Taylor deviations, which are inherently correlated to QE, affect underpricing and therefore the results still hold some merit.

### 5.3 Conclusions

The findings of this paper comes down to mainly three different things. Firstly, it proves that interest rates are positively related towards IPO underpricing, although probably not for previously thought reasons. Instead of affecting investors view of expected return, changes in the interest rates are likely to affect underpricing mostly through the changes in capital supply that these changes implies. It also therefore questionable if interest rates should be seen as an institutional explanation to underpricing, or as something affecting the different asymmetric explanation models and only indirectly affects underpricing.

The second finding is that Taylor deviation explains more of a firm's underpricing than interest rates does. We also claim that it is a better explanatory variable than interest rate, since they capture more or less the same thing. It is for this reason that we argue that interest rates mainly affect underpricing through changes in capital supply, since Taylor deviation measures excess or shortfalls in capital injection to the market. This means that underpricing is affected by the cash supply in the market and we argue that this has to do with that the cash supply decides the

amount of bad firms going public, which affects underpricing through different asymmetric models. It is also notable that this effect reverses with large positive Taylor deviations. We also found that this relationship has proven to hold better for the period 2009-2017 than for the period 2001-2009.

The third and final finding of this paper is that NIRP has as far as we can see not had any own effect on the underpricing premium. QE on the other hand seems to be negatively correlated with underpricing, meaning that when QE is applied underpricing in the markets decrease. We believe that this yet again can be explained by the changes in the capital flow to the market and the impacts this has on the asymmetric explanation models. Although, there is a risk that the impact of QE on underpricing is just a result of collinearity with Taylor deviation. Nonetheless both NIRP and QE are inherently connected to interest rates and Taylor deviations and since they affect underpricing NIRP and QE at least indirectly affect underpricing as well.

In order to further advance this research it would be interesting to look at how pure capital flow to the markets would affect underpricing. If it would be possible to find a measurement for available capital to the market and regress that on underpricing our argumentation of capital flows being the true variable affecting underpricing could be tested. Further on extending the research to include more developing economies would also increase the usage of the results.

All in all, we have found that both interest rates and Taylor deviations affects IPO underpricing, probably through impacts on the capital supply to the market, but that Taylor deviation is a better explanatory variable for underpricing. In addition we see some weak connections between QE and underpricing, but can not prove any connection between NIRP and IPO underpricing.

## References:

- Arteta, C. Kose, M. Stocker, M. & Taskin, T. (2018) Implications of Negative Interest Rate Policies: An Early Assessment *Pacific Economic Review* 2018;23 pp 8-26
- Benveniste, L. & Wilhelm, W. (1990) A comparative analysis of IPO proceeds under alternative regulatory environments *Journal of Financial Economics* pp 173-207
- Bordo, M. D., & Landon-Lane, J. (2013). *Does expansionary monetary policy cause asset price booms; some historical and empirical evidence* (No. w19585). National Bureau of Economic Research.
- Brooks, C (2014): *Introductory Econometrics for Finance*, third edition, Cambridge University Press
- Buckland, R. Herbert, P. J. Yeomans, K.A. (1981) Price discount on new equity issues in the UK and their relationship to investor subscription in the period 1965–75. *Journal of Business and Accounting*, 8 (Spring) , pp. 79-96
- Claessens, S. Kose, M & Terrones, M (2012) How do Business and Financial Cycle Interact? *Journal of International Economics* 89 pp 178-190
- Cornelli, F. & Goldreich (2001) Bookbuilding and Strategic Allocation *The Journal of Finance* Vol 56, NO 6 pp 2337-2369
- Darmouni, O.M. & Rodnyansky, A. (2017); The Effects of Quantitative Easing on Bank Lending Behavior, *The Review of Financial Studies*, Volume 30, Issue 11, 1 November 2017, Pages 3858–3887
- Francis, B., Hasan, I., Lothian, J., & Sun, X. (2010). The Signaling Hypothesis Revisited: Evidence from Foreign IPOs. *The Journal of Financial and Quantitative Analysis*, 45(1), 81-106. Retrieved from
- Fung, J. K., & Che, S. (2009). Initial day return and underpricing cost in advance payment initial public offerings. *Hong Kong Institute for Monetary Research*.
- Hameed, A. & Rose, A. (2018) Exchange rate behavior with negative interest rates: some early negative observations *Pacific Economic Review* 2018;23 pp 27-42
- Hughes, P. & Thakor, A (1992) Litigation Risk, Intermediation and the Underpricing of Initial Price Offerings *The Review of Financial Studies*, Vol 5, Nr 4 pp 709-742

- Ibbotson, R. G. (1975). Price performance of common stock new issues. *Journal of financial economics*, 2(3), 235-272.
- Jennkinson, T. & Jones, H. (2004) Bids and Allocation in European IPO Bookbuilding *The Journal of Finance* Vol 59, NO 5 pp 2309-2338
- Jobst, A., & Lin, H. (2016). Negative Interest Rate Policy (NIRP): Implications for Monetary Transmission and Bank Profitability in the Euro Area. *International Monetary Fund*.
- Koh, F., & Walter, T. (1989). A direct test of Rock's model of the pricing of unseasoned issues. *Journal of Financial Economics*, 23(2), 251-272.
- Levis, M. (1990). The winner's curse problem, interest costs and the underpricing of initial public offerings. *The Economic Journal*, 100(399), 76-89.
- Ljungqvist, A. (2007). IPO underpricing. *Handbook of corporate finance: Empirical corporate finance*, 1, 375-422.
- Loughran, T., & Ritter, J. (2004). Why has IPO underpricing changed over time?. *Financial management*, 5-37.
- Loughran, T. Ritter, J. & Rydqvist, K. (1994) Initial Public Offerings: International Insights *Pacific-Basin Finance Journal* 2 pp 165-199
- Loughran, T., & Ritter, J. (2004). Why Has IPO Underpricing Changed over Time? *Financial Management*, 33(3), 5-37.
- Nikolsko-Rzhevskyy, A., & Papell, D. H. (2013). Taylor's rule versus Taylor rules. *International Finance*, 16(1), 71-93.
- Ritter, J. (1984) The "Hot Issue" Market of 1980. *The Journal of Business* , Vol 57, Nr 2, 215-240
- Ritter, J. (2018). Initial Public Offerings: Updated Statistics [pdf] Available at: [https://site.warrington.ufl.edu/ritter/files/2018/01/IPOs2017Statistics\\_January17\\_2018.pdf](https://site.warrington.ufl.edu/ritter/files/2018/01/IPOs2017Statistics_January17_2018.pdf) [Accessed: 15 april 2018]
- Rock, K. (1986). Why new issues are underpriced. *Journal of financial economics*, 15(1-2), 187-212.
- Rydqvist, K. (1997) IPO underpricing as tax efficient compensation. *Journal of Banking and Finance* 21 pp 295-313



Taylor, J. B. (1993, December). Discretion versus policy rules in practice. In Carnegie-Rochester conference series on public policy (Vol. 39, pp. 195-214). North-Holland.

Tran, A. & Jeon, B. (2011). The dynamic impact of macroeconomic factors on initial public offerings: evidence from time-series analysis. *Applied Economics*, 43(23), pp. 3187-3201.

## Appendix:

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## 2. List of regressions

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  - 2 Fixed effects model with interest rate as explanatory variable
  - 3 Fixed effects model using only sub-sample from 2001 to 2009
  - 4 Fixed effects model using only sub-sample from 2009 to 2017
  - 5 OLS with Taylor deviation as explanatory variable
  - 6 Fixed effects model with Taylor deviation as explanatory variable
  - 7 Fixed effects model using only sub-sample from 2001 to 2009
  - 8 Fixed effects model using only sub-sample from 2009 to 2017
  - 9 Fixed effects model
  - 10 Fixed effect model with dummy variables for negative interest rate and quantitative easing
  - 11 Fixed effects with control variables
  - 12 Fixed effects with control variables using only sub-sample from 2009 to 2017
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  - 14 Fixed effect model with dummy variables for negative interest rate and quantitative easing
  - 15 Fixed effects with control variables
  - 16 Fixed effects with control variables using only sub-sample from 2009 to 2017
  - 17 Fixed effects with control variables (Taylor Deviation excluded)
  - 18 Fixed effects with control variables (QE excluded)

### 3. List of Countries

1. Australia
2. Canada
3. Chile
4. China
5. Denmark
6. Finland
7. France
8. Germany
9. Indonesia
10. Israel
11. Italy
12. Japan
13. Mexico
14. New Zealand
15. Norway
16. Poland
17. Russia
18. South Africa
19. Sweden
20. Switzerland
21. United Kingdom
22. United States

#### 4. List of Databases Used

BLOOMBERG

OECD.stat

Datastream