Master Thesis

Estimating the impact of Unexpected Federal Open Market Committee Policy Shocks on Factor Returns

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Preface

It was September 2015 when I became interested in the discussion surrounding the rate hiking path which the Federal Reserve of America wished to embark upon. I was intrigued by the importance attributed to the first rate hike in more than a decade by the financial markets and the media. This historical moment eventually occurred on December the 16th of 2015. I had primarily witnessed expansionary monetary policies in the time span where I studied the field of Economics. The proposition by the Federal Reserve of America to keep the assets which it purchased in the aftermath of the Global financial crisis on its balance sheet whilst normalizing interest rates, a combination of conventional and unconventional monetary policy, fed my curiosity. I became especially interested in the impact of these policies on stock prices.

I therefore wanted to do research within this field, and De Nederandsche Bank (DNB - the Dutch Central Bank) offered me this opportunity. At this institution I could contribute directly with my research. At DNB, I pursued my interest to find out more on the topic by delving into previous research and by discussing the issue with my supervisor Jakob de Haan (Head of Research at DNB) as well as other colleagues at the Research Department. On the basis of various different researches done by previous academics, and through collecting different ideas from colleagues at DNB I was able to develop a model which can be employed to explain the relationship between factor returns and unexpected monetary policy changes.

During this endeavour I received support from several persons. I would therefore like to use this opportunity to thank them. I would like to thank both Roy Kouwenberg and Jakob de Haan for their supervision, their time, their advice and the learning process which they helped me through. I would like to thank my family for their encouragement and helping me to reach this point.

Executive Summary

This study investigates how returns on size, value and momentum factor portfolios constructed with stocks listed on the NASDAQ, AMEX and NYSE are influenced by the Federal Reserve's monetary policy shocks in the 1994-2016 period. The VAR framework contains macroeconomic variables, the Overnight rate, factor returns, and it is extended so that it can respond to unconventional monetary policy shocks. The VAR model also includes forward looking proxies such as the Federal funds futures which allows for the inclusion of the market's expectations with respect to future monetary policy and therefore monetary policy shocks in the VAR framework by definition 'unexpected'. Risk aversion is also included in the model through the VIX to control for crisis years. The results for the conventional monetary period (1994 – 2009) indicate that the earnings to price and the dividend to price value factors react negatively to unexpected monetary policy shocks, these effects are found to be temporary. The momentum anomaly reacts positively and permanently to an unexpected positive conventional monetary policy shock, therefore evidence is found for the excess sensitivity channel during the conventional monetary policy period. The results for the nonconventional monetary period (2009 – 2016) manifest that past winner stocks, growth stocks and large capitalization stocks benefited disproportionately more from a negative unexpected monetary policy shocks. Hereby showing that the credit channel and the risk premium channel of monetary transmission are inactive during the unconventional monetary policy period. Furthermore this research shows that the forward looking proxies for monetary policy shocks: the one-month ahead Federal funds futures and the yield curve (spread between 10-year treasury rates and the Federal funds rate) are better specifications for monetary policy shocks as compared to the Overnight rate. The latter is the proxy which has been used predominantly in VAR models studying factor returns with respect to monetary policy.

Keywords: conventional monetary policy, unconventional monetary policy, factor returns, market risk premium

JEL Classification Codes: E44, E52, E58, G12

Contents

1. Introduction

On December the 16th 2015 the highly anticipated rate hike by the Federal Open Market Committee (FOMC) was witnessed. The interest rate normalization program is expected to continue into 2016, and is aimed at moving away from the Zero Interest Rate Policy (ZIRP) which the Federal Reserve of America embarked upon since the Great Recession. The ZIRP era saw different unconventional monetary policy measures being introduced such as Quantitative Easing (QE) and Operation Twist. Prior to the Great Recession the Federal Reserve of America primarily engaged in conventional monetary policy. Monetary policy by the Federal Reserve is manifested to be a risk factor in US equity markets (see for example Jensen et al., 1996; Thorbecke, 1997; Rigobon & Sack, 2004; Bernanke & Kuttner, 2005; Maio, 2013). A risk factor influences the market excess return (the market risk premium) which is the return that the stock market provides in excess of the risk-free rate. These studies document the negative effect of rate hiking on market excess returns. Bernanke and Kuttner (2005) conclude that:

"Further exploration of the link between monetary policy and the excess return on equities is an intriguing topic for future research."

This paper extends upon the above papers by concentrating on the impact of conventional and unconventional monetary policies on the cross-section of stock returns. Therefore, in response to this quotation I introduce the following research question:

How do the size, value and momentum factor returns based on stock portfolios from the AMEX, NASDAQ and NYSE respond to the FOMC's policy shocks during the 1994-2016 timespan?

This question allows to analyze the impact of the Federal Reserve's policies on stocks with different characteristics. Furthermore it allows to look into the presence and the working of monetary policy transmission channels (e.g. the risk premium channel, the balance sheet channel and the bank lending channel) as discussed by Bernanke and Gertler (1995). Some channels are proven to be (in)active depending on the monetary policy and the time period (Bernanke and Kuttner, 2005). For example, research by Kontonikas and Kostakis (2013) indicates that monetary policy has ceased to be a risk factor in their second subsample ranging from 1984 to 2007. To the contrary, work by Maio (2013) indicates that the monetary transmission channel is indeed present during a similar timeframe. Therefore the academic debate has room for additional insights. Furthermore these insights could provide interesting feedback to policy makers (e.g. the Federal Reserve) and to institutions investing in factor portfolios (e.g. mutual, sovereign and pension funds).

To provide an answer to this topic question, this study utilizes a Vector Auto Regressive (VAR) model which combines macroeconomic variables with monetary variables and the factor portfolio returns. The model is inspired by the model employed by Kontonikas & Kostakis (2013) and is adapted to include risk aversion (to account for crises), forward-looking measures (as to include market participant expectations), and unconventional monetary policies. Monetary policy shocks are measured through changes in the proxies for monetary policy: the Overnight rate, the Shadow rate (Wu & Xia, 2014), the Federal funds futures and the spread between 10-year treasury rates and the Federal funds rate. This paper then focusses on the impact of these shocks on the factor portfolio returns. The 1994-2016 sample range is used as it covers both the conventional and unconventional monetary policy eras. 1994 is taken as a starting point for the sample because the Federal Reserve became more transparent in it communication of future monetary policy (Maio, 2013).

The paper finds that during the conventional subsample (1994 – 2009) the momentum anomaly enjoys a positive and permanent return in response to an unexpected increase in a conventional monetary policy shock. This provides support for the excess sensitivity channel during the conventional monetary policy period (Bernanke and Kuttner, 2005). The value factors as measured through the earnings to price and the dividend to price ratios respond negatively to unexpected monetary policy shocks. Since these effects are temporary, the credit channel is shown to be inactive which is in line with the findings by Kontonikas and Kostakis (2013). The results for the unconventional monetary period (2009 – 2016) manifest that past outperformers, growth stocks and large capitalization stocks performed better in response to an unexpected negative monetary policy shock. Hereby showing that the credit channel and the risk premium channel of monetary transmission are inactive during the unconventional monetary policy period. These findings contribute to the body of research on the impact of (un)conventional monetary policy on the cross-section of stock returns. Furthermore this paper shows that forward looking proxies for monetary policy: the one-month ahead Federal funds futures and the spread between 10-year treasury rates and the Federal funds rate are good specifications for unexpected monetary policy shocks as significant factor return impulse responses are found on the basis of shocks in these proxies. These findings contribute to the discussion in Rudebusch (1998) where valid proxies for monetary policy are discussed with respect to VAR frameworks.

The paper will commence with a look into past studies to establish the relevance of the research as well as a look into studies which provide insights into the VAR model which will be employed for the estimation of impulse responses of the factor portfolio returns. The VAR framework is then be presented in the methodology section. In the results each factor return proxy will be discussed, finalizing with a conclusion and recommendations.

2. Literature Review

2.1 Monetary policy as a risk factor

The equity risk premium, or the market excess return, is the return that the stock market provides in excess of the risk-free rate (1-month treasury bills). The level of the equity risk premium is directly influenced by risk factors, a risk factor is a variable that increases risk/volatility. Monetary policy is indicated to be a risk factor which influences excess returns in equities (Bernanke & Kuttner, 2005). These authors argue that the effect of monetary policy on stock markets is present, however that it is responsible for only a minor portion of total stock price variation. Bernanke and Kuttner (2005) find that the reaction of stock prices to FOMC statements cannot in its entirety be attributed to conventional monetary policy's effects. Alternatively, the effect of monetary policy statements on equities comes from a combination of expectations in relation to future excess returns and future dividends. Therefore tighter monetary policies (or the expectation thereof) can increase the riskiness of stocks, negatively impacting stock prices due to an increase in the expected equity risk premium. In essence, the discount rate employed in the dividend discount model influences the stock price of a company. This is *the risk premium channel* of monetary shock transmission of monetary policy to stock markets. Other explanations are also offered as to explain the returns related to FOMC policy such as market overreaction and market over-sensitivity. The paper by Jensen, Mercer and Johnson (1996) also indicate that the monetary environment is crucial in determining expected asset returns. Their research is based on the Fama and French (1989) model which looks into expected returns on stocks and bonds and links their returns to business cycles. Jensen et al. (1996) extend this analysis by including monetary policy and find that the results found in Fama and French (1989) vary significantly as a consequence. Thorbecke's (1997) looks into the Fed funds rate specifically, and also applies an event study where each event is defined as a Federal Reserve policy change. As a preliminary hypothesis, to confirm the results that monetary tightening negatively impacts stock market returns, the following is proposed:

H01a: The market excess return reacts negatively to contractionary monetary policy shocks

H01b: The S&P500 return reacts negatively to contractionary monetary policy shocks

Asides from the risk premium channel as discussed by Bernanke and Kuttner (2005), monetary policy negatively impacts stock markets due to *the credit channel* too. The first pillar of this channel is *the balance sheet channel*. The balance sheet channel theorizes that large capitalization firms and growth firms are less risky to lend to and therefore have cheaper and easier access to credit as compared to their smaller sized peers. Furthermore the channel expects that an increase in interest rates will increase interest payments on debt outstanding, and that a firm's assets decline in value due to net discounted value (Walsh, 2003). The second pillar of the credit channel is *the bank lending channel*. This channel indicates that monetary policy tightening will tighten the credit provided by the banking system (Walsh, 2003). Therefore firms dependent upon the supply of credit, or firms with lower credit ratings are expected to be negatively impacted.

Related to the risk premium channel and the credit channel, it is documented that different factor stock portfolios have different exposures to monetary policy. To check for the presence of the credit transmission mechanism of monetary policy, value and size sorted portfolio returns should be compared across the lowest and highest deciles. Value portfolios are sorted upon book to market and earnings to price ratios for example. Size portfolios are sorted on market capitalization. From the theoretical foundation described by Walsh (2003), it is to be expected that monetary tightening would induce a larger decrease in returns of small sized companies and value companies as compared to large capitalization and growth companies. Owyong (2011) focusses on monetary cycles, and shows that value returns decline during rising interest rate cycles and increase during declining interest rate cycles. Arshanapalli et al. (2006) confirm that the size factor return and the value factor return are lower during restrictive monetary policy periods as compared to expansionary monetary policy cycles. In their study the size factor return is found to be close to zero during rate hiking cycles. Gertler and Gilchrist (1994) provide the theoretical framework for this occurrence, which is further documented in the empirical work done by Thorbecke and Coppock (1995). Thorbecke (1997) shows that monetary policy has a larger effect on small firms as compared to large firms:

H02: The return on the size factor (small minus big capitalization stocks) reacts negatively to contractionary monetary policy shocks.

Financially constrained stocks are more heavily influenced by increases in the Federal Funds Rate as compared to lesser financially constrained stocks (Thorbecke, 1997; Maio, 2013). Fama and French (1995) link value firms to distressed firms and therefore value firms are on average more likely to be credit constrained. This explains why the returns of value stocks are more responsive to rate hiking cycles. The same is shown with respect to the returns of small capitalization stocks relative to big capitalization stocks (Thorbecke, 1997; Maio, 2013). Additionally, Jensen and Mercer (2002) find that the size factor return, when isolated and when pooled in a model with value factor return and beta, only persists during interest rate cutting cycles. During rate hiking cycles this excess return is found to be insignificantly different from zero. Value can be decomposed into different proxies, this paper will look into the book to market ratio (B/M), cash flow to price ratio (CF/P), the earnings to price ratio (Earnings/P), and the dividend to price ratio (Div/P). Based on the findings by Fama and French (1995) and Jensen and Mercer (2002):

H03: The return on the value factor (value minus growth stocks) reacts negatively to contractionary monetary policy shocks:

> *H03a: The return on the value factor (high B/M stocks minus low B/M stocks) reacts negatively to contractionary monetary policy shocks,*
>
> *H03b: The return on the value factor (high CF/P stocks minus low CF/P stocks) reacts negatively to contractionary monetary policy shocks,*
>
> *H03c: The return on the value factor (high Earnings/P stocks minus low Earnings/P stocks) reacts negatively to contractionary monetary policy shocks,*
>
> *H03d: The return on the value factor (high Div/P minus low Div/P stocks) reacts negatively to contractionary monetary policy shocks.*

Using portfolios sorted on past performance (1-month, 2 to 12-months and 13 to 36-months) it is possible to study the market overreaction and market over-sensitivity to monetary policy changes that Bernanke and Kuttner (2005) reveal. Momentum returns tends to be a lot higher during rate hiking periods as compared to expansionary monetary policy periods (Arshanapalli et al., 2006). The full sample results by Kontonikas & Kostakis (2013) indicate that past losers are significantly more sensitive to monetary policy shocks. Lakonishok, Schleifer and Vishny (1994) indicate that investors overreact to good and bad news and this behavioral phenomenon might therefore explain the excess-sensitivity of past performers to monetary shocks:

H04: The return on the momentum factor (past outperformer minus loser stocks) reacts positively to contractionary monetary policy shocks:

> *H04a: The return on the Long Term Reversal momentum factor (13 to 36-months loser minus 13 to 36-months outperformer stocks) reacts negatively to contractionary monetary policy shocks,*
>
> *H04b: The return on the Short Term Reversal momentum factor (1-month loser minus 1-month outperformer stocks) reacts negatively to a contractionary monetary policy shocks,*
>
> *H04c: The return on the Momentum Anomaly factor (2 to 12-months outperformer minus 2 to 12-months loser stocks) reacts positively to contractionary monetary policy shocks.*

The hypotheses H01 through H04 are well-established within the conventional monetary policy era however due to the time-varying nature of the impact of monetary policy on stock markets, and due to the varying nature of the monetary policies themselves, these hypotheses are still very relevant for the period analysed in this study. Indeed the time-varying nature of the impact of monetary policy on stock markets has been documented in detail (Park & Ratti, 2000; Laopodis, 2010; Kontonikas & Kostakis, 2013). This time-varying relationship between monetary policy and stock market returns can be related to the hypothesis that some monetary policy transmission mechanisms might be inactive during certain time-spans (Bernanke and Kuttner, 2005). In the time-period which this paper examines there have been several different monetary policy regimes, with the most obvious regimes being conventional (1994-2009) and unconventional (2009-present). The unconventional monetary policy period saw several smaller regimes, the QE & Operation Twist period (November 2008 through May 2013), the era of "tapering" which consisted of the Federal Reserve scaling back its asset purchase programs (in June 2013 Bernanke first announced this intention, on which he only followed through in February 2014, asset purchases were finalized during October 2014 (Aizenman et al., 2014)), and the current policy cycle which is the rate normalization program (which was first announced in November 2014). Based on the diversity of monetary policies enacted over the period proposed in this study, the first four hypotheses are still academically interesting to explore. Little research has been performed on the impact of unconventional monetary policy by the Federal Reserve on factor portfolio returns during the post-2008 period. For example, Kontonikas & Kostakis (2013) end their sample period in 2008. Therefore each hypothesis H01 through H04 will be judged on the basis of the conventional monetary policy sample, the unconventional monetary policy cycle, and the entire sample period *separately*.

There are two studies which focus on stock returns in European markets and unconventional monetary policy. Fiordelisi et al. (2014) find no significant results for the 2007-2012 period. Haitsma et al. (2016) do find that unconventional monetary policy announcement surprises impact factor returns in the post-crisis period, through their daily event-study. The authors provide evidence for the presence of the credit channel of monetary policy during the unconventional monetary policy era. Their findings manifest that value, size, and momentum portfolio returns react similarly to conventional monetary surprises as to unconventional monetary surprises. According to the results by Haitsma et al. (2016), the four null hypotheses discussed above can be considered relevant over the conventional and unconventional monetary policy regimes for the entire sample period 1994-2016.

2.2 Conceptualization of the Macro-based VAR-Model

To check for the effect of monetary policy on financial variables vector autoregressive (VAR) models are often employed (Bernanke et al., 2004; Wright, 2012). The Methodology Section will introduce the vector autoregressive model which is aimed at providing indications on the movements of factor returns in response to unexpected shocks associated with FOMC policy over the 1994 – 2016 time period. These VARs are based on several combined methodologies, where the Kontonikas and Kostakis (2013) approach is taken as a reference point.

Kontonikas and Kostakis (2013) form the basis for the methodology to be proposed as they study factor portfolio returns in relation to monetary policy through a VAR framework. The authors apply a macro-based VAR framework on a monthly frequency over the time span 1967-2008, with the following endogenous variables: industrial production growth, consumer price index growth, commodity price index growth, changes in the Federal funds rate, the Strongin variable (the residual of non-borrowed reserves regressed on total reserves), and nominal returns on factor portfolios. The inclusion of macroeconomic variables in the endogenous factor is defended upon the grounds provided by Bernanke and Blinder (1992), they manifest the direct relationship between shocks in the Federal funds rate and changes in macroeconomic variables. The study by Kontonikas and Kostakis (2013) finds that over the entire sample period growth stocks, large capitalization stocks, and past winner stocks are significantly less vulnerable to conventional monetary policy shocks as compared to their respective opposites (value stocks, small capitalization stocks, and past loser stocks). After a positive shock in the Federal funds rate, value portfolio returns decrease by 0.86% per month whilst growth stock returns only decrease by 0.51% per month; in comparison, the market index contracts by 0.65% per month. Kontonikas and Kostakis (2013) explain that the higher exposure which value stocks have to monetary policy shocks might explain the higher premium from a risk perspective. Furthermore this result is indicative of the importance monetary policy on the balance sheet transmission/ lending channel (Bernanke & Kuttner, 2005). In line with the balance sheet transmission/ lending channel hypothesis, Kontonikas and Kostakis (2013) find similar results for the size factor returns, where small capitalization stocks are more sensitive to monetary policy shock. The impulse response analysis indicates that a contraction shock in conventional monetary policy leads to a decrease of 0.66% for small capitalization stocks and a decrease of 0.56% for large capitalization stocks. When double-sorting on the basis of size and book to market, the effects of an interest rate hike is even more pronounced, with small value stocks postulating a negative portfolio return of 0.84% and large growth stocks a negative portfolio return of 0.49%. The results by Kontonikas and Kostakis (2013) indicate that past losers stock returns are significantly more sensitive to contractions in monetary policy as compared to past winners, with a differential impact on returns of 0.24% on a monthly basis. A equity risk premium based justification related to risk exposure to monetary policy cannot be provided for this phenomenon where past winners are less sensitive as compared to past losers.

The results discussed in the previous paragraph are representative for the entire sample period, noteworthy however is that the results across the subsamples 1967-1983 and 1984-2007 only manifest significant results during the 1967-1983 period. The subsample analysis is conducted with respect to a structural break analysis which indicates a break-point from 1983 onwards. The responses to monetary policy shocks for value portfolios indicates that they are less exposed to monetary policy as a risk factor in the post-1983 subsample. Respectively, the size portfolio impulse responses of the returns are not significantly different when comparing the lowest to the highest deciles. Possible explanations which the authors provide for this phenomenon is that the disinflation mission which Paul Volcker embarked upon was successfully finalized by 1983, subsequently the Federal funds rate became less volatile. Another reasoning is that financial deregulation in the 1980's led to a reduced impact of monetary policy shocks on value and small capitalization stocks through the bank lending channel. Thirdly, the futures market, which became more accessible since 1989, allowed for companies to protect themselves against interest rate risk. Boivin and Giannoni (2006) also provide evidence for the above arguments, as their results manifest that monetary policy has had a weaker impact on the economy in the post-1983 period.

Maio (2013) also takes a VAR approach for the sample period 1963-2008 when looking into the impact of monetary policy shocks on the cross section of equity returns. Maio (2013) provides results that are coherent with Kontonikas and Kostakis (2013). Maio specifies that the effect of a Federal funds rate change on portfolio returns is due to the effect which the change has on future expected cash flows, adding that this effect dominates the discount rate (equity risk premium) effect. Maio also performs a subsample analysis around the 1983 landmark, and their findings largely concur with Kontonikas and Kostakis (2013). When comparing the pre-1983 to the post-1983 period, most return spreads (difference in returns between lowest factor-sorted decile portfolio and highest decile portfolio) are insignificant. A second subsample analysis is performed with 1994 as a breaking point, this is because the Federal Reserve increased its transparency with regard to policy announcement which allows markets to be better informed on the future path of FOMC policy. The spread between returns become more pronounced for most factor-sorted portfolios in the post-1994 subsample, however these results are not significant, which the authors explain to be due to the short sample period (1994-2008). Following this line of reasoning, the 1994 breakpoint is used in this study as the starting date of the sample period.

As mentioned previously, in contrast to the paper by Kontonikas and Kostakis (2013), Haitsma et al. (2016) find economically significant effects of conventional and unconventional monetary policy surprises on the EURO STOXX 50 Index, for portfolios sorted by industry, and for factor portfolios for the sample period 1999-2015. Through the use of an event study the authors indicate that stock market responses to monetary policy shocks have not died out in the post 1983 period in the euro-area. The results by Haitsma et al. (2016) portray the importance of incorporating monetary policy expectations by the market into a model when studying responses by stock portfolios, something which Kontonikas and Kostakis (2013) do not take into account.

The reason why this study adopts a methodology somewhat similar to the one proposed by Kontonikas and Kostakis (2013) is in liaison with the advantages which the method entails. Due to the dynamic structure of the macroeconomic and financial variables it is very useful to be able to treat all variables as endogenous due to the uncertainty related to the causal relations between the variables (Sims, 1980). Even though the causal relations are not certain, structural VAR analysis allows to analyze the impact of monetary policy shocks on factor returns. Consequently VAR models allow to determine the relations between designated variables through impulse response analysis. Furthermore, VAR models are more useful than an event study or a simultaneous equations model, when the aim is to make forecasts. This is because the model integrates past information. In the light of the Federal Reserve's current 'normalization' program this is a valued characteristic of the VAR approach as it allows for the estimation of future factor return movements in the aftermath of the unconventional monetary policy era. Indeed the VAR model allows forecasts for factor returns to be made conditional upon the future path of the Federal funds rate.

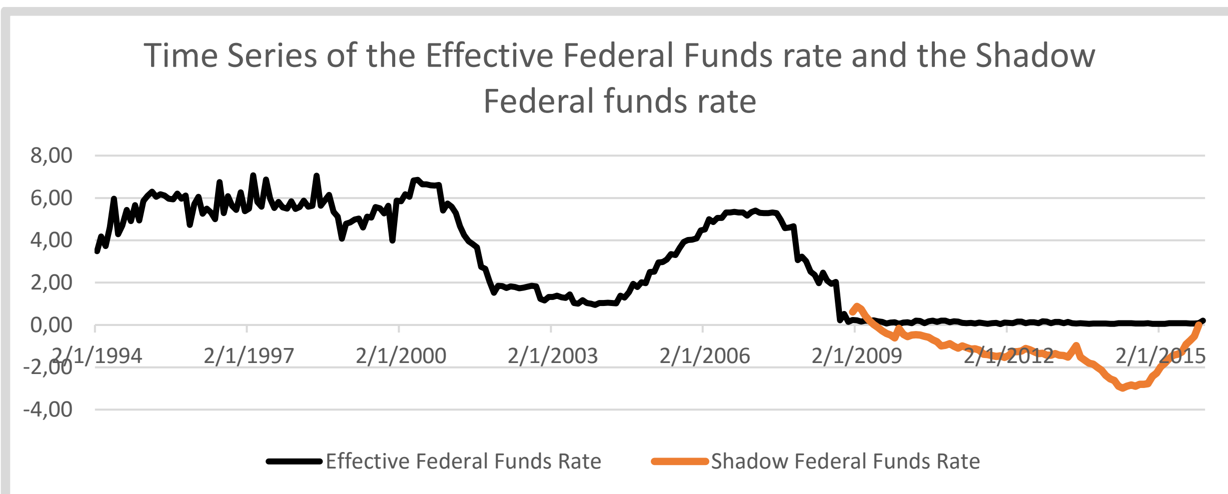
2.3 Monetary Shock Specification

Throughout this paper, monetary shocks are considered '*unexpected'* because if they are expected the shocks should already be priced into the proxies for monetary policy, therefore an expected shock in monetary policy should not occur. The study includes the Overnight rate and the Shadow rate together with the forward looking proxies: the Federal funds futures and the Spread between 10-year treasury rates and the Federal funds rate, this allows for the integration of market expectations. This subsection will introduce these proxies in detail.

2.3.1 The Overnight rate & the Shadow rate

Since Kontonikas and Kostakis (2013) study the period 1967-2008, they do not deal with the unconventional monetary policies which have been enacted in the U.S. since 2008. This allows the authors to define unexpected monetary policy shocks through a shock in the Federal funds rate. If the period of unconventional monetary policy (post-2008) is included, then the specification of the endogenous Federal funds rate variable has to be somewhat adjusted. This is in liaison with the fact that there were very little interest rate shocks during the Zero Interest-Rate Policy (ZIRP) era. Therefore looking to the Shadow Federal funds rate can serve as a proxy for unconventional monetary policy. This rate, which was first conceptualized by Black (1995), is a hypothetical rate which is allowed to go below zero. Wu and Xia (2014) develop the concept for the ZIRP era further. Wu and Xia also indicate that the Shadow rate is a good tool in VAR models for identifying monetary policy shocks. The time series for the effective Federal funds rate and the Shadow Federal funds rate can be viewed in Figure 1. This study employs sub-samples, the first identifying the conventional monetary period, the second the unconventional monetary policy period. The break is placed at the point where the Overnight rate intersects with the Shadow rate. Therefore the first subsample is the 1994m01 – 2009m03 period, the second subsample is the 2009m04 – 2016m02 period. The entire data sample contains the Overnight rate dataset until 2009m03 and then merges with the Shadow rate dataset thereafter. This choice is made because Wu & Xia (2014) identify the first few observations in their Shadow rate dataset to be less reliable due to estimation errors.

Figure 1



2.3.2 Forward looking proxies

The study includes (forward looking) proxies which allow for the inclusion of market expectations (during the conventional and unconventional monetary eras) which is key when studying factor portfolio returns through VAR models (Brissimis & Magginas, 2006). This is because the VAR methodology as proposed by Kontonikas and Kostakis (2013) has several draw-backs in theory. The foremost important drawback is addressed by Bernanke et al. (2004). They address the phenomenon that market participants (in the form of central banks and the private sector) are in possession of information which a simple VAR method cannot take into account due to limitations with regard to the amount of variables which are allowed to be included (related to the a limitation on degrees of freedom). Therefore the effects of monetary policy shocks measured by a VAR system could be misleading. Market participants might already have expectations in advance of the announcement due to forward-guidance by FOMC members from prior FOMC announcements. Therefore a factor-augmented vector autoregressive (FAVAR) model is recommended by Bernanke et al. (2004). However the expectations from market participants can be embodied in single forward looking variables, therefore the laborious FAVAR approach as proposed by Bernanke et al. (2004) is deemed unnecessary in the approach utilized in this study. The forward looking variable particularly relevant for the conventional monetary period is the Federal funds futures and the forward looking variable relevant to the unconventional monetary period is the difference between long term treasury rates and the short term Federal funds rate. These two proxies for market expectations are discussed below, under Sections 2.3.2a and 2.3.2b.

2.3.2a Forward looking proxies: the Federal funds futures

Daily fluctuations in Federal funds futures contracts convey the beliefs, opinions, and assessments as to where the Federal funds rate will be in the near term by agents participating in the market (Hamilton, 2009). Federal funds futures contracts are very strong predictors of the fed funds rate and the accuracy of these predictions has significantly improved over time. Hamilton shows this by comparing the mean squared errors (MSE) of forecasts from futures values to the MSE from random walk values over the full dataset (1988-2006) to the more recent dataset (2003-2006). The more recent dataset shows a higher percentage MSE improvement. Swanson (2006) provides an explanation for this phenomenon, showing that the Federal Reserve has greatly increased transparency, through more explicit announcements with regard to policy and future policy goals. Indeed, Swanson indicates that a structural break took place from February 1994 onwards. Swanson looks at forecasts by the private sector in particular, Carlson, et al. (2006) manifest the same results with regard to central bank transparency as of February 1994 via Federal funds futures. They indicate that Federal funds futures with horizons of two to three months are particularly accurate in forecasting the Federal funds rate.

Other authors which manifest the amelioration in the precision of the market's predictions incorporated in the fed funds futures are Lange, Sack and Whitesell (2003). Lange et al. (2003) also refer to "gradualism" which is implemented when adjusting the Federal funds rate target, this also positively affects the predictability embodied in fed funds futures. Brissimis & Magginas (2006) include the expected value of the Federal funds rate through the one-month Federal funds futures contracts. They conclude that an unexpected shock to a VAR model through a monetary policy announcement can be more accurately measured when making a monetary policy announcement shock conditional upon the expectations implied by these one-month futures contracts. Kontonikas and Kostakis (2013) only find significant results in their pre-1983 sub-period, this might be due to the fact that they did not look into the information already possessed by the market. From the set of financial instruments which are able to measure near-term market expectations of rate hikes, Gürkaynak et al. (2007) find that the Federal funds futures is the best instrument in terms of its predictive power when it comes to forecasting monetary policy. This is indicated to be the case for a time horizon of 6 months or less. When the time horizon is expanded to one year then Eurodollar futures perform equally well in terms of predictive power as compared to the fed funds futures. Additionally fed funds futures prices are claimed to be a good measure of the market's expectations of near-term changes in the Federal funds rate. When attempting at explaining the movements in Federal funds futures prices Hamilton (2009) finds that growth in previous employment is significant in predicting Federal funds futures prices. Furthermore there appears to be daily serial correlation in the price changes of the futures.

2.3.2b Forward looking proxies: Spread between long-term treasury rates and the Federal funds rate

The spread between long-term treasury rates and the Federal funds rate is a method of identifying unexpected monetary shocks, especially during the unconventional monetary policy era. In this period the Federal funds rate is at (or very close to) the lower bound (zero) and therefore the Federal funds futures market is relatively stable (with only a small amount of variation). This undermines its qualities as a proxy for market expectations on monetary policy. Therefore shocks in spread the between long-term treasury rates and the Federal funds rate prove more useful. This approach is recommended by Glick and Leduc (2013). The analysis which the authors use focuses on intraday price movements, and therefore the data and methodology which they employ is not of use in my approach. Gagnon et al. (2011) indicate the influence of the unconventional monetary policy measures on long term treasury rates, indicating that the market quickly responds to integrate new information in the treasury yields and term premiums.

From the literature it is clear that the Federal funds futures and Long-term treasury rates are efficient tools, each in their own right, as they embody information on current monetary policy and monetary policy goals signaling. Furthermore, to be able to make the correct inferences with respect to the impulse responses it is necessary to include this information known to the market. Therefore during the conventional monetary policy era the Kontonikas and Kostakis (2013) approach can be improved by including, asides from changes in the Federal funds rate, forward-looking proxies such as the Federal funds futures and Long-term treasury rate futures as control variables.

Another proxy for unconventional monetary policy, although not forward looking, is seasonally adjusted central bank assets. The seasonally adjusted central bank assets can be subdivided into 3 major categories: U.S. treasuries, Mortgage Backed Securities (MBS), and Agency debt. This is the proxy Gambacorta, Hofmann and Peersman (2014) use for the reflection of unconventional monetary policy in the light of being unable to use the Federal funds rates due to the lower bound limit. They also look into the monetary base, however the central bank asset proxy is deemed more accurate as a gauge for unconventional monetary policy. This is because when graphing the time series evolution, the monetary base grows at a slower pace as compared to the central bank balance sheet. Gambacorta, Hofmann and Peersman (2014) recognize that this method fails to consider composition effects. Also, it fails to take into account that markets are forward looking (the markets might front-run central bank purchases). On the basis of these negative qualities this study will not use this proxy for the specification of unexpected monetary shocks.

2.4 Risk Aversion

Another difference to the Kontonikas and Kostakis (2013) VAR model, to be proposed in the methodology section, is that I include the Volatility Index (VIX) which measures the implied volatility on the S&P500 index. The VIX is a common proxy used for the measurement of financial risk aversion (for further profundity please see Whaley (2000)). Gambacorta et al. (2014) stress that the VIX is an excellent proxy to extract exogenous monetary policy events from endogenous market reactions to uncertainty and market risk during crisis periods. Additionally Gambacorta et al. (2014) explain that both the variables central bank balance sheet size and the VIX moved in sync during the 2008 crisis period, this means that failure to integrate the endogenous movements of the Federal Reserve’s balance sheet with the VIX in the same model can lead to biases in the results. A potential result from failure to integrate the VIX in the model could be that changes in factor returns could be attributed to monetary policy shocks whilst they are actually a result of market uncertainty. The VIX is indeed considered a risk factor in relation to factor portfolio returns (Banerjee et al., 2007).

The importance of combining the VIX with an endogenous set of macroeconomic variables is further determined by Bacchetta and Wincoop (2010). Their study reveals that the inclusion of the VIX is especially crucial during crisis periods as these periods are sensitive to shifts in market perceptions formed on risks related to macroeconomic variables. These perceptions consequently influence equity prices. In stable times these macroeconomic variables are of lesser influence upon the perceptions of risk of equity investors.

3. Methods

The following model will be considered for this study (equation 1):

$$x_{\ t} = \sum_{i=1}^{p} a_i x_{t-i} + bw_t + \varepsilon_t,\ t = 1, 2, \dots, T, \tag{1}$$

In equation 1, $x_{\ t}$ is a (p × 1) vector of the monthly time series of the monetary policy proxy, of the macroeconomic variables, and the factor portfolio returns variable. In the above equation w_t is an exogenous variable with a (q × 1) vector. The coefficient matrices a_i and b are of the form (m × m) and (m × q), and ε_t is the vector error process. Similar to Kontonikas and Kostakis (2013) I base this model on the assumptions (i), (ii) and (iii) as defined by Pesaran and Shin (1998):

(i) $E(\varepsilon_t) = 0$; $E(\varepsilon_t, \varepsilon_t{'}) = \omega$ for all t, where ω is a (m × m) positive matrix; $E(\varepsilon_t, \varepsilon_t{'}) = 0$ for all $t = t'$; and $E(\varepsilon_t | w_t) = 0$

(ii) All roots of $\left| I_m - \sum_{i=1}^{p} a_i z^i \right| = 0$ fall outside the unit circle, where I_m is an identity matrix of the form (m × m)

(iii) $x_{t-1}, x_{t-2}, \dots, x_{t-p}, w_t,$ are not perfectly collinear where, $t = 1, 2, \dots, T$

Assuming assumption (ii) holds then the vector of dependent variables $x_{\ t}$ will be covariance stationary and then (1) can be rewritten accordingly:

$$x_{\ t} = \sum_{i=0}^{\infty} \gamma_i \varepsilon_{t-i} + \sum_{i=0}^{\infty} G_i w_{t-i}\ ,\ t = 1,2, \dots, T:, \tag{2}$$

Where $\gamma_i = a_1\gamma_{i-1} + a_2\gamma_{i-2} + \cdots + a_p\gamma_{i-p}$, $(i = 1, 2, \dots)$ are the (m × m) coefficient matrices with $\gamma_0 = I_m$, $\gamma_i = 0$ for $i < 0$, and $G_i = \gamma_i b$. The model used in the paper by Kontonikas and Kostakis (2013), specifies $x_{\ t}$ to include the variables: growth rate of industrial production, growth rate of the Consumer Price Index, growth rate of the Commodity Price Index, the Strongin variable (based on the portion of non-borrowed reserves that is orthogonal to total reserves), change in the Federal funds rate and the excess return of a stock portfolio. Furthermore their model only includes a constant as an exogenous variable. In order to derive a valid model for testing factor returns the Kontonikas and Kostakis model was taken as a starting point.

The first issue encountered when studying the impulse responses of the model proposed by Kontonikas and Kostakis (2013), seen under Appendix 1, is that the price puzzle is present, albeit not significantly (as the Standard Error (S.E.) lines are above and below the horizontal axis). The price puzzle is a common counter-intuitive occurrence in macroeconomic VAR models and entails that inflation shows a positive impulse response to a tightening in monetary policy (Brissimis & Magginas, 2006). Bernanke and Boivin (2003) and Brissimis and Magginas (2006) describe how the price puzzle can be resolved by introducing the Producer Price Index (PPI) as an exogenous variable in the VAR model. Therefore the Producer Price Index for all commodities is adopted in the model I employ in this research. Since PPI (all commodities) is now included in the VAR framework, the Commodity Index employed by Kontonikas & Kostakis (2013) as an endogenous variable loses the little contributive value it had within the model and is therefore omitted. Appendices 2 and 3 show that the price puzzle is resolved. Appendix 2 covers the 1994 – 2009 period, Appendix 3 covers the 2009 – 2016 period.

Asides from the price puzzle, the 'Strongin' variable which Kontonikas and Kostakis (2013) employ as an endogenous variable creates a lot of noise in the VAR-model due to the 2008-2009 period. This Strongin variable is based upon the portion of non-borrowed reserves that is orthogonal to total reserves: the residual in the regression with non-borrowed reserves as dependent variable and total reserves as independent variable. However due to the liquidity crisis lasting through the 2007-2010 period this variable contains extreme data points. Therefore there is a need for other measures of monetary policy which have a higher accuracy. Bernanke and Kuttner's (2005) argue that market participants (central banks and the private sector) are in possession of information that a simple macro-VAR does not take into account. Namely, the one-month-ahead Federal Funds futures values are included in the endogenous vector, this is also endorsed in the paper by Brissimis & Magginas (2006). Furthermore the spread between 10-year treasury rates and the Federal funds rate also contains forwards looking information on monetary policies (as discussed in Section 2), therefore this spread is also included as an endogenous variable in the model which I propose. The inclusion of these two variables leads to a better model fit.

Furthermore the target Federal funds rate data which Kontonikas & Kostakis (2013) use varies too little (data values are sometimes recursive over successive months), which leads to a poor specification of unexpected monetary policy shocks. The Overnight rate as a proxy for monetary policy changes on a more frequent basis and is therefore used together with the Shadow rate. To be able to aggregate the pre-2009 period of conventional monetary policy with the post-2009 period of unconventional monetary policy into one model, the Overnight rate dataset (for the period 1994m01 – 2009m03, 2016m01-2016m02) is combined with the Wu-Xia Shadow rate dataset (2009m03 – 2015m12) into one dataset (1994m01 – 2016m02). For illustrative purposes, the time series for the Overnight rate and the Shadow Federal funds rate can be viewed in Figure 1. Monetary policy shocks in the VAR are to be determined through shocks in the Overnight or Shadow rate, this method allows to circumvent non-stationarity problems. This method of identification is widely applied in the literature (Thorbecke, 1997; Jensen and Mercer, 2002; Chen, 2007; Kontonikas and Kostakis (2013); Maio (2014)).

The Kontonikas & Kostakis (2013) models includes 1 lag across their entire paper, this is based on the Aikaike Information Criterion (AIC). When estimating the model proposed under equation 1, the Schwarz Criterion (SC) (which is more conservative as it puts a penalty on additional variables) indicates that 3 lags should be included. Indeed when analyzing the adjusted R-squares it becomes clear that 3 lags lead to a better model fit as compared to the same model with 1 lags. The model with 3 lags has an adjusted R-squared value of 0.36 versus 0.30 for the 1 lag model. Thus, according to the SC and the adjusted R-squares, I adhere to 3 lags throughout this thesis.

When adopting all of the changes addressed above, a considerable increase in the adjusted R-squared was found for the model for the 1994-2016 sample period. The model by Kontonikas and Kostakis (2013) had an adjusted R-squared of 0.21 whilst the model proposed in this study has an adjusted R-squared of 0.35. The model which contains the endogenous variables inflation (CPI), industrial production (IP), excess market returns (the market risk premium), the change in the Overnight rate, the one-month-ahead-continuous Federal funds futures index, the spread between long term treasury rates and the Federal funds rate and as exogenous factor a constant and the Producer Price Index for all commodities (PPI), passes as a sound model as the impulse responses of the endogenous variables are in accordance with the theoretical and empirical expectations as described by Bernanke and Kuttner's (2005).

On the basis of the above discussion the complete VAR model will include the following endogenous variables (x_t in equation (1)):

- Percentage change of industrial production (IP)
- Percentage change of the Consumer Price Index (CPI)
- The Overnight rate / the Shadow rate (depending on the time period)
- The Federal funds futures values
- Spread between long-term treasury rate and the Federal funds rate:

$(ten\ year\ treasury\ rate - Federal\ funds\ rate)_t$

- Percentage change in the Volatility Index (VIX)
- Return on the factor portfolio j, or the Market risk premium, or the S&P500 index

In equation (1), the exogenous factor w_t includes an intercept term and the producer price index:

- Constant
- Percentage change in the Producer Price Index (PPI) for all commodities

The Federal funds futures variable is defined following the method by Kuttner (2001), who suggests that the change in the implied rate of the Federal funds futures is an adequate proxy for the unanticipated monetary policy shocks. Furthermore Brissimis & Magginas (2006) indicate that the forward looking proxy reflects monetary policy expectations. The VIX variable is specified in accordance with the research conducted by Gambacorta et al. (2014).

The factor porfolios are based on proxies for size, value and momentum. For size, the proxy is market capitalization. For the value factor, four proxies are used: the book to market ratio, the dividend to price ratio, the earnings to price ratio and the cash flow to price ratio. For the momentum factor, three time spans for past returns are used: 1-month, 2 to 12-months and 13 to 36-months. The factor portfolios j are constructed on a monthly value weighted basis using stocks listed on the NASDAQ, AMEX or NYSE, with the returns calculated as follows:

- The Size factor: the return on the lowest 20% market capitalization stocks minus the return on the highest 20% market capitalization stocks
- The momentum anomaly: the return of the firms that performed in the top 20% over the past 2-12 months minus the return of the 20% firms that performed poorest over the past 2-12 months
- The Long Term Reversal Momentum anomaly: the return of the 20% stocks with lowest returns over the past 13-60 months minus the return of the 20% stocks with the highest returns over the past 13-60 months.
- The Short Term Reversal Momentum anomaly: the return of the 20% stocks with lowest returns over the past 1 month minus the return of the 20% stocks with the highest returns over the past 1 month.
- The Book-to-Market Value factor: the returns of the highest 20% B/M stocks minus the returns of the lowest 20% B/M stocks

- The Cash flow to price value factor: the returns of the highest 20% CF/P stocks minus the returns of the lowest 20% CF/P stocks
- The Earnings to Price value factor: the returns of the highest 20% E/P stocks minus the returns of the lowest 20% E/P stocks
- The Dividend to Price value factor: the returns of the highest 20% Div/P stocks minus the returns of the lowest 20% Div/P stocks

The factor portfolios returns are constructed upon the extreme quintile portfolios rather than deciles as it limits the influence of firms with extreme ratios (for the value and size factors) and with extreme past performance (for the momentum factors). Firms with financial distress (extreme value ratios and low capitalization stocks) will have higher return volatility and therefore might be influence the factor returns strongly. Thus to mitigate the influence of such stocks quintiles were opted for rather than deciles when constructing the factor portfolio returns.

The unexpected monetary policy shocks are identified by one-standard shocks in the Overnight rate/ Shadow rate, the Federal funds futures or the spread between long term and short term rates. As we are interested in the impact of these shocks on the factor portfolio returns, the results section will present the factor portfolio returns in Impulse Response form as this form has an intuitive interpretational value. In the VAR model, an ordering according to the Cholesky factorization (Sims, 1980) will not be applied. This is in compliance with the work by Kontonikas and Kostakis (2013), who consider it a necessary limitation when taking into consideration the uncertainty related to the causal direction of certain macroeconomic and financial variables. The solution, the Generalized Impulse Response (GIR) function, is suggested by Pesaran and Shin (1998). The GIR functions to the monetary policy shocks to be presented in this paper are the variables of specific interest which include the returns of the jth factor portfolio.

Finally, one might consider the specification of x_t to be relatively parsimonious as there are many macroeconomic (control) variables which could be added, such as GDP growth, changes in unemployment, changes in the durable goods orders report, and so forth. However due to the constraint in the number of endogenous variables (degrees of freedom) the choice for a smaller number of endogenous variables can be justified. Furthermore the combination of the macroeconomic variables presented above is often employed in monetary policy VAR models (Brissimis & Magginas, 2006; Kontonikas and Kostakis, 2013).

4. Data

The study comprises the February 1994 – March 2016 period. Thomson Reuters is the primary source for all the data downloaded (with exception for the portfolio returns). All data is monthly and representative of the United States of America. US Industrial Production data is retrieved from Thomson Reuters and provided by the Federal Reserve, it is seasonally adjusted. US Consumer Prices data comes from the Bureau of Labor Statistics, U.S. Department of Labor, also seasonally adjusted. The proxy for the commodity price index variable is the Standard and Poor's Goldman Sachs Commodity Index (GSCI). For the Strongin variable, non-borrowed and total reserves are retrieved from the Thomson Reuters database. This data is manipulated such that the Strongin variable in line with the work by Kontonikas and Kostakis. To this end, the residual of the regression of non-borrowed reserves on total reserves is calculated on a monthly basis. I do not discuss the 'Strongin' variable and the commodity price index in further detail since it is only used to specify the model by Kontonikas and Kostakis under appendix 1. All other data is described in Table 1.

For the factor portfolios, value-weighted returns are retrieved from the Kenneth-French database. The market risk premium (benchmark) is the value weighted return of all CRSP firms listed on the NYSE, NASDAQ and the AMEX (with CRSP code 10 or 11) with the one-month treasury rate subtracted. Data on the volatility index (VIX) is only available as of March 26th, 2004 which is retrieved from the CBOE website. To complete the VIX time series for the sample period, all data prior to March 2004 is based on the VIX levels as calculated by Whaley (2000) also available on the CBOE website. The data on the Federal funds one-month-ahead futures is retrieved from the Thomson Reuters Database and is traded on the eCBOT exchange. Furthermore, Wu-Xia (2014) provide a database for the Shadow Federal funds rate. The long-term Treasury rate spread variable is based upon the 10-year Treasury bond interest rate minus the Federal funds rate. The source of this data is The Conference Board. The index for the PPI (all commodities) was also retrieved via the Thomson Reuters Database, its original source is the Federal Reserve Bank of St. Louis (FRED). The Interbank rate/ the Overnight rate, is also downloaded via Thomson Reuters, and originates from the OECD databases.

5. Results

5.1 Descriptive Statistics

In Table 1 the descriptive statistics of these variables are presented. It can be seen for example that the Shadow rate ranges between 0.0 and -2.99% during the sample. The Federal funds futures values a spread between 92.71 and 99.92. The expected Federal funds rate can be calculated on the basis of these values when subtracting the futures value from 100. When doing this with the average: (100 - 97.01) an average Federal funds rate of 3% is found. This is the mean *expected* Federal funds rate over the entire sample period.

On the basis of this Table, the data is deemed functional. There are no outliers which cannot be explained, yet the distributions of the data series do have extreme tails, this is especially the case of the factor portfolio returns. The kurtosis further validates this. Furthermore when inspecting for combined skewness and kurtosis, the Jarque-Bera coefficients indicate that not a single variable presented in Table 1 is normally distributed.

When inspecting the factor portfolio returns, it is clear that the means are positive indicating that factor premiums are still existent in the sample period studied. Furthermore it is visible that factor returns are very volatile across the sample, evident from the minimum and maximum values as well as the standard shock values. The momentum strategy has the highest average monthly return over the sample of 0.56%. Likewise it also has the highest standard deviation coefficient.

Since the VAR model includes four monetary variables, and as it is a fair question to ask whether these variables are correlated, Table 2 is included. Indeed strong correlation between these variables can lead to erroneous results. From Table 2 it is not perceivable that multicollinearity amongst the different monetary variables is an issue. The Federal funds futures variable shows some correlation with the other variables (albeit inversely), whilst the spread between the 10-year treasury rate and the Federal funds rate exhibits very little correlation with the other variables. Making the monetary policy shock proxy conditional upon the other monetary proxies increases the VAR model's accuracy as discussed in Section 3.

Table 1

Table 1a: Descriptive Statistics: Macro and Monetary Variables

	CPI	IP	VIX	Shadow rate	Overnight rate	F. Fund Futures	Spread	PPI (all comm.)
Mean	0.18	0.17	2.12	-1.25	3.99	97.01	1.61	0.16
Maximum	1.38	2.05	134.57	0.00	6.54	99.92	3.72	2.99
Minimum	-1.77	-4.31	-38.49	-2.99	0.15	92.71	-1.16	-5.33
Std. Dev.	0.28	0.66	21.07	0.88	1.85	2.39	1.27	1.10
Skewness	-1.40	-1.80	1.67	-0.01	-0.59	-0.05	-0.25	-0.98
Kurtosis	14.20	12.53	9.45	2.94	1.85	1.37	1.92	7.41
Jarque-Bera	1477.90	1145.63	584.51	0.01	20.12	28.70	15.73	252.49

Table 1b: Descriptive Statistics: Factor Portfolio Returns & Market Risk Premium

	Momentum	Size	CF/P	B/M	Div/P	LT Reversal	ST Reversal	Earnings/P	Rm-Rf
Mean	0.56	0.17	0.10	0.06	0.14	0.17	0.33	0.27	0.58
Maximum	16.80	29.03	13.61	14.64	13.97	11.91	20.22	14.79	11.34
Minimum	-39.24	-20.43	-10.38	-9.98	-17.69	-9.88	-18.96	-10.28	-17.15
Std. Dev.	6.76	4.52	3.20	3.39	4.32	3.78	5.16	3.33	4.41
Skewness	-1.66	0.93	0.17	0.29	0.12	0.37	0.25	0.42	-0.69
Kurtosis	11.10	10.42	4.39	4.62	4.62	3.29	5.82	5.07	4.08
Jarque-Bera	842.83	647.74	22.52	32.80	29.37	6.94	90.18	54.73	34.11

notes: the sample period ranges from January 1994 to February 2016, the frequency of the variables is on a monthly basis and therefore each variable has a total of 266 observations, with exception for the Overnight rate and the Shadow rate. The Overnight rate is used over the period January 1994 - March 2009 and December 2015-February 2016, whilst the Shadow rate covers the April 2009-November 2015 period. Each VAR model is composed of the endogenous variables: CPI, IP, VIX, Shadow rate/ Overnight rate, Fed futures, Spread between the 10-year treasury rate and Fed funds rate, and one of the Factor portfolios. The exogenous variables are always a constant and the PPI. CPI, IP, VIX and PPI are in percentage change form. The Shadow rate, the Overnight rate, the Fed fund futures and the Spread are all given in terms of their original values. The factor portfolio returns are calculated on the basis of difference between the extreme quintiles. Rm-Rf is the market risk premium, where Rf is the monthly T-bill rate.

Table 2: Correlation Matrix: Monetary Variables

	F. fund futures	Shad.&Overn. rate	Shadow rate	Spread	Overnight rate
Fed. fund futures	1.00	-0.72	-0.73	-0.48	-0.59
Shadow& Overnight rate	-0.72	1.00	1.00	0.41	1.00
Shadow rate	-0.73	1.00	1.00	0.39	N/A
Spread	-0.48	0.41	0.39	1.00	0.17
Overnight rate	-0.59	1.00	N/A	0.17	1.00

notes: the fields denoted with N/A indicates that these data periods do not overlap

5.2 Market Risk Premium and the S&P500

The VAR-model impulse responses for each factor portfolio and for the Market Risk Premium (which serves as a benchmark) is calculated for different sample periods and across different monetary policy shock specifications and are reported in Table 3, Table 4 and Table 5. These impulse responses are given in percentage returns. The different sample periods include the conventional monetary period presented in Panels 1 (1994m01-2009m03), the unconventional monetary period presented in Panels 2 (2009m04 – 2016m02), and the entire sample period presented in Panel 3. The monetary policy shock specifications include the Overnight rate for the conventional monetary period (Table 3), the Shadow rate for the unconventional monetary period (Table 3), the Federal funds futures (Table 4), and the Spread between long term treasury rates and the Federal funds rate (Table 5). Next to each impulse response, the tables also include the cumulative impulse responses. This allows to see whether the effect of a monetary shock on factor returns is persistent. The monetary policy shocks are specified by a one-standard deviation shock in the Overnight funds rate, the Shadow rate, the spread between ten year treasury yields and the Federal funds rate, and the Federal funds futures market. Therefore each panel will be presented three times were the impulse responses are determined by the proxy for unexpected monetary shocks.

Before proceeding to the factor portfolio returns I study the market risk premium and the S&P500 such that the first two hypotheses can be checked and such that initial conclusions can be made with respect to the risk premium channel. The model employed contains the endogenous variables inflation (CPI), industrial production (IP), excess market returns (the market risk premium) / the S&P500/ the factor portfolio J, the change in the Overnight rate/ the Shadow rate, the one-month-ahead-continuous Federal funds futures index, the spread between Long Term (LT) and Short Term (ST) rates, and as exogenous factors a constant and the Producer Price Index for all commodities (PPI).

Table 3, Panel 1, indicates that the market risk premium reacts negatively to a contractionary shock in monetary policy in the first period by 0.95%, significant at the 5% level. The cumulative impulse response coefficient indicates that the effect isn’t permanent. During the unconventional monetary period (Panel 2) a shock in the Shadow rate does not lead to a significant effect in the market risk premium. When the entire sample (Panel 3) is studied it is again found that a contractionary shock leads to a first period impulse response which is negative and significant at the 5% level, albeit the cumulative impulse response being insignificant. Even though the cumulative impulse responses are insignificant, the one period impulse responses indicate that the market (at least initially) responds to a positive shock in the Overnight rate with lower excess returns.

Contrarily to Table 3, Table 4, across all Panels 1, 2 and 3, shows insignificant first period impulse responses. In Panel 1, a significant positive cumulative impulse response is found to a positive shock in the Federal funds futures. The cumulative impulse responses for Panels 2 and 3 are also positive however insignificant. The positive nature of these coefficients is in line with the expectation that a contraction in monetary policy (a positive shock in the Federal funds rate) leads to lower market returns.

Table 5, where the shock is defined by the spread between long term and short term interest rates yields interesting results. In Panel 1 the cumulative impulse response is -2,36% significant at the 5% level. Thus a monetary contraction shock leads to lower market excess returns during the conventional monetary policy period. During the unconventional monetary period a contractionary monetary shock leads to a positive first period impulse response of 1,64% significant at the 5% level, the insignificance of the cumulative impulse response indicates that this effect is non-lasting. The positive coefficient is a surprising result and indicates that the unconventional monetary loosening which the Federal Reserve engaged in in the post-crisis period had a (one period) negative effect on excess market returns. The overall sample, in Panel 3, indicates a positive one period impulse response and a negative cumulative impulse response significant at the 10% and 5% level respectively. These results are in line with the results from the individual sub-samples.

The hypothesis that in general, contractions in monetary policy lead to lower stock prices due to the risk premium channel is thus tested through the Market Risk Premium impulse responses in Tables 3, 4 and 5:

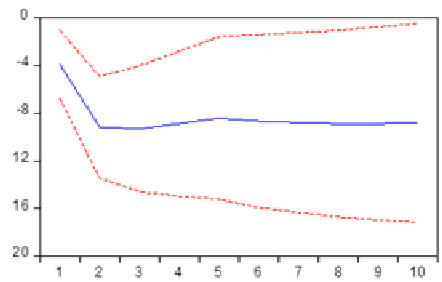
H01a: The market excess return reacts negatively to contractionary monetary policy shocks.

On the basis of the significant impulse responses found in Panel 1 H01a is not rejected. On the basis of the impulse responses presented in Panel 2 (Table 5) H01a is rejected. With respect to the entire sample period (Panel 3) the significant impulse responses indicate that H01a is not rejected (Table 5 indicates that the cumulative impulse response is permanent and negative at the 5% level).

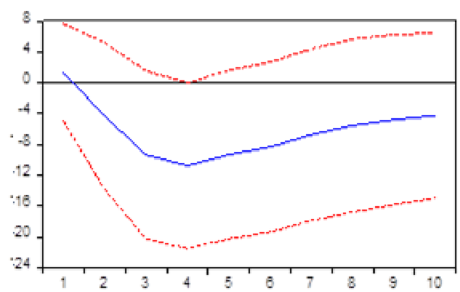
Figure 2: Generalized Impulse Responses of the S&P500 to a shock in the Overnight rate (1994m01 – 2009m03) and Shadow rate (2009m04 – 2016m01)

Endogenous variables: CPI, IP, S&P500, VIX, Overnight rate/ Shadow rate, Fed. Funds Futures, Spread between LT and ST rates, Exogenous variable: Constant, PPI (all commodities), Lags:3. The blue line denotes the impulse response, the red lines denote ± 2 standard deviations.

Generalized Impulse Response of S&P500 to a Shock in the Overnight Rate:



Generalized Impulse Response of S&P500 to a Shock in the Shadow Rate:



As a secondary test for this hypothesis, the market risk premium is replaced with the S&P500 index. The results of this endeavour can be found in Figure 2. This analysis is limited to the Overnight and the Shadow rate for illustrative purposes (as it demonstrates the principle). From Figure 2 it is observed that the impulse response of the S&P500 on a shock in the Overnight rate is negative and significant over the entire ten month impulse response period. The effects of the contractionary monetary shock is predominantly present in the first two months, after which the impulse response stabilizes. The impulse response of the S&P500 to the Shadow rate also presented in Figure 2, albeit insignificantly different from zero (as seen from the 95% confidence interval denoted by the red lines which is below and above the zero line) is negative as well.

Since a significant negative impulse response was found for the S&P500 index over the 1994 – 2009 period, H01b is cannot be rejected:

H01b: The S&P500 return reacts negatively to contractionary monetary policy shocks.

However, from Figure 2, the negative impulse response of the S&P500 is insignificant over the unconventional monetary period (2009 – 2016), this indicates that unconventional monetary policy shocks have a lesser impact on stock market returns. This conclusion is backed by Table 3, Panel 2, where a shock in the Shadow rate didn't significantly impact the market risk premium.

Since H01a and H01b cannot be rejected over the conventional monetary period, thus there is evidence for the risk premium channel which complies with the findings of Jensen, Mercer and Johnson (1996), Thorbecke's (1997), and Bernanke and Kuttner (2005). Therefore tighter monetary policies increase the riskiness of stock indices, negatively impacting stock prices due to an increase in the expected equity risk premium. During the unconventional monetary period however, this risk premium channel appears not to be present from the analysis. Therefore it is questionable whether monetary policy is a risk factor during the unconventional monetary policy period. The factor return analysis in Section 5.3 will shed more light on this.

5.3 Factor Returns

5.3.1 Market Capitalization (Size)

The VAR-model impulse responses of the size factor portfolio, constructed upon going long the smallest capitalization quintile and shorting the largest capitalization quintile, shows interesting results. For Panels 1, irrespective of the proxy used for monetary shocks, it is clear that the size factor return is not influenced by monetary policy as a risk factor. The 1-period impulse responses are insignificantly different from zero, and this is confirmed by the 10-period cumulative response which is also insignificantly different from zero. These findings confirm the results by Kontonikas and Kostakis (2013) that there are no factor returns in their second subsample (1984-2007).

Panels 2 yield significant results for the 1-period impulse responses for the size factor return. A positive one standard deviation shock in the Shadow rate leads to a 1-period impulse response of 0.72%. The respective 10-period cumulative response is 7.99%, albeit insignificant. Since the cumulative coefficient is larger than the 1-period impulse response coefficient indicates that there is some lasting effect, however the insignificance of the figure indicates that the size factor return is not structurally affected by a monetary policy shock. A positive shock in the Federal funds futures values leads to a significant negative 1-period impulse response of 1.35%. The fact that the sign of the impulse response coefficient is reversed when compared to the Shadow rate is intuitive, since a positive shock in the Shadow rate is associated with a monetary contraction, whilst a positive shock in the futures values is associated with monetary loosening. The inverse relation can also be seen from Table 2. The spread proxy for monetary shocks indicates a significant 1-period impulse response of 1.43%, and a significant cumulative 10-period response of 12.62%. These responses indicate that monetary policy enacted in the post crisis era (which was expansionary) benefited larger capitalization firms disproportionally more, according to the cumulative impulse response in Panel 2, Table 5, this was a lasting effect.

Panel 3 indicates that the size factor return has a positive impulse response for the entire sample period when the shock is measured according to the combined Overnight and Shadow rate dataset (Table 3). This is refuted by the results from Table 4 and 5 as these indicate that the size factor return impulse response is not significantly different from zero.

For the conventional monetary policy subsample H02 is rejected as no significant results were found. Across the unconventional monetary policy subsample positive size factor return impulse responses are found in response to a contractionary monetary policy shock, therefore H02 is rejected for this period. From the results in Panels 3, H02 also has to be rejected:

H02: The return on the size factor (small minus big capitalization stocks) reacts negatively to contractionary monetary policy shocks.

H02 is rejected since the size factor reacts positively to contractionary monetary policy shocks during the unconventional monetary period (Panels 2). This holds across all proxies for monetary policy for the 1-month impulse responses, the spread proxy (Table 5) indicates that this effect is permanent. Since expansionary monetary policy was predominant during this time frame large capitalization stock returns are shown to have responded more favourable as compared to smaller capitalization stock returns. This indicates that the balance sheet (credit) transmission mechanism of monetary policy is not present during the 2009m04 – 2016m02 period. This is not in line with the theoretical expectations formed in Walsh (2003) nor with the empirical work performed by Thorbecke and Coppock (1995), this is can be explained by the unconventional nature of the monetary policies enacted during this time frame.

Table 3:

Generalized impulse responses of factor sorted portfolios to one s.d. innovations in the Overnight rate (panel 1), the Federal funds Shadow rate (panel 2) and the combined Overnight and Shadow rate dataset (panel 3)

	Panel 1: 1994m01-2009m03		Panel 2: 2009m04-2016m02		Panel 3: 1994m01-2016m02	
Sorting criterion for decile portfolios	Impulse Response	Cumulative I.R.	Impulse Response	Cumulative I.R.	Impulse Response	Cumulative I.R.
Market Capitalization (size)	0.08	0.34	**0.72***	7.99	**0.57****	**11.63****
	(0.32)	*(5.52)*	*(0.40)*	*(6.41)*	*(0.28)*	*(4.77)*
Long Term reversal (momentum)	-0.01	5.05	0.66	-7.10	0.07	7.05
	(0.34)	*(5.34)*	*(0.69)*	*(12.51)*	*(0.32)*	*(5.64)*
Short Term reversal (momentum)	-0.62	4.82	0.20	-3.15	-0.12	6.91
	(0.59)	*(9.11)*	*(0.67)*	*(8.61)*	*(0.47)*	*(7.20)*
Momentum Anomaly	-0.13	**-33.25****	0.01	3.48	0.12	**-26.71****
	(1.03)	*(11.76)*	*(0.63)*	*(3.60)*	*(0.83)*	*(10.19)*
Book Equity to Market Equity ratio (value)	-0.091	0.10	0.16	-5.44	0.23	**10.37****
	(0.21)	*(3.56)*	*(0.42)*	*(6.90)*	*(0.20)*	*(3.66)*
Cash-flow to Price ratio (value)	-0.15	-1.60	0.40	0.21	0.24	4.54
	(0.25)	*(3.56)*	*(0.36)*	*(3.90)*	*(0.21)*	*(3.16)*
Earnings to Price Ratio (value)	0.02	-0.29	**0.72***	-3.46	**0.47***	**8.23***
	(0.35)	*(5.30)*	*(0.41)*	*(5.43)*	*(0.28)*	*(4.96)*
Dividend to Price ratio (value)	0.04	**7.84****	-0.41	5.25	-0.26	5.23
	(0.30)	*(3.86)*	*(0.49)*	*(7.31)*	*(0.27)*	*(3.67)*
Market Risk Premium (benchmark)	**-0.95****	-0.65	-0.06	-0.93	**-0.94****	-0.76
	(0.32)	*(1.14)*	*(0.41)*	*(0.94)*	*(0.26)*	*(0.85)*

notes: this table shows the generalized 1-period and the 10-period cumulative impulse responses for factor portfolio returns, calculated with respect to the methodology of Pesaran and Shin (1998). The endogenous variables included are CPI, IP, VIX, Spread between 10 year treasury rates and the Federal funds rate, the combined Overnight and Shadow rate dataset, the Federal funds futures, and the factor portfolio returns. The exogenous variables are a constant and the PPI for all commodities. The lag order of the VAR model is set to 3. Asymptotic standard errors for the impulse responses are shown in parantheses. * stands for statistical significance at the 10% level. ** stands for statistical significance at the 5% level. All significant impulse responses are emboldened.

Table 4:
Generalized impulse responses of factor sorted portfolios to one s.d. innovations in the one-month-ahead Federal funds futures

	Panel 1: 1994m01-2009m03		Panel 2: 2009m04-2016m02		Panel 3: 1994m01-2016m02	
Sorting criterion for decile portfolios	Impulse Response	Cumulative I.R.	Impulse Response	Cumulative I.R.	Impulse Response	Cumulative I.R.
Market Capitalization (size)	-0.24	0.18	**-1.35****	2.60	-0.42	-3.26
	(0.32)	*(6.11)*	*(0.43)*	*(6.90)*	*(0.28)*	*(5.28)*
Long Term reversal (momentum)	0.55	5.01	**-1.19***	-1.97	0.44	4.28
	(0.34)	*(6.18)*	*(0.68)*	*(12.08)*	*(0.32)*	*(6.24)*
Short Term reversal (momentum)	0.29	15.61	-0.05	8.05	0.12	10.27
	(0.59)	*(10.06)*	*(0.67)*	*(10.33)*	*(0.47)*	*(7.88)*
Momentum Anomaly	0.38	2.68	-0.60	-1.10	0.16	13.62
	(1.02)	*(13.12)*	*(0.63)*	*(4.05)*	*(0.83)*	*(11.17)*
Book Equity to Market Equity ratio (value)	0.00	-0.22	-0.63	1.32	-0.18	-4.48
	(0.213)	*(3.75)*	*(0.42)*	*(6.90)*	*(0.20)*	*(3.93)*
Cash-flow to Price ratio (value)	-0.02	3.05	-0.35	-2.93	-0.14	0.36
	(0.252)	*(3.67)*	*(0.36)*	*(4.06)*	*(0.21)*	*(3.36)*
Earnings to Price Ratio (value)	**0.46***	7.03	**-0.71***	0.06	0.21	1.32
	(0.35)	*(5.74)*	*(0.44)*	*(5.98)*	*(0.28)*	*(5.25)*
Dividend to Price ratio (value)	**1.12****	4.67	0.52	-6.80	**1.11****	4.92
	(0.29)	*(4.54)*	*(0.49)*	*(8.33)*	*(0.26)*	*(4.14)*
Market Risk Premium (benchmark)	-0.11	**1.72***	-0.36	1.44	0.08	0.92
	(0.32)	*(0.96)*	*(0.41)*	*(1.05)*	*(0.26)*	*(0.77)*

notes: this table shows the generalized 1-period and the 10-period cumulative impulse responses for factor portfolio returns, calculated with respect to the methodology of Pesaran and Shin (1998). The endogenous variables included are CPI, IP, VIX, Spread between 10 year treasury rates and the Federal funds rate, the combined Overnight and Shadow rate dataset, the Federal funds futures, and the factor portfolio returns. The exogenous variables are a constant and the PPI for all commodities. The lag order of the VAR model is set to 3. Asymptotic standard errors for the impulse responses are shown in parantheses. * stands for statistical significance at the 10% level. ** stands for statistical significance at the 5% level. All significant impulse responses are emboldened.

Table 5:

Generalized impulse responses of factor sorted portfolios to one s.d. innovations in the spread between 10-year treasury rates and the Federal funds rate

	Panel 1: 1994m01-2009m03		Panel 2: 2009m04-2016m02		Panel 3: 1994m01-2016m02	
Sorting criterion for decile portfolios	Impulse Response	Cumulative I.R.	Impulse Response	Cumulative I.R.	Impulse Response	Cumulative I.R.
Market Capitalization (size)	0.05	-1.78	**1.43****	**12.62****	0.29	2.81
	(0.31)	*(6.06)*	*(0.43)*	*(6.49)*	*(0.28)*	*(5.01)*
Long Term reversal (momentum)	-0.44	0.76	**3.01****	**18.62***	0.39	6.87
	(0.34)	*(5.98)*	*(0.65)*	*(11.41)*	*(0.32)*	*(5.81)*
Short Term reversal (momentum)	0.50	-10.41	**1.57****	6.71	**0.74***	-6.08
	(0.59)	*(9.70)*	*(0.66)*	*(7.81)*	*(0.45)*	*(7.48)*
Momentum Anomaly	-1.30	**33.45****	**-1.23****	-4.28	-0.96	**28.11****
	(1.02)	*(12.89)*	*(0.62)*	*(3.61)*	*(0.83)*	*(10.26)*
Book Equity to Market Equity ratio (value)	-0.28	-4.32	**1.34****	**10.92***	0.08	0.10
	(0.21)	*(3.84)*	*(0.41)*	*(6.62)*	*(0.20)*	*(3.74)*
Cash-flow to Price ratio (value)	-0.22	-4.24	-0.29	0.44	-0.31	-1.90
	(0.25)	*(3.87)*	*(0.36)*	*(4.24)*	*(0.21)*	*(3.17)*
Earnings to Price Ratio (value)	**-0.83****	-7.69	**0.70***	**10.82****	**-0.59****	-0.27
	(0.34)	*(5.85)*	*(0.40)*	*(5.62)*	*(0.28)*	*(4.92)*
Dividend to Price ratio (value)	**-0.81****	-5.99	**-2.77****	**-19.06****	**-1.05****	-4.64
	(0.29)	*(4.49)*	*(0.44)*	*(7.09)*	*(0.26)*	*(3.81)*
Market Risk Premium (benchmark)	0.23	**-2.36****	**1.64****	-0.01	**0.49***	**-1.73****
	(0.32)	*(1.13)*	*(0.39)*	*(0.95)*	*(0.27)*	*(0.77)*

notes: this table shows the generalized 1-period and the 10-period cumulative impulse responses for factor portfolio returns, calculated with respect to the methodology of Pesaran and Shin (1998). The endogenous variables included are CPI, IP, VIX, Spread between 10 year treasury rates and the Federal funds rate, the combined Overnight and Shadow rate dataset, the Federal funds futures, and the factor portfolio returns. The exogenous variables are a constant and the PPI for all commodities. The lag order of the VAR model is set to 3. Asymptotic standard errors for the impulse responses are shown in parantheses. * stands for statistical significance at the 10% level. ** stands for statistical significance at the 5% level. All significant impulse responses are emboldened.

5.3.2 Book Equity to Market Equity ratio (Value)

The value factor based on the book equity to market equity ratio (B/M) is constructed by taking the returns of the highest 20% B/M stocks and subtracting the returns of the lowest 20% B/M stocks. For the conventional monetary period subsample no significant results are found. On the basis of this value proxy, the monetary transmission channel seems to be inactive during this period. Therefore confirming the second subsample results by Kontonikas and Kostakis (2013).

The cumulative impulse response coefficient in Table 3, for the entire sample (Panel 3) indicates that there is an average monthly effect (10-month cumulative impulse response divided by 10) of 1.03%, significant at the 5% confidence level. This result is particular as no significant subsample impulse responses were found. During the unconventional monetary policy era, it is found that the spread between LT rates and ST rates is a good method of specifying unexpected monetary policy shocks. Table 5 shows that in response to unexpected monetary tightening shocks value (high B/M stocks) outperform growth (low B/M stocks). This is the case as the 1-period impulse response of the value factor is 1.34% and the average effect (10-month cumulative impulse response divided by 10) is 1.09%. Since this period was predominantly characterized by negative monetary shocks there is thus evidence that growth stocks outperformed value stocks. Therefore it seems that the monetary transmission channel, the credit channel in the case of value stocks, was inactive during this period. On the basis of the results for both subsamples and the entire sample period H03a is rejected:

H03a: The return on the value factor (high B/M stocks minus low B/M stocks) reacts negatively to contractionary monetary policy shocks.

5.3.3 Cash Flow to Price ratio (Value)

The value factor based on the cash flow to stock price ratio (CF/P) is insignificant in its impulse responses to unexpected monetary policy shocks across all three proxies for monetary policy across all three panels. Therefore H03b does not hold across the subsamples or the entire sample is rejected:

H03b: The return on the value factor (high CF/P stocks minus low CF/P stocks) reacts negatively to contractionary monetary policy shocks.

Gambacorta (2009) explains the influence which changes in monetary policy have on cash flows and thereby returns, which the author links to the risk taking channel and the credit channel. Therefore it is interesting that no impulse responses are found. The insignificant results can be explained in two ways.

Firstly, the credit channel and the risk taking channel (as discussed by Gambacorta, 2009) is not present during the sample period, a notion which seems to be refuted when looking at the other factor portfolio impulse returns (especially in Table 5, Panel 2). A second possibility is that cash flow to price ratios might be a poorer proxy for the value factor during the sample period.

5.3.4 Earnings to Price ratio (Value)

The VAR-model impulse responses of the earnings to price value factor (E/P), constructed through the returns of the highest quintile E/P stocks minus the returns of the lowest quintile E/P stocks are presented under Tables 3, 4 and 5. Firstly, the positive one-month impulse response under Panel 1, Table 4, with a coefficient of 0.46% indicates that value stocks are more sensitive to a contraction in monetary policy as compared to growth stocks, providing evidence for the credit channel. The respective cumulative impulse response takes the value of 7.03%, albeit insignificant, it does indicate that that a positive shock in the Federal funds futures (monetary loosening) leads to a higher value return on the basis of E/P. This result is confirmed when looking at Panel 1, Table 5, where a positive shock in the yield curve (monetary contraction) has a negative 1-month response of 0.83%. Again, the respective cumulative impulse response of -7.69% confirms the negative effect, however it is not significant.

When turning to Panels 2, there is again evidence that monetary loosening has a stronger positive effect on growth firms as compared to value firms (as was the case when studying the B/M value factor). A positive shock in the Shadow rate leads to a one period impulse response of 0.72% significant at the 10% level, a positive shock in the Federal funds futures leads to a one period impulse response of -0.71% significant at the 10% level, and a positive shock in the spread between LT and ST rates leads to a one period impulse response return of 0.70% significant at the 10% level. The respective cumulative impulse responses for the Shadow rate and the Federal funds futures indicates that the effect is temporary as they are not significantly different from zero. However the respective cumulative impulse response as a consequence of an unexpected shock in the yield curve proxy (Table 5) has the coefficient 10.82% significant at the 5% level. Thus there is evidence that monetary loosening during the unconventional monetary policy era benefits growth firms more than value firms.

When analysing the entire sample period, it is found that overall an unexpected contraction in monetary policy as measured by the Overnight and Shadow rate leads to an increase in the E/P value factor return. One standard deviation shocks in the Overnight and Shadow rate yield a one-month impulse response of 0.47% and a 10-month cumulative response of 8.23%, both significant at the 10% level. A shock in the spread between LT and ST rates yields a one month impulse response of -0.59% significant at the 5% level.

Therefore, according to Table 5, the monetary transmission channel is apparent during the 1994 – 2016 period and value stocks are more sensitive to monetary shocks as compared to growth stocks. Table 3 refutes this as it portrays contradicting results.

To conclude this subsection, from the significant impulse responses, the conventional period indicates that the credit channel is present (negative value factor returns in response to a monetary shock). Thus for the conventional monetary policy period H03c is not rejected. During the unconventional period positive value factor returns in response to a monetary shocks were found, indicating that the credit channel was inactive. Therefore for the second subsample H03c is rejected. For the entire sample mixed results were found and consequently H03c has to be rejected:

H03c: The return on the value factor (high Earnings/P stocks minus low Earnings/P stocks) reacts negatively to contractionary monetary policy shocks.

5.3.5 Dividend to Price ratio (Value)

When analysing the dividend to price (Div/P) value factor the first interesting result is that a positive shock in the Overnight rate leads to a positive cumulative impulse response of 7.84%, significant at the 5% level. This is a similar to the momentum anomaly which also manifests a significant and sizeable cumulative impulse response to a positive shock in the Overnight rate (see Section 5.3.8 for further explanation). Like the momentum anomaly the result for the Div/P factor return is counterintuitive as it would imply that growth firms are more sensitive to monetary contractions than value firms, which opposes prior empirical evidence (Thorbecke, 1997; Kontonikas & Kostakis, 2013; Maio, 2013). It is also opposed by the evidence provided in Panels 1 in Table 4 and Table 5 for the Div/P value factor. Where it is manifested that value stocks are more sensitive to a contraction in monetary policy relative to growth firms. On the basis of the insignificant results across Panel 1, Table 3, and due to the counterintuitive cumulative impulse response coefficients found for the momentum anomaly and the Div/P value factor, I therefore conclude that the Overnight rate is a very poor proxy for unexpected shocks in monetary policy (this argumentation is extended in Section 5.3.8).

For the conventional monetary policy subsample, Table 4 indicates that the dividend value factor exhibits a positive one-period impulse response of 1.12% at 5% significance level, the cumulative response indicates that there is a certain robustness to this one period impulse response as it is higher at 4.67%, albeit insignificant. Table 5 indicates that the dividend value factor shows a -0.81% impulse response to an unexpected shock in the yield curve (spread proxy). The respective cumulative response supports this 1-

period impulse response, as it is lower at -5.99%, albeit insignificant. Thus value stocks as measured through the Div/P ratio are more sensitive to a contraction in monetary policy relative to growth firms during the conventional monetary era providing support for the credit channel (across Tables 4 and 5).

During the unconventional monetary subsample period the spread between 10-year treasury rate and the Federal funds rate is again the proxy for monetary policy that yields significant results. Noteworthy is that the results of the dividend based value factor conflict with the results of the E/P and B/M value factors and with the size factor. According to the monetary transmission channel the value factors and size factors should all behave in similar ways. The results for the dividend based value factor are -2.77% and -19.06% in response to an impulse in the yield curve for the one period and cumulative impulse responses respectively. Both coefficients are significant at the 5% level. The economic interpretation is that value firms are more sensitive to the monetary transmission channel than growth firms.

The full sample also indicates that value firms are more sensitive to contractions in monetary policy than growth firms. This is indicated through the significant 1-period impulse responses in Table 4 and 5, Panel 3. These impulses aren't permanent as the respective cumulative impulse responses are insignificantly different from zero.

From this discussion it can be concluded that H03d is not rejected across all three (sub)-samples.

H03d: The return on the value factor (high Div/P minus low Div/P stocks) reacts negatively to contractionary monetary policy shocks.

5.3.6 Long Term Reversal (Momentum)

The VAR-model impulse responses of the Long Term (LT) reversal factor portfolio, constructed upon going long the stock portfolio with the lowest returns over the past 13-60 months whilst shorting the stock portfolio with stocks which exhibited the highest returns over the past 13-60 months, again confirm the results by Kontonikas and Kostakis (2013) that there are no factor returns in their second subsample (1984-2007). Indeed, irrespective of the proxy used for monetary shocks, there are no impulse responses or cumulative impulse responses which are significantly different from zero in Panel 1 for the Long Term reversal factor. The same goes for the results under Panels 3 for the entire sample period. The period of unconventional monetary policy however, presented under Panels 2, indicates that the LT reversal factor return is impacted by unconventional monetary policy shocks. When the Federal funds futures is used to specify monetary shocks, the 1-period impulse response is -1.19% and significant at the 10% level. This effect is not structural according to the 10-period cumulative impulse response which is slightly lower at -

1.97% albeit insignificant. As expected from the correlations in Table 2, a positive response is found when using the spread to define shocks in monetary policy. The 1-period impulse response return is 3.01% and the 10-period cumulative impulse response is 18.26%, significant at the 5% level and 10% level respectively.

The economic interpretation of these results does not conform to the overreaction/ oversensitivity hypothesis. During the period of unconventional monetary policy companies which performed well in terms of stock returns over the past 13-60 months outperformed stocks which performed poorly during this timeframe as a result of a negative (expansionary) monetary policy shocks.

With respect to the fourth hypothesis, the results indicate that H04a is rejected with respect to the conventional monetary policy subsample and with respect to the entire sample as no significant impulse responses are found. For the unconventional monetary policy era the fourth hypothesis is also rejected:

H04a: The return on the Long Term Reversal momentum factor (13 to 36-months loser minus 13 to 36-months outperformer stocks) reacts negatively to contractionary monetary policy shocks.

5.3.7 Short Term Reversal (Momentum)

The VAR-model impulse responses of the Short Term (ST) reversal factor portfolio, constructed through subtracting the return of the quintile with the highest returns over the past 1 month from the quintile with lowest returns over the past 1 month shows that there is no significant impact from monetary shocks for Table 3 and Table 4. Largely indicating that monetary policy is not a risk factor influencing the behaviour of 1 month stock momentum.

There is some evidence which contradicts this conclusion however, again originating from Table 5 where the spread between long term rates and short term rates is employed to specify monetary policy shocks. Significant 1-period impulse responses are found for the Panels 2 and 3, significant at the 5% and 10% level respectively. Both impulse responses are positive indicating that past month loser stocks outperform past month winner stocks during contractionary (positive) monetary shocks. As the impulse response coefficient is significant at the 5% level during the unconventional monetary period, and significant at the 10% level during the entire sample period it can be assumed that the significance of the impulse response in Panel 3 is largely due to the significance of the impulse response in the second subsample. Furthermore, since the unconventional monetary policy era was characterized by expansionary monetary policy (negative monetary policy shocks) the interpretation is that past month winners thus performed better than past month losers in response to unexpected shocks. This again refutes the overreaction hypothesis. On the basis of the insignificant cumulative responses in Panels 2 and 3, it is evident that this effect is temporary and mean reverts towards zero.

Thus, one month (short term) stock momentum returns are not significantly influenced by monetary policy shocks, this is conclusive over all three (sub)-samples, H04b is rejected:

H04b: The return on the Short Term Reversal momentum factor (1-month loser minus 1-month outperformer stocks) reacts negatively to a contractionary monetary policy shocks.

5.3.8 Momentum Anomaly

The momentum factor is produced when buying the top performers over the past 2-12 months and selling the poorest performing firms over this time period. Firstly, contrary to the results by Kontonikas and Kostakis (2013) there is a significant response during the conventional monetary policy era. In Panels 1 of Table 3 and Table 5 no significant first period impulse responses are found, however the cumulative 10-period impulse response is significant at the 5% level and is of sizeable nature. This indicates that market participants are not overreacting (since the 1-period impulse response is insignificant) in response to the shock but that the contractionary monetary policy enacted influences winner stock returns relative to loser stock returns. In Table 3, Panel 1, the cumulative response is -33.25% to a positive one standard deviation shock in the Overnight rate whilst in Table 5, Panel 1, the cumulative response is 33.45% to a positive one standard deviation shock in the spread between long term and short term rates. As can be seen from Table 2, the spread variable has a small positive correlation coefficient with the Overnight rate, however what is striking is that the cumulative impulse response in both Panels 1 of Table 3 and Table 5 are almost the same in size yet inverse. This effect found in the conventional monetary period dominates the entire sample period when inspecting the results in Panels 3. Where a significant negative cumulative impulse response of 26.71% is found for Table 3 and a significant positive cumulative response of 28.11% is found for Table 5.

As stated in Section 5.3.5 the result from Panel 1, Table 3 is not in line with expectations. In Section 5.3.5 it was discussed that possibly the Overnight rate is a poor proxy for unexpected monetary policy shocks, however it is also possible that these results are related to outliers within the momentum factor return dataset during the crisis years related to the Nasdaq bubble and the Global financial crisis. Even so, the endogenous variable VIX should partially explain the momentum factor returns during the crisis periods in the VAR model.

From Panel 1, Table 3, it is to be inferred that winner stocks are more sensitive to a tightening of monetary policy as compared to loser stocks. Where winner stocks perform on average 3.33% worse per month than loser stocks in response to rate tightening (average is calculated on the basis of the 10-month cumulative impulse response divided by 10). When studying the sub-period analysis by Kontonikas and Kostakis (2013), particularly the period 1984-2007, they too find that the decile portfolio with the highest 2-12 months returns has an negative impulse response which is larger than the impulse response of the decile with the stocks with the lowest 2-12 month returns in response to a positive shock in the Federal funds rate. Their result is however not statically different from zero.

Furthermore, this results is counterintuitive to the results as expected by Liu and Zhang (2008) who expect winner stock returns to be less sensitive to monetary policy shocks as compared to loser stocks in response to monetary tightening. This is because winner firms have a higher expected growth in productivity and investment. Indeed it was hypothesized that, according to the excess sensitivity channel, investors punish past losers more extremely than past outperformers in response to rate tightening shocks. This hypothesis is rejected on the basis of the impulse response to a shock in the Overnight rate.

However when studying Table 5, Panel 1, a more intuitive result is found with respect to the cumulative impulse response, now we do find evidence for the excess sensitivity channel. With an unexpected positive shock in the yield curve/ spread between long term and short term rates (contractionary monetary policy), a positive cumulative response is found where winner stocks perform on average 3.35% better per month than past loser stocks (the 10-month cumulative impulse response divided by 10). However, the magnitude of this coefficient is of some concern as discussed above (this is possibly linked to outliers in the momentum factor returns).

During the unconventional monetary policy era (Panel 2), a significant 1-period impulse response is found when using the spread as a specification for unexpected unconventional monetary policy shocks. A negative coefficient of 1.30% significant at the 5% level implies that, during a period of monetary expansion, winner stocks outperformed loser stocks as a result of unexpected (negative) monetary policy shocks. This result is in line with the other significant results found for the LT and ST reversal portfolio returns during the unconventional monetary policy period.

In conclusion, since the results from Table 3, Panel 1, are deemed inconclusive, Table 5 is considered for the conventional monetary policy sample period. Therefore H04c is not rejected for the conventional monetary policy period. For the unconventional monetary subsample no permanent effect is found (since the cumulative impulse response is insignificantly different from zero) and therefore H04c is rejected. For the entire sample period Table 5 is again considered and therefore H04c is not rejected:

H04c: The return on the Momentum Anomaly factor (2 to 12-months outperformer minus 2 to 12-months loser stocks) reacts positively to contractionary monetary policy shocks.

6. Conclusion & Recommendations

The research aims to provide additional insight into fluctuations of factor returns in relation to monetary policy. The risk factor highlighted in this study is unexpected shocks in monetary policy. The conventional monetary period as well as the unconventional monetary period from January 1994 to March 2016 is studied. Monetary policy shocks are measured in three ways. The conventional way is through the Overnight rate, but since markets are forward looking this might not be the ideal way to measure unexpected monetary policy shocks. Therefore the Federal funds futures are also used to measure monetary policy shocks. As the period analyzed also includes an era of unconventional monetary policy other proxies for unexpected monetary shocks were also necessary. Therefore the Wu-Xia Shadow rate and the spread between long term treasury rates and the Federal funds rate are considered. Factor based portfolio returns are then investigated so as to see whether monetary policy shocks impact stocks with specific characteristics differently.

Overall the analysis indicated that the Overnight rate is a malfunctioning proxy when the purpose is to measure factor portfolio responses to unexpected monetary policy shocks. The results for the factor returns upon a shock in the Overnight rate in Table 3 contradict regularly to previous academic findings and to the results presented in Tables 4 and 5. However, as seen from the appendices, the Overnight rate is functional in macroeconomic VAR models. The Shadow rate is shown to be a good proxy for finding responses to unconventional monetary policy surprises in the stock market. However it is only able to uncover some significant factor portfolio returns. The spread between long term treasury rates and the Federal funds rate is a better proxy as compared to the Shadow rate for measuring unexpected shocks in monetary policy. Shocks in the spread between long term rates and short term rates uncover impulse responses which are similar to the impulse responses from a shock in the Shadow rate. However the spread proxy also finds significant impulse responses for factor portfolios which a shock in the Shadow rate does not recognise. This is an important conclusion and is also in accordance with expectations since the Federal Reserve actively targeted the yield curve during the unconventional monetary policy period (e.g. Operation Twist). The Federal funds futures are also interesting proxies for monetary policy shocks. The sign and magnitude of the factor portfolio returns which ensue from a one standard deviation shock in the Federal funds futures concur with the returns found when the shock was specified by the spread proxy for monetary policy shocks.

Furthermore the Federal funds futures is a better proxy for unexpected monetary policy shocks as compared to the Overnight rate as it includes the expectations of market participants and is therefore forward looking.

The forward looking proxies for monetary policy shocks (the Federal funds futures and the spread between the 10-year treasury and the Federal funds rate) perform better in identifying monetary policy shocks as compared to the Overnight rate. This is attributed to the Federal Reserve's policy break in 1994 were it decided to become a more transparent institution by providing more forward-guidance to market participants (Maio, 2013). The reason that Kontonikas and Kostakis (2013) find no significant factor portfolio returns in the 1984 – 2007 subsample can be related to this breakpoint. The results for the Federal fund futures in Table 4, Panel 1, indicate that there are 1-period value factor returns present in response to monetary policy shocks (when the proxy for value is E/P or Div/P). Something which Kontonikas and Kostakis could not uncover since their VAR model did not include forward looking measures/ market participant expectations. Therefore this paper provides support to the case made by Rudebusch (1998) who poses the question *"do measures of monetary policy in a VAR make sense?"* in the title to his research. Indeed forward looking measures based on financial markets need to be integrated in a VAR model in order for the model to be valid and accurate.

With respect to the factor returns, the hypothesis in relation to the size factor expected a negative relation with unexpected monetary policy shocks. During the conventional monetary policy period no significant results were found, which is in line with the findings by Kontonikas and Kostakis (2013). During the unconventional monetary policy period positive impulse responses were found in response to a contractionary shock in monetary policy. According to the size factor, this indicates that the risk channel and the credit channel were not present during the sample period.

For the value factors, generally coherent results are found with an exception for the dividend to price proxy for value. The general hypothesis, just like the size factor, is that the value factor reacts negatively to unexpected monetary policy shocks due to the credit transmission channel and the risk premium channel. The book equity to price and the cash flow to price ratios both indicate that no significant impulse responses are found during the conventional monetary policy period. Again results which confirm that the monetary transmission channel is inactive during this period in line with the results by Kontonikas and Kostakis (2013). The earnings to price ratio value proxy disputes this as significant first period impulse responses are found to shocks in the Federal funds futures or in the spread between LT and ST rates proxies. Where value stocks are influenced disproportionately more as compared to growth stocks in the light of a contractionary monetary shock. This does provide evidence for the risk premium channel and the monetary transmission channel. However, according to the insignificant cumulative impulse responses these effects are not structural. Therefore in general the hypothesis that the value factor reacts negatively to unexpected conventional monetary policy shocks does not hold. With respect to the value factors during the unconventional monetary policy period the (cumulative) impulse responses of the book equity to price value proxy and the earnings to price value proxy react positively to a shock in the spread between 10 year treasury rates and the Federal funds rate. However the dividend to price proxy indicates the opposite effect during the unconventional monetary policy period. On the basis of the book equity ratio and the earnings to price ratio the hypothesis for value has to be rejected, meaning that the credit channel or the risk premium channel were inactive during the unconventional monetary policy subsample. Lastly, the entire sample manifests mixed results and therefore the hypothesis that the value factor is negatively impacted by unexpected monetary policy shocks is inconclusive.

During the unconventional monetary period the size factor and the proxies for value (with exception for the dividend based value proxy) indicate that growth firms and large capitalization firms had a higher exposure to monetary shocks as compared to value firms and small capitalization firms. Since the monetary shocks were predominantly of expansionary nature this means that growth firms and large capitalization firms had higher returns as a consequence of monetary policy shocks. Value firms are more likely to be credit constrained (Fama and French; 1995). This should explain why the returns of value stocks are more responsive to rate hiking cycles. However, the fact that positive value factors are found across the different proxies during the unconventional subsample can be explained by the ZIRP. Since interest rates are at the lower bound (close to zero percent) the credit channel is likely inactive. This is indicated by the results in Panels 2 (with an exception for the value factor defined by the Dividend to Price ratio). The reason for the outperformance of value stocks against growth stocks in response to a contractionary shock in monetary policy (especially in Table 5) rather than the effect being zero indicates that there is a monetary transmission channel present. Since the impulse responses are insignificant when the shock is defined by the Shadow rate or the Federal funds futures, the monetary transmission channel present has to be related to the yield curve (the difference between long term and short term interest rates). Further research should try to expose the nature and the working of this monetary transmission channel in more detail. The risk premium channel could possibly be taken as a starting point for this analysis, because the market risk premium (the benchmark in Tables 3, 4 and 5) is insignificantly different from zero during the unconventional monetary policy subsample. This indicates that the risk premium channel was inactive during the unconventional monetary period, which can partially explain why the size and value factor returns are positive rather than negative. This is unlike the effects found for the conventional subsample and the entire subsample were the market risk premium reacts negatively to an unexpected shock in monetary policy.

With respect to the momentum proxies, the general hypothesis formed is that past outperformers have a higher return than past underperformers in response to a contractionary shock in monetary policy. In general it is found that for the momentum factors constructed on the past 1 month returns no significant factor returns are found in response to an unexpected shock in monetary policy. Thus monetary policy is not a risk factor with respect to short term momentum. For longer term momentum, constructed on the past 2-12 months (momentum anomaly) returns and the past 12-36 months (Long Term reversal) returns, monetary policy shocks do lead to permanent impulse responses. The impulse responses are positive in response to monetary tightening shocks and therefore confirm the null hypothesis of market overreaction/ oversensitivity to monetary policy changes. This indicates that loser stocks are more sensitive to monetary policy shocks in line with Bernanke and Kuttner (2005).

This paper has practical implications. The idea for this paper arose when the stock markets were pricing in the first rate hike in more than a decade by the Federal Reserve which eventually occurred on December the 16th, 2015. After more than a decade of expansionary monetary policy such a transition back to conventional monetary policy could prove interesting in its impact on the stock markets. Therefore the aim was to create a combined model which could provide answers on stock characteristics and their respective returns over both conventional and unconventional monetary eras. Economic and political developments have limited the Federal Reserve in its path towards rate normalization over the first half of 2016. Therefore it is evident that unconventional monetary policy and its impact on stock returns will remain relevant in the foreseeable future. The consequences of unconventional monetary policy on stocks with different characteristics should be studied in more depth. The VAR model which this study proposes could be enhanced such that factor return forecasts can be made for the normalization period. Another interesting topic for further study, on the basis of the results that winner, growth and large capitalization firms perform better than loser, value and small sized firms in response to unconventional (expansionary) monetary policy shocks is its impact on employment and growth. Small firms are known to add more to economic growth and employment than large firms (Birch, 1997; Edmiston, 2007; Moscarini & Postel-Vinay, 2012). Therefore on the basis of the above results and on the basis of the Federal Reserve's target to reduce unemployment, the question should be posed whether the Federal Reserve has been targeting the right companies through its unconventional monetary policies.

7. Limitations

Several noteworthy limitations are addressed in this section and plausible solutions to these limitations are suggested.

A first limitation with respect to the Federal funds futures proxy for monetary policy shocks is that, although a good predictor as portrayed by Gürkaynak et al. (2007) and Hamilton (2009), it is not perfect. Nosal (2001) shows that fed funds futures may overestimate the expectations on the Feds Funds rate during interest rate hike periods (and vice versa during decreases in interest rate periods). This means that there is the possibility that the Federal funds futures variable contains a small amount of bias. A recommendation for future research is to use the Eurodollar futures as a robustness check.

Another interesting caveat raised by Carlson et al. (2005) with respect to the Federal funds futures as a forward looking proxy is that the accuracy of the Federal funds futures is diminished at the inception of a recession. This is intuitive as economic shocks are more difficult to foresee, therefore the communication which is aimed at providing transparency about future policy is less relevant and leads to forecasting errors by the market. This is particularly relevant in this study since the year 2008 is included in the sample period. A partial solution for this issue was the inclusion of the VIX in the VAR model as a control variable.

Monetary shock identification is done through one standard shock changes in the proxies for monetary policy: the Overnight rate, the Shadow rate, the Federal funds futures and the spread between LT and ST rates. Other identification techniques are also possible and should be considered in further research. Identification through heteroscedasticity (Rigobon, 2003) is one plausible method. Its advantage being that it can serve as a robustness check for the identification techniques used in this paper. Haitsma et al. (2016) use identification through heteroscedasticity for this purpose. Rogers et al. (2014) also use identification through heteroscedasticity together with the dates of central bank announcements for identifying monetary policy shocks.

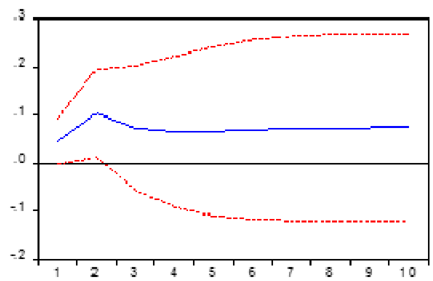
A last limitation worth discussing is that the factor portfolios created on the basis of stocks listed under the AMEX, NYSE or the NASDAQ may be influenced by external variables which are not included in the VAR model. Monetary policy enacted by the ECB is a relevant example. A solution might be to include a proxy for ECB monetary policy in the VAR model. However, VAR models have a limited amount of variables which they can include as there is a limit to the degrees of freedom. Therefore one cannot add any amount of variables to the VAR model. An assumption the VAR model therefore makes is that US stocks are solely influenced by US monetary policy and US macro variables. Many studies employing VAR models make this assumption (Kontokinas & Kostakis, 2013; Haitsma et al., 2016). Bayesian VARs often do allow for more variables to be included, therefore with such an approach the VAR model could be expanded to take into account European monetary policy.

8. Appendices

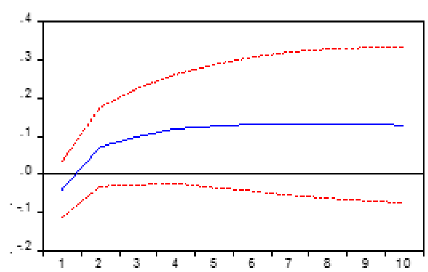
Appendix 1: Replication of the Kontonikas & Kostakis model over the 1994m01- 2016m02 period

Endogenous variables: CPI, IP, Excess Market Return, Commodity Price Index, Strongin, Target Fed. Funds Rate, Exogenous variable: Constant, Lags:1. The blue line denotes the impulse response, the red lines denote ± 2 standard deviations.

Generalized Impulse Response of CPI to a Shock in the Fed. Funds Rate:



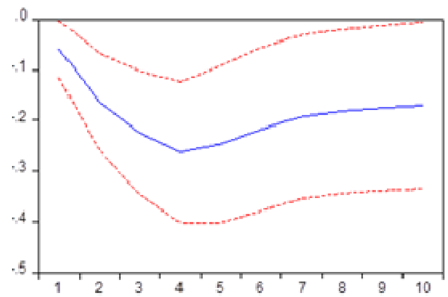
Generalized Impulse Response of IP to a Shock in the Fed. Funds Rate:



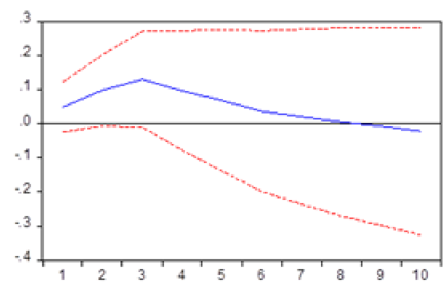
Appendix 2: Generalized Impulse Responses of the Macroeconomic Control Variables to a shock in the Overnight rate (1994m01 – 2009m03)

Endogenous variables: CPI, IP, Excess Market Return, VIX, Overnight rate, Fed. Funds Futures, Spread between LT and ST rates, Exogenous variable: Constant, PPI (all commodities), Lags:3. The blue line denotes the impulse response, the red lines denote ± 2 standard deviations.

Generalized Impulse Response of CPI to a Shock in the Overnight Rate:



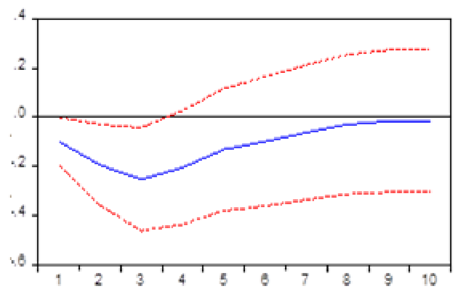
Generalized Impulse Response of IP to a Shock in the Overnight Rate:



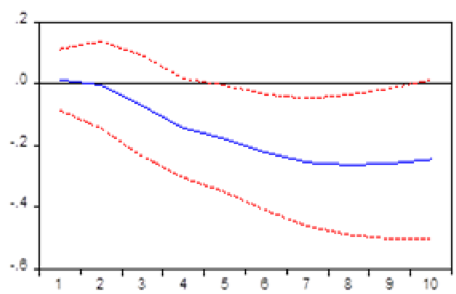
Appendix 3: Generalized Impulse Responses of the Macroeconomic Control Variables to a shock in the Shadow rate (2009m04 – 2016m02)

Endogenous variables: CPI, IP, Excess Market Return, VIX, Shadow rate, Fed. Funds Futures, Spread between LT and ST rates, Exogenous variable: Constant, PPI (all commodities), Lags:3. The blue line denotes the impulse response, the red lines denote ± 2 standard deviations.

Generalized Impulse Response of CPI to a Shock in the Shadow Rate:



Generalized Impulse Response of IP to a Shock in the Shadow Rate:



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