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Evaluating the Risk Premium in the Cross-Section of Commodity Futures

by

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Abstract

Departing from the increased interest in and beneficial characteristics of investments in commodity futures evident in the literature. This paper evaluates the existence of factors that may explain the cross-section of commodity futures through macro, equity and commodity specific factors. The models employed are estimated through the Fama-Macbeth two step approach on individual contracts as test assets, instead of the more common approach of using portfolios as test assets. The dataset consist of 15 continuous time series of agricultural, metal and energy futures prices over a timeframe of nearly 30 years. We evaluate whether the capital inflow into commodity futures has had a significant effect on the explanatory power of our models. Further, a test for the continued segmentation between equity and commodity markets is conducted. Our findings show that the commodity futures market is segmented, as evident in the low explanatory power of the macro and equity motivated factors. We do not find any factor that can effectively price the cross-section of commodity futures in our dataset. Lastly, we identify a slight improvement of the explanatory power of some of our models relative to previous research. We credit this to the increase in capital inflow to commodity futures, as argued by previous research.

Keywords: Commodity Futures, Risk Premium, Asset Pricing Models, Fama-MacBeth, Specific Factors.

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1 Introduction

The exchange of commodities is not a new occurrence. People and nations have been trading between themselves ever since we realized that trade meant we could consume a more diverse basket of goods. This has created the foundation for a market that today is a diverse and intricate environment where commodities and various derivatives exchange hands on a daily basis. With a severe financial crisis in recent history, low interest rates and deteriorating potential in traditional asset classes, alternative investment prospects have received more attention (Kat & Oomen, 2007). Further, the growth apparent in developing countries such as China, India and Brazil (amongst others) leaves investors to expect that, over time consumption will increase and thus, commodity prices as well. Thus the scope of investors has expanded in the search of new alternative investment products to facilitate hedging and diversification. Research has shown that post 2008, commodity investments received an increase in interest with little evidence to halt the trend (Tang & Xiong, 2012; Lübbers & Posch, 2016). The rise in popularity can largely be attributed to their low correlation with equities while maintaining an expected return comparable with equities (Erb & Harvey, 2006; Bodie & Rosansky, 1980; Gorton & Rouwenhorst, 2006; Daskalaki & Skiadopoulos, 2011).

Leading this development is the commodity futures and index funds (Daskalaki & Skiadopoulos, 2011). The rationale behind the bias towards contracts and indices rather than the underlying asset, is that these assets have been shown to be more liquid and thus easier to trade (Hull, 2015). Hence, for an investor with the goal of managing risk and performance in asset allocations, commodity futures and indexes provide an appealing asset class. An important note is that investing in commodity futures and indexes has received more attention from institutional (large) investors relative to that of small investors. It appears irrational that small investors have forgone the opportunity of including an asset with the capabilities of reducing risk with low impact on return in a well-balanced portfolio. One intuitive reason behind this may be that the large investors have the prerequisites to analyze and price these contracts effectively and smaller investors have not been able to do this to the same extent.

Research show that strategies focused on investments in futures and indices produce average returns comparable with the S&P 500 index, while simultaneously being negatively correlated with equities (Bodie & Rosansky, 1980; Gorton & Rouwenhorst, 2006). Erb and Harvey (2006) show in a simple example that the historical return of the commodity index (GSCI) and the historical return of the S&P 500 give similar results. Further, when combined with equal weights the two indices in a portfolio give the same return but with a lower risk. This leaves an initial insight that including commodity futures in a portfolio could potentially be a good hedge whilst maintaining returns. However, investors understand that evaluating investment prospects should include some analysis other than historical analysis. In the case of equities this is a well-developed area where several models and frameworks have been developed to assess the characteristics of asset returns, one of which is asset pricing models.

The main purpose of the asset pricing literature is to create and discover a model that has the ability to explain the risk premium of a financial asset with the use of some factor. The research on factors attempt to identify a common factor that can be used to explain the risk premium in a broad setting. In the literature there are several distinguished models that have shown successful, for example macro factor models and equity motivated factor models. In the equities universe these models have been tested frequently, therefore the existing literature is extensive. However, in the case of applying models and factors to futures the research is less extensive. Existing research has arrived at conflicting results regarding when and if theories that perform well on equities perform adequately when applied to futures. Further, factors designed to be specific for commodities also struggle to provide any conclusive evidence and the conflicting evidence has in some studies been credited to the segmentation between equities and commodities. Commodities are a very broad set of products ranging from consumption goods that are driven largely by supply and demand, such as corn and wheat, to more speculative goods as precious metals. There are also commodities that do not fit into one single category but is instead a combination of these, such as oil. Further, futures are suspected to be heterogeneously structured, emphasizing the conflicting evidence on commodity specific factors. However, there is evidence suggesting that there are subsectors within commodities that exhibit characteristics that might enable the application of a common factor on the specific sector.

As previously mentioned, investing in futures and indices has been receiving more attention in recent times. This is an important observation for the notion of a heterogenous commodity futures market. Previous research has shown that futures have been subject to a period of large capital inflows after the early 2000s and as a result commodities have become increasingly more correlated with each other (Tang & Xiong, 2012).[1] Therefore, there is a possibility that theory and models that have been unable to take the heterogenous structure into account in the past may have more success now. Further, Tang and Xiong showed that the financialization has increased the correlation between commodities internally, again strengthening the relevance of evaluating commodity specific factors with an updated dataset.

Drawing on the conflicting evidence in previous research on the existence of common factors that explain the cross section of futures risk premium. This paper is motivated by the increasing interest along with the documented financialization of futures, bringing the heterogeneous structure of futures into question again. We examine this by using a set of asset pricing models to an updated data set. Firstly, the macro factor models and equity motivated factors are tested on the dataset to evaluate the segmentation between the two markets. Later the commodity specific factors are employed to evaluate the heterogenous structure of the futures market. The study will attempt to answer the following research questions.

1. *Has the capital inflow into the commodity futures market influenced the explanatory power of asset pricing models in the cross-section?*
2. *Is there a heterogenous structure within commodity futures?*

[1] This is referred to as the financialization of commodities by Tang and Xiong (2012).

2 Literature Review and Theoretical Background

2.1 Previous Literature

The asset pricing literature aims to develop theory and methods to price the cross section of returns through a common factor. This is to enable the analysis of investment decisions on a more effective scale for anyone who wants to make better informed decisions on asset allocation. Research has shown that there are factors that are idiosyncratic to a specific asset or a specific set of assets; however the goal of the literature is to develop a systematic factor that has the power to explain the broad cross section of assets. In the asset pricing universe we are familiar with several factors that have been developed and tested to price assets. Three examples of accepted factors are market, value and size made famous by Eugene Fama and Kenneth French (1993). However, while being well developed and accepted the asset pricing literature has been considered successful in the pricing of equities but less successful in other areas. When pricing the cross section of commodities the literature is more conflicting and a consensus may be hard to identify.

In the context of testing the effectiveness of asset pricing theory on commodity futures, earlier research does this in the time series dimension. Time series research investigate the assets individually mainly through two different approaches. Firstly, through a stochastic discount factor (SDF) and secondly through commodity specific factors. In the SDF domain Dusak (1973) investigated whether commodity futures have a risk premium related to the systemic risk in the market. Her research takes the classical CAPM model and found that the premiums on three commodity futures were insignificantly different from zero. This is in line with Bodie and Rosansky (1980) who found that the price changes in chosen commodity futures carried virtually no systematic risk. Breeden (1980) expanded this research and found that when the number of commodities is extended and an alternative model is introduced (CCAPM), there is evidence to support the notion of risk premiums arising in some commodities.

In the domain of commodity specific factors the research is mainly motivated by the hedging pressure hypothesis (Cootner, 1960; Keynes, 1930) and the theory of storage (Working, 1949; Brennan, 1958).[2] Motivated by the shortcomings in the research by Dusak (1973) where a very small sample of commodities and a mis specified model was used. Carter, Schmitz and Rausser (1983) provide additional research investigating the existence of a risk premium provided by the CAPM model and introduced a relaxation to the assumptions made by Dusak (1973). It was showed that when investors were allowed to be net long as well as net short in addition to the existence of a well-diversified portfolio containing not only common stock but also commodity futures, significant systematic risk was present in the contracts (Carter, Schmitz & Rausser, 1983). Hirshleifer (1989) studied the existence of risk premiums in commodity futures created by the covariation of futures to stock market returns and found evidence suggesting that output and demand shocks are positively correlated giving rise to a premium.

More recent studies in asset pricing theory on commodity futures, attempt to discover observable factors that have the power to price the cross section of commodity futures. The research attempts to fit different extensions of the CAPM model to identify factors explaining the risk premium, while letting the beta to vary across commodities. Jagannathan (1985) tests the CCAPM on a small set of three commodity futures and reject the model over monthly horizons. de Roon and Szymanowska (2010) find that the CCAPM explain some of the systematic variation but only at quarterly horizons. However the authors call for further investigations in other more specified versions of models that better account for the nature of commodity contracts. Further, Daskalaki, Kostakis and Skiadopoulos (2014) reject all macro factor and equity motivated factor models in their paper. Studies investigating factors more directly related to commodities find evidence supporting the existence of factors that explain the risk premia of commodity futures. Additional research suggests that once one controls for commodity specific factors the risk premium is insignificant (Miffre, 2012). Basu and Miffre (2013) find that hedging pressure can be used to capture risk premiums by constructing portfolios that exploit the amount of interest in a specific contract from hedgers and speculators. To the contrary Gorton, Hayashi and Rouwenhorst (2012) reject hedging pressure as a factor but find support for inventory related factors to contain information about risk

[2] The theory of storage and hedging pressure hypothesis is further discussed in section 2.3.1 and 2.3.2 respectively.

premiums. Bakshi, Gao and Rossi (2013) also find evidence supporting the inventory related factors to report significant risk premiums. Daskalaki, Kostakis and Skiadopoulos (2014) test the pricing power of several commodity related factors, basis, momentum and hedging pressure. They reject hedging pressure in line with Miffre (2012) and find no significance for the inventory related factors (basis and momentum) to price the commodity futures, in contrast to Bakshi, Gao and Rossi (2013). However, the research by Daskalaki, Kostakis and Skiadopoulos (2014) use individual futures returns in contrast to portfolios, which is deviant from the majority of the other asset pricing literature. They argue that since the futures market have few commodities and thus too few portfolios can be formed. This will in turn suppress the heterogenous structure of individual commodities.

Tang and Xiong (2012) reported that since the early 2000s the prices of non-energy commodities have become increasingly more correlated with oil prices. They argue that this increase is largely due to the financialization of commodity futures arising from an increased capital inflow to commodity index investing. Lübbers and Posch (2016) second these results by showing that the entire commodity sector is increasingly more correlated with oil and gold prices also credited as a result of an increased inflow of capital. The findings by Tang and Xiong (2012) and Lübbers and Posch (2016) suggest the assumption of heterogenous commodities may have lost some importance.

2.2 Macro and Equity Motivated Asset Pricing Models

This study employs several asset pricing models that have been frequently mentioned and tested in previous research relevant for this paper. The following is an account of the theory behind them, for the estimation of the models in this study please refer to section 3.3. Denote the beta construction for the K-factor asset pricing model:

$$E(R_i) = \beta_i' \lambda, \qquad i = 1,2,\dots,N, \tag{1}$$

Where R_i represent the excess return of futures i , β_i is the $(K * 1)$ vector of betas for return of futures i with exposure to factor k, and λ is the $(K * 1)$ factor risk premium vector.

In financial economics one of the more frequently discussed topics is the balance between risk and expected return. The widespread CAPM (Sharpe, 1964), is a widely accepted one-factor asset pricing model that was one of the early models to offer a measurable rationale. The model describes the relation between an assets expected excess return and its exposure to market risk. The model states that if an asset exposure to risk increases (decreases) the expected return of said asset increase (decrease) (Campbell, Lo & MacKinlay, 1997). The beta formulation in this model is:

$$\beta_i = \frac{Cov(R_{i,t+1}, \mathrm{R}_{m,t+1})}{Var(R_{m,t+1})} \tag{2}$$

The Consumption-CAPM (CCAPM) is an extension to the original model which focuses on the consumption beta rather than the market beta. The rationale behind the model is that commodity prices should be related to aggregate consumption as higher consumption for a commodity, should increase the demand for the product and consequently also induce an increase in price of that specific commodity (Breeden, 2005; Erb & Harvey, 2006). The CCAPM links macroeconomic conditions with the commodity market as the expected return and the risk premium of a commodity future is defined by an investor’s growth in aggregate consumption (Jagannathan, 1985). The intuition behind the model is rather simple since an increase in consumption expenditure should also lead to greater demand and thus an increase in price. The consumption beta is defined as:

$$\beta_{i,c} = \frac{Cov\left(R_{i,t+1}, g_{c,t+1}\right)}{Var\left(g_{c,t+1}\right)} \tag{3}$$

$$where: g_{c,t+1}=(\frac{\mathrm{C}_{\mathrm{t+1}}}{\mathrm{C}_{\mathrm{t}}})\text{-}1)$$

Where g_{t+1} and C_t is consumption growth and consumption at time t respectively.

Previous research has given support to monetary policy influencing the prices of different commodities (Anzuini, Lombardi & Pagano, 2013). The existence and growth of money increase the volume of transactions and trades while reducing transaction costs of acquiring consumptions goods. The decrease of transaction costs in turn affects the consumers marginal utility of wealth and thus also has an impact on the choices that consumers take in the market (Daskalaki, Kostakis & Skiadopoulos, 2014).

The money beta formulation:

$$\beta_{i,m} = \frac{Cov\left(R_{i,t+1}, g_{m,t+1}\right)}{Var\left(g_{m,t+1}\right)} \tag{4}$$

$$where: g_{m,t+1}=(\frac{\mathrm{M}_{\mathrm{t+1}}}{\mathrm{M}_{\mathrm{t}}})\text{-}1)$$

In the equities universe Fama and French (1993) found that small companies as well as companies with a high book to market ratio tended to outperform bigger firms along with firms with a low book to market ratio. The popular three factor model of Fama-French (1993), which adds size and value to the market risk factor in the CAPM, is widely accepted when it comes to pricing equities and bonds. In addition, Carhart's four factor model (1997) expands the Fama-French setting by adding a momentum factor which has shown to be an additional significant factor in the pricing of equities (Jegadeesh & Titman, 1993). Momentum refers to the tendency of equity returns to maintain a positive trend if they have been positive in the past, and thus continue to suffer from negative returns if the opposite is true. Recent studies have shown that a liquidity risk factor significantly prices the cross-section of equities, stating that if the price of equities decrease and volume transactions are high, returns will reverse with a stronger magnitude than if transactions are normal (Pástor & Stambaugh, 2003). Together, these factors have been recognized to give details about the cross-section of equities.

2.3 Commodity Specific Factors

2.3.1 Theory of Storage

Since future contracts are reliant on an underlying asset these contracts carry different types of risk. Namely, the risk related to inventory levels, cost of storage and interest rates at any given time. Running out of a commodity in storage, due to a production shortage or an increase in demand would influence the price. Hence, a commodity with a high inventory level would be less subject to fluctuations in production or demand and vice versa (Erb & Harvey, 2006). This phenomenon has been referred to as the convenience yield and states that if inventories are low the convenience yield is high and if the opposite is true the convenience yield is low (Kaldor, 1939). The latter is considered more favorable when considering price risk since the commodity carries a lower risk of being out of storage. This approach to the theory of storage, while being intuitive to understand, is complicated to apply. Today there is no obvious provider of data on storage costs or convenience yields and the data available is rarely of the same format (Daskalaki, Kostakis & Skiadopoulos, 2014). Since commodities are produced and traded globally observing inventory levels is difficult and therefore the theory of storage is challenging to implement.

Previous research provides two different perspectives on the theory of storage (Fama & French, 1987). The first perspective associates to the theory of storage as mentioned above, where the difference between spot and futures price consists of storage costs, interest rates and the convenience yield.[3]

$$F_t, T - S_t = S_t r_t + w_t - c_t \tag{5}$$

Where S_t is the spot price at time t, F_t, T is the commodity futures contract value for delivery at date T, r_t is the interest charge on a dollar from t to T, w_t is the storage cost per unit of commodity and c_t is the convenience yield from an additional unit of inventory. As previously mentioned this approach comes with some difficulties since these variables are not directly observable, as discussed above. Therefore, an alternative solution credits the difference between spot and futures price to market expectations of the risk premiums and fluctuations in spot prices.[4] In this paper the latter will be henceforth referred to when addressing the theory of storage since it provides a straightforward and practical approach.

According to Chaves and Viswanathan (2016) by expressing the price of the nearest contract available and the spot price as $F_t^{(1)}$ and S_t respectively one gets the excess return from investing in the nearest term contract and selling it in the second nearest term with the following equation:

$$R_{t+1} = \frac{S_{t+1}}{F_t^{(1)}} = \frac{S_{t+1}}{S_t} * \frac{S_t}{F_t^{(1)}} \tag{6}$$

Taking logs on each side, rearranging and computing the expected value at time t we get:

$$s_t - f_t^{(1)} = E_t[r_{t+1}] - E_t[\Delta \mathrm{s}_{\mathrm{t+1}}] \tag{7}$$

Where lower case letters correspond to log-variables. The left-hand side of equation 7 corresponds to the basis, the right-hand side correspond to the expectations about the risk premiums ($E_t[r_{t+1}]$) and the fluctuations in spot prices ($E_t[\Delta \mathrm{s}_{\mathrm{t+1}}]$) (Chaves & Viswanathan,

3 For a more in depth reading see Kaldor (1939), Working (1949) and Brooks, Prokopczuk and Wu (2013).
4 For a more in depth reading see Dusak (1973) and Chaves and Viswanathan (2016).

2016). As can be seen in equation 7, the basis makes it possible to understand the expectations of speculators in the futures market. For example, if a future is quoted at a price lower than the spot price, consequently the basis takes on a positive value and the speculators on the market either believes that commodity futures should give a positive return since they expect an increase in the futures price, or they believe in a negative spot price change when the spot price decreases. Hence, if the basis is instead negative, the reverse relationship holds true.

2.3.2 Hedging Pressure Hypothesis

Futures markets exist largely to enable investors to diversify and decrease the probability of an unwanted price change to occur in the future. Namely investors want to "hedge" their positions (Keynes, 1930). The hedging pressure hypothesis, derived from the underlying rationale for the existence of future markets, treats the relation between investors going long and investors going short. For hedging to take place in the futures market a hedger sells its inventory on a contract stating that he needs to deliver the goods at some point in the future. For this to occur, a counterpart must be willing to accept this transfer of risk in price fluctuations on the underlying good (Keynes 1930). By the hedging pressure hypothesis, the counterparty in this case will require compensation for this risk and thus if a contract has a demand of short sellers that exceed that of long, there will be a higher risk premium required on the stated contract (Cootner, 1960).

The hedging pressure hypothesis has been extended by several research papers and it has been shown to be a determinant of risk premiums in commodity futures by some research (Hirshleifer, 1989; Hirschleifer, 1990; de Roon, Nijman & Veld, 2000; Stoll, 1979). Notably, Hirshleifer, (1989; 1990) introduced the effects of non-participation on risk premiums arising from the change in hedging pressure due to the deterrence of certain investors in the market. As shown by Basu and Miffre (2013) introducing hedging pressure sorting for the choice of commodities in a portfolio can significantly improve its risk adjusted excess return.

Constructing the hedging pressure variable is straightforward and intuitive. In Daskalaki, Kostakis and Skiadopoulos (2014) the authors calculate the hedging pressure as $HP_{i,t}$ for commodity contract i at time t:

$$HP_{i,t} = \frac{\#\ of\ Short\ Hedges - \#of\ Long\ Hedges}{Total\ \#\ of\ Hedges} \tag{8}$$

When commodity i has a positive $HP_{i,t}$, a positive return would be expected from a long position and vice versa for a short position (Daskalaki, Kostakis & Skiadopoulos, 2014).

2.3.3 Momentum in Commodities

A debate is still ongoing concerning the risk premia of momentum and its underlying factors and despite many years of empirical research the debate is still alive. Momentum is considered to be driven by a number of different underlying factors and it is established in empirical data. For equities, one of many suggestions is presented by Jegadeesh and Titman (1993) who explain momentum as a result of investor overreaction to news. Market participants consider new information with higher relevance and puts more emphasis on this than older news (Asness & Moskowitz, 2013). Hence, investors in the stock market are compensated with a risk premium for bearing the risk associated with the markets tendency to overreact to both negative and positive news (Bondt, Werner & Thaler, 1987). That momentum constitutes of psychological effect as a consequence of new information is according to literature a fact. However, there exist alternative explanations for the existence of momentum beyond psychological. A conclusion made by Asness and Moskowitz (2013) is that there exist a significant relationship between liquidity risk and momentum. The intuition is that assets with a high past performance are subject to a higher liquidity risk than other assets and therefore, investors are requiring a risk premia. However, Asness and Moskowits (2013) conclude that the relationship between liquidity risk and momentum is small despite the fact of significant values.

The commodity market differs somewhat to other assets as the market is connected to a physical market. Gorton, Hayashi and Rouwenhorst (2012) argue that momentum in this market is driven by the storage level of the commodity. They show that a high momentum portfolio picks commodity futures with a low level of storage while the low portfolio does the contrary. Clearly, this suggest that momentum and the basis is related and might be the reason for that previous research conducted on commodity specific factors finds significant risk premiums for momentum and the basis (Szymanowska, et al., 2014; Bakshi, Gao & Rossi, 2013; Yang, 2013). Hence, the existence of risk premiums and its relation to momentum in commodity markets is explained as the underlying dynamic associated to the level of inventories of the commodity. Since commodity futures are subject to speculation, investors in the commodity market investing in speculative futures might be compensated for the phycological behavior of investors, in a similar way as for the equity markets.

2.4 Market Segmentation, Integration and Heterogeneity

One of the major concerns to consider when models developed in the area of equities are applied to commodities, is the notion that equity and commodity markets appear to be segmented (Erb & Harvey, 2006; Kat & Oomen, 2007; Daskalaki, Kostakis & Skiadopoulos, 2014; Bessembinder, 1992; Gorton & Rouwenhorst, 2006). This raises an important notion, when testing a dataset consisting of commodities the structure of said market is of importance when analyzing the results. However, there is no obvious and straightforward way to test for the integration of the two markets. The equity motivated models offer an attractive solution to this. In line with previous research testing whether the macro factor models and equity factor models are able to price the cross section of commodity futures gives an indication on the integration (Bessembinder, 1992; Daskalaki, Kostakis & Skiadopoulos, 2014).

Further, commodities also appear to be heterogeneous (Kat & Oomen, 2007; Daskalaki, Kostakis & Skiadopoulos, 2014; Erb & Harvey, 2006). Thus, if commodity contracts behave individually, factors aimed to explain the cross section of returns should prove to have difficulties in doing so. Erb and Harvey (2006) show that the correlations between commodities are generally low and especially across commodities in different sectors. They do however provide support for some notable correlation between commodities within the same sector. Kat and Oomen (2007) second these results by stating that correlations between sectors of commodities are low and insignificant while within sectors higher correlations can be found. Investing in commodities and their futures is a relatively new strategy for investors that first gained traction in the early 2000s and has since, mainly through index investing become a more common occurrence (Tang & Xiong, 2012). This has led to the financialization of commodities and raises an alternative perspective to the above-mentioned issue of the heterogeneous structure of commodity futures. Research has shown that commodity markets are becoming increasingly more correlated as investment across the markets increased (Tang & Xiong, 2012; Aït-Youcef, 2018). These findings suggest that the heterogeneity of commodity futures may be weakening over time and its significance may deteriorate in the future.

As mentioned above, research has shown that despite the heterogeneous structure there are correlations between commodities to be found. Erb and Harvey (2006) show that slightly improved correlations can be found within sectors of commodities. Namely, the sectors metals, energy and agriculture show some evidence of internal correlation. Further, Lübbers and Posch (2016) and Daskalaki, Kostakis and Skiadopoulos (2014), find that principal component analysis identifies that the explanatory power for common factors in these sub groups are significantly higher than for the whole commodity sector. This leaves an important insight when choosing to segment commodities with the goal of applying methods to price the cross section of their excess returns.

2.5 Normal Backwardation and Contango

Normal backwardation originates from John Maynard Keynes (1930) when he argued that futures markets exist to enable hedging. Short hedgers who are eager to relocate the risk of a price decrease of a specific commodity to a speculator, must provide an incentive for the counterparty to take on said risk. This is facilitated by setting the futures price today at a discount. Thus the price of the future contract will move up towards the expected future spot price, hence it is normally backwardated. This insight suggest that futures prices should be less than the expected spot price for the underlying commodity and a positive return could be realized as the futures price converge to the spot (Erb & Harvey, 2006). Thus, according to normal backwardation, going long in futures contracts will earn an excess return equal to the cost of insurance to hedge a specific price risk. Therefore, a long only portfolio of futures should theoretically yield positive returns (Erb & Harvey, 2006). However, no conclusive evidence for the existence of normal backwardation can be found today. The hedging pressure hypothesis offers a rationale behind the conflicting evidence. Since hedgers necessarily not only have to be short but can also go long the hedging pressure hypothesis allows for this. This is intuitive since a firm could be exposed to both long and short exposures to commodities. Consider a producer where production is heavily reliant on a single raw material, this firm would be exposed to risk of an increase in raw material price. In this case the producer might want to go long in that commodity future to counteract this risk. Thus in the hedging pressure hypothesis a futures contract can be in both contango and backwardation instead of normal backwardation (Cootner, 1960).

3 Methodology and Data

3.1 Data Collection

The study follows a comparative examination approach, to extend on prior research that covers time-series and the cross-section (Dusak, 1973; Bodie & Rosansky, 1980; Daskalaki, Kostakis & Skiadopoulos, 2014; Shang, Yuan & Huang, 2016). To be able to evaluate the performance of the models in the study, we compare the models by their ability to explain the variation in commodity futures returns and the corresponding risk premiums. We collect the commodity futures returns as secondary data provided by Thomson Reuters and the data are then statistically investigated. The chosen time interval is January 1989 to December 2017 which comprises almost 30 years of data about the commodity futures markets.

The aim of this study is to investigate risk premiums of commodity futures in a cross-sectional setting and factors that may explain them. All commodity futures data are collected from the same source, Thomson Reuters which provide us with commodity futures and futures spot prices in continuous time-series format. We will follow the approach suggested by Bianchi, Drew and Fan (2015) where the continuous time-series is pre-constructed by the data supplier Thomson Reuters. We have data on 15 different commodities trading on the Intercontinental exchange (ICE), Chicago Board of Trade (CBT) and the New York Mercantile Exchange (NYM).

To compute the commodity futures risk premium in the macro motivated factor setting, the equity motivated factor setting and the commodity motivated factor setting, we make use of the risk-free rate, in line with previous research we proxy this with the one-month US Treasury Bill retrieved from Thomson Reuters. For the capital asset pricing model (CAPM) the Fama-French market factor is collected from Kenneth French's website.[5] The consumption variable in the consumption capital asset pricing model (CCAPM) is calculated with data from nondurable consumption in NIPA table 2.3.5. Due to the limited data

5 The Fama-French market factor constitutes of the value weighted return of all stocks in the United States listed on AMEX, NASDAQ and NYSE.

availability of this variable, the model tis estimated with quarterly frequency. The money variable in MCAPM and MCCAPM is proxied by the seasonally-adjusted M2 money available by the Federal Reserve Bank of St. Louis. For the equity motivated factors we obtain data of the market, value, size and momentum variable from Kenneth French's website while the liquidity factor in the Fama-French-Carhart-Pastor and Stambaugh model is obtained from Robert Stambaugh website. For the basis variable, we make use of the data already collected as well as their corresponding spot prices collected from Thomson Reuters. Data for the hedging pressure factor is obtained from the US Commodity Futures Trading Commission where we collect the open long and short interest of hedgers (commercial traders) for each commodity contract.

3.2 Data Construction

Except from downloading preconstructed available data, this study requires calculation and construction of variables.[6] The consumption growth variable in CCAPM is constructed as the monthly percentage change in consumption of nondurable goods and the money factor in MCAPM and MCCAPM is calculated as the monthly percentage change in the seasonally-adjusted M2 money.

For the commodity specific factors, we construct three different zero-cost portfolios in line with Daskalaki, Kostakis and Skiadopoulos (2014). For the hedging pressure, when the open short and long interest of hedgers net out to be positive, hedgers are assumed to be net short that commodity. This entails that, as previously stated, a strategy going long in the commodity with a positive hedging pressure should yield a positive return. If the hedging pressure is negative, hedgers are assumed to be net short and a negative return of the same strategy would be expected. Hence, we create a mimicking portfolio by calculate the hedging pressure as in equation 8 each month for every individual future contract and construct a high minus low hedging pressure (HML_{HP}) factor by taking a long (short) position in a portfolio consisting of futures with positive (negative) hedging pressure and vice versa at each point in

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6 Preconstructed variables in this study are the market factor, value, Size, Momentum and liquidity in CAPM, MCAPM, the Fama-French three-factor model, Fama-French-Carhart model, Fama-French-Carhart--Stambaugh model.

time t. Commodities are subject to inventory risk related to the chance of a shortage of the commodity in the market. If a specific commodity has high inventory levels the risk of suffering an unwanted increase in prices is lower than if the same commodity would have a low inventory level. As previously discussed, the inventory levels of commodities are difficult to observe and therefore the basis offers an alternate solution to the problem. A commodity with a relatively high basis suggests a low storage level for the commodity. Research has pointed out that a portfolio containing commodities subject to a relatively high basis has been superior in performance, in terms of returns, than a portfolio with commodities that have a relatively low basis (Gorton & Rouwenhorst, 2006; Fama & French, 1987). Given these studies and the associated theoretical framework put forward in literature, we create a basis factor that corresponds to this relationship. Thus with the same rationale as in the hedging pressure, the portfolios formed on the basis as a risk factor will take long positions in commodities with high basis and short positions in low basis. The monthly basis variable is calculated in accordance with equation 7. We construct this factor by creating a high minus low basis (HML_B) portfolio based on the same rationale as for hedging pressure, a long (short) position in futures with a relatively high (low) basis and vice versa at each point in time t.

The momentum factor has a somewhat trivial intuition behind it, simply suggesting that if returns have been positive in the past, they tend to continue to be positive. Gorton, Hayashi and Rouwenhorst (2012), apply the momentum ideology to commodities and present evidence supporting that momentum is existent in these assets as well. However the intuition behind it is somewhat different. In commodities the momentum factor relates to the price increase from a shortage in inventories and the prolonged price increase due to the processing time to restock inventories. To exploit the risk of prolonged price increases we have constructed a momentum factor that again exploits the same strategy as previously mentioned. We calculate the momentum at each point in time t as the past twelve-month average return, skipping the most recent month in accordance with Asness and Moskowitz (2013) and then construct a high minus low momentum risk factor (HML_{MOM}) by taking a long position in the commodities with positive (negative) past twelve-month return and again contrariwise for the short portfolio. In accordance with Asness and Moskowits (2013) we measure momentum by the use of the twelve last month's cumulative raw return, excluding the nearest month's return which is common practice in momentum literature.

We repeat the above-mentioned process and construct mimicking portfolios consisting of commodity futures with the 4 highest positive and 4 lowest negative hedging pressure, basis and commodity specific momentum. For all commodity specific factors, subsequently we compute the mimicking portfolio excess return the first day of the next month the portfolio is then rebalanced. The process is repeated for the entire sample period creating a time series of the portfolio excess returns when exposed to the three commodity specific factors.[7]

3.3 Econometric Method

In order to evaluate the research question appropriately, this paper will apply relevant models and associated factors existent in previous research. The purpose of this paper is not to develop a new or superior model but rather to evaluate the performance when applied to a recent dataset. Therefore, the most relevant models existent in related literature will be applied with the purpose of testing the applicability of on a broad set of commodity futures, see table 1. A priori, the macro-factor and equity motivated factor models are expected to have little explanatory power as mentioned in section 2. However, they are included and tested on our dataset since this offers a test for the integration of the two markets. Further, to account for the heterogenous structure of our dataset, the futures will be grouped based on theory from section 2.4 and tested again. We compare the constructed factors to their theoretical behavior and empirical evidence in an attempt to evaluate their reliability. Consequently, we evaluate the set of macro, equity and commodity motivated factor models by their ability to explain the variation in commodity futures returns as well as the significance level and magnitude of the reported coefficients of the factors and constants.

7 We will however not present the results for these mimicking portfolios, more on this in section 3.4.

Table 1 Asset Pricing Models

Macro-Factor Models
CAPM
CCAPM
CAPM + Money Growth (MCAPM)
CCAPM + Money Growth (MCCAPM)
Equity Motivated Factor Models
Fama-French three-factor model (FF3)
Fama-French, Carhart four-factor model (FF4)
Fama-French three-factor model and Pastor-Stambaugh Liquidity factor (FF3+L)
Fama-French, Carhart four-factor model and Pastor-Stambaugh liquidity factor (FF4+L)
Commodity Specific Models
Equity Motivated Factor Models
Hedging Pressure risk factor
Basis Risk factor
Momentum risk factor

Note: A list of the asset pricing models employed in this paper

The models presented in table 1 are estimated with the Fama-Macbeth (1973) two pass regression. The cross-sectional general model for N futures is:

$$\boldsymbol{R}_t = \gamma_{0t}\iota + \gamma_{1t}\boldsymbol{\beta}_m \boldsymbol{X}_t \boldsymbol{\Gamma}_{2t} + \varepsilon_t \tag{9}$$

Where R_t is the $N * 1$ vector of futures excess returns for time t, ι is a $N * 1$ vector of ones and β_m is the $N * 1$ vector of β:s, $\Gamma_{2t} = (\gamma_{2t}, \gamma_{3t}, \dots, \gamma_{k+1,t})'$ is the $(k * 1)$ vector of the coefficients for the k additional explanatory variables, $\boldsymbol{X}_t$ and ε_t is the error term with mean vector 0 and intertemporally homoscedastic covariance matrix Ψ_t. The method applies two steps in order to estimate the model above. Firstly, since the betas are assumed not to be known this has to be estimated. The following time series regression is estimated to accomplish this:

$$\begin{aligned}
R_{1,t} &= \alpha_1 + \beta_{1,F_1}F_{1,t} + \beta_{1,F_2}F_{2,t} + \cdots + \beta_{1,F_m}F_{m,t} + \varepsilon_{1,t} \\
R_{2,t} &= \alpha_2 + \beta_{2,F_1}F_{1,t} + \beta_{2,F_2}F_{2,t} + \cdots + \beta_{2,F_m}F_{m,t} + \varepsilon_{2,t} \\
&\vdots \\
R_{n,t} &= \alpha_n + \beta_{n,F_1}F_{1,t} + \beta_{n,F_2}F_{2,t} + \cdots + \beta_{n,F_m}F_{m,t} + \varepsilon_{n,t}
\end{aligned} \tag{10}$$

Where, $R_{i,t}$ is the excess return of future i (total = n) at time t, $F_{j,t}$ is factor j (total =m) at time t, β_{i,F_j} are the factor loadings on factor j for excess return of future i and t goes from 1 to T. This results in n estimates of $\hat{\beta}$ (beta is constant over time) used in the second step where T cross-sectional regressions of futures excess returns on $\hat{\beta}$ are estimated:

$$\begin{gathered} R_{i,1} = \gamma_{1,0} + \gamma_{1,1}\hat{\beta}_{i,F_1} + \gamma_{1,2}\hat{\beta}_{i,F_2} + \cdots + \gamma_{1,m}\hat{\beta}_{i,F_m} + \varepsilon_{i,1} \\ R_{i,2} = \gamma_{2,0} + \gamma_{2,1}\hat{\beta}_{i,F_1} + \gamma_{2,2}\hat{\beta}_{i,F_2} + \cdots + \gamma_{2,m}\hat{\beta}_{i,F_m} + \varepsilon_{i,2} \\ \vdots \\ R_{i,T} = \gamma_{T,0} + \gamma_{n,1}\hat{\beta}_{i,F_1} + \gamma_{n,2}\hat{\beta}_{i,F_2} + \cdots + \gamma_{n,m}\hat{\beta}_{i,F_m} + \varepsilon_{i,T} \end{gathered} \tag{11}$$

Where, γ are the regression coefficients that estimates the factor risk premium for each factor, γ goes from 1 through n as for every regression i. This in turn produces $m + 1$ series of $\hat{\gamma}_j$ (including the constant) for each time period with length T. By averaging the $\hat{\gamma}_j$ over time we obtain the risk premium $\hat{\gamma}_j$ for each factor F_j that are analyzed by calculating the t-statistic:

$$t_{stat,j} = \frac{\hat{\gamma}_j}{\hat{\sigma}(\hat{\gamma}_j)} \text{ , } j = 0,1, \dots, m \tag{12}$$

Where

$$\hat{\gamma}_j = \frac{1}{T}\sum_{t=1}^{T}\gamma_{j,t} \tag{13}$$

And

$$\hat{\sigma}^2(\hat{\gamma}_j) = \frac{1}{T}\frac{1}{T-1}\sum_{t=1}^{T}\left(\hat{\gamma}_{j,t} - \hat{\gamma}_j\right)^2 \tag{14}$$

$t_{stat,j}$ has a t distribution with $T - 1$ degrees of freedom.

The errors in variables problem that arise when estimating the betas in the first step of the regression, may cause an underestimation of the beta value and overestimation of additional coefficients. A common approach to reduce this problem is to use portfolios instead of individual assets. However, as previous research argues for a heterogeneity structure in commodity futures, the construction of portfolios as test assets in a study of heterogenous assets might possibly make estimates of the risk premiums inefficient and mask some of the relevant information contained within the assets (Daskalaki, Kostakis & Skiadopoulos, 2014). Hence, in this study we will adhere using individual commodity futures returns to assign the beta values for each asset in the first step of the regression. Cochrane (2005) illustrates that coefficient estimates after regressing a cross-sectional second pass are indistinguishable from the estimates resulting after averaging the coefficients every chosen time-period. Balvers and

Huang (2009) argues that under the notion of beta stationarity, it is ideal to estimate betas exploiting the full sample at hand. Given these arguments, we employ the Fama-Macbeth (1973) two-pass method using the full sample period when regressing the cross section of the fifteen individual commodity futures excess returns. Using a large timeframe when estimating the beta will in turn reduce the sampling variance, which will help with the errors in variables problem. This will in turn increase the denominator used to estimate the betas in the first step regression. Additionally, to correct for outliers in our dataset, we winsorsize the data by replacing the top and bottom 1% of the observations in the data with the largest value not considered an outlier.

3.4 Quality and limitations of data

The dataset in this research is secondary and obtained via publicly available databases, we make use of continuous time series constructed by the data supplier for the futures prices and thus we have restricted control over the quality. Also, there are variables constructed by the authors in this paper and thus bears the risk of human error.

The commodity futures are chosen due to their diversity and ability to comprise 30 years of data. There exist shortcomings of the use of commodities futures portfolios as test assets. To begin with, there exist only a limited and relatively small number commodities and futures and only a narrow range of portfolios can be constructed. This drawback creates econometric difficulties for the models that we test. Further, there is a possibility that the construction of the portfolios can hide the heterogeneous features of specific commodities that can result in efficiency losses and in turn yield estimates of the risk premiums that are misrepresenting. However, the data available for the commodity futures, macro, equity and commodity specific factors are used in past empirical studies to efficiently interpret the models we are testing (Balvers & Huang, 2009; Basu & Miffre, 2013; Daskalaki, Kostakis & Skiadopoulos, 2014; Bianchi, Drew & Fan, 2015). Note that, there exists additional commodities in the futures market that due to selection criteria have been excluded in this study. Thus, arguments can be made to recommend an alternative combination of commodities futures based on different selection criteria.

To test for the stationarity in the data, we performed an augmented Dickey-Fuller test where the null hypothesis of unit root presence is rejected. Hence, we do not have a problem with stationarity in our sample. Further, the econometric model described above can also suffer from multicollinearity problems. To study this we conduct the variance inflation factor (VIF) and use the rule of thumb, VIF≥10, signifying multicollinearity. We find that we do not have a problem with multicollinearity either.

One part of this paper tests the ability of a constructed factor mimicking portfolio to explain the cross section of commodity futures risk premiums. Our approach to this is to create portfolios that take long (short) positions in commodities that score high (low) in a commodity specific factor. However, one can argue that traditional high minus low portfolios only takes positions in the commodities (in our case) present in the top (bottom) 20%. We do not argue with this logic and thus we have constructed factor mimicking portfolio that follows this rationale. Our results and consequently the reason for their absence in the paper is that they do not improve the performance of our tests. When we attempt to explain the cross section of commodity futures risk premiums with factors that are constructed by taking positions in only the contracts with the highest scoring, we receive lower t-stats and R^2 compared to our alternate approach. These results can be obtained on request.

4 Empirical results and discussion

4.1 Descriptive statistics

The descriptive statistics for the 15 commodity futures excess returns from the timespan January of 1989 to December of 2017 are presented in table 2. The annualized mean, standard deviation, Sharpe ratio, maximum and minimum value for each commodity future are presented accordingly.

Table 2 Descriptive Statistics: Future Excess Return

	Mean	Std Dev	Sharpe Ratio	Max	Min
Agricultural					
Cocoa	2.40%	29.10%	0.08	38.27%	-23.25%
Coffee	4.30%	38.30%	0.11	58.38%	-31.42%
Corn	1.70%	26.70%	0.06	32.37%	-34.17%
Cotton	2.10%	28.50%	0.07	24.14%	-22.97%
Soybean	1.40%	25.60%	0.05	31.86%	-35.51%
Sugar	6.20%	42.00%	0.15	19.02%	-17.79%
Wheat	1.10%	27.90%	0.04	61.36%	-44.87%
Metals					
Copper	3.90%	25.90%	0.15	58.31%	-36.39%
Gold	2.10%	15.90%	0.13	40.27%	-28.47%
Palladium	10.10%	32.80%	0.31	28.89%	-30.06%
Platinum	1.00%	21.90%	0.05	25.97%	-26.21%
Silver	4.60%	28.50%	0.16	20.98%	-29.25%
Energy					
Heating Oil	8.00%	34.60%	0.23	38.70%	-52.70%
Natural Gas	10.80%	49.80%	0.22	38.71%	-20.62%
WTI Oil	7.20%	32.50%	0.22	35.58%	-35.17%

Note: Descriptive statistics for the 15 separate commodity futures studied in this research from the time-period January 1989–December 2017. The table report the annualized mean returns, standard deviations, annualized Sharpe ratios, maximum and minimum returns for monthly frequencies.

The highest average excess return can be found in the Natural Gas and Palladium futures and the nearest contender, Heating Oil is trailing by roughly two percent. As a group the energy commodities present the highest average return and the agricultural commodities the lowest as a group. When taking the standard deviation into account energy has the highest average standard deviation and Natural Gas the highest of them all. Gold appears to have the lowest standard deviation out of all the commodities. The Sharpe ratios present a measure for the risk adjusted performance in each commodity and again the energy futures present the greatest risk adjusted average excess return both individually and as a group. The worst performer is again the agricultural futures where their weaker average excess return along with a relatively similar standard deviation to the rest of the futures gives a low Sharpe ratio. Interestingly Palladium produce a superior risk adjusted average excess return amongst the commodities outperforming the second best with 0,07.

4.2 Assessing the Asset Pricing Models

4.2.1 Macro factor models

The data presented in table 3 consist of the constants, risk premia and the corresponding $R^2$and adjusted R^2 from the Macro-factor models obtained from the Fama-Macbeth cross-sectional regression. The CAPM and MCAPM are estimated with monthly frequency as well as quarterly, and the CCAPM and MCCAPM only with quarterly frequency.

Evident in table 3, all traditional macro factor models are inadequate at explaining the variation of commodity futures excess returns since they all produce insignificant risk premiums. The traditional CAPM setting carries out insignificant risk premiums on both monthly and quarterly frequencies with low adjusted R^2 of 0.00%. The weak explanatory power of the CAPM is in line with earlier research on the commodity futures market. For further reading on this topic, see Daskalaki, Kostakis and Skiadopoulos (2014) and Jagannathan (1985).

From table 3, the risk premia for the consumption variable in the CCAPM is insignificant and positive. We do however report a relatively high adjusted R^2 of 60.41% for the model that include the consumption factor. This result indicates that the consumption factor proposes some explanatory power of the cross-sectional variation of commodity futures returns, but in spite of this the outcomes of the model is not sufficient in terms of t-values. Results presented by de Roon and Szymanowska (2010) find significant values and a goodness of fit of the CCAPM on commodity futures returns of 54%. de Roon and Szymanowska (2010) also showed that the CCAPM does not perform well under monthly frequencies as the model barely explains any of the variation of commodity futures excess returns. The reason for this may be the consequence of the sluggishness associated with demand and supply elasticities of the underlying commodities, giving further arguments in favor of the hypothesis that relates increased consumption to have a positive impact on commodity futures returns. In their study de Roon and Szymanovska (2010) implement the Fama-Macbeth regression in a similar way as we do, namely by estimating the entire sample period, and not rolling betas in the first step of the regression. Nevertheless, we retrieve smaller, yet insignificant consumption risk premiums for the commodity futures contracts we are examining and this may be due to the choice of commodity futures contracts. Given the result of de Roon and Szymanovska and the fact that the CCAPM explains around 60% of the variation in our sample of commodity futures return, we cannot reject that this factor may be important in pricing futures returns as well as explaining the variation in them. Thus commodity futures prices may to some extent be related to aggregate consumption and the supply and demand of the underlying commodity.

When running the regression including the money growth factor, MCAPM and MCCAPM, the explained variation of the model is highly increased in comparison to the traditional CAPM, yet still low, with an adjusted R^2 of 12.90% for the MCAPM on monthly frequency and 15.24% on quarterly frequency. The MCCAPM gives an adjusted $R^2$of 57.46 on quarterly frequency. All models, regardless of frequency gives insignificant risk premiums suggesting that money growth has no real implication in the pricing of the cross-section of commodity futures excess returns. The high adjusted R^2 in the MCCAPM is probably due to the inclusion of the consumption factor as discussed above, giving further arguments in favor of the importance of this factor for commodity futures returns. Daskalaki, Kostakis and Skiadopoulos (2014) present a similar result implying that the market factor traditionally used in the CAPM-setting and the money growth factor has none or little effect on the excess returns of commodity futures.

Table 3 Macro Factor Models

	Monthly Frequency		Quarterly Frequency			
	CAPM	MCAPM	CAPM	CCAPM	MCAPM	MCCAPM
Constant	0.003	0.002	0.0171	0,006	0.009	0.007
t-stat	*1.437*	*0.859*	*2.433*	*0.734*	*1.028*	*0.796*
Market	-0.003	-0.003	0.010		-0.007	
t-stat	*-0.281*	*-0.256*	*0.353*		*-0.210*	
Consumption Growth				0.003		0.003
t-stat				*1.227*		*1.177*
Money Growth		-0.001			-0.002	0.000
t-stat		*-0.954*			*-1.037*	*-0.117*
R^2	2.16%	25.35%	2.91%	63.24%	27.34%	63.53%
$Adj. R^2$	0.00%	12.90%	0.00%	60.41%	15.24%	57.46%

Note: Results for the macro factor models studied in this research. We assess the CAPM and MCAPM at monthly frequencies and CAPM, CCAPM, MCAPM, MCCAPM on quarterly frequencies. We use the Fama–MacBeth (1973) method to estimate the risk premiums for the models. Presented in the table is the constant, risk premiums, t-statistics, R^2 and adjusted R^2. Results are presented for monthly and quarterly frequencies. The test assets are the 15 separate commodity futures studied in this research from the time-period January 1989–December 2017.

4.2.2 Equity motivated factors

In this part of our study we test the equity motivated factors that are found successful in pricing equities in previous studies. We run the three-factor-model originally presented by Fama-French model (1993), Carhart's (1997) momentum extension to the Fama-French model as well Pastor and Stambaugh (2003) liquidity factor extension, their abbreviations can be found in table 1. Results are presented in table 4.

Adding the Fama-French (1993) size and value factors to the market factor, increases the explanatory power of the model. The adjusted R^2 increases from 0% in the CAPM to 21.91% in the Fama-French three-factor-model, yet all risk premiums are insignificant indicating that the equity motivated factors in the original Fama-French (1993) setting have none or little effect in explaining the variation in returns of commodity futures. Adding Carhart's (1997) momentum factor to the Fama-French setting (1993) decreases the adjusted R^2 to 14.14% and again with insignificant risk premiums. Adding the liquidity factor to the Fama-French setting and the Fama-French-Carhart setting, again produces insignificant risk premiums but the goodness-of-fit of the model increases to 35.09% for the Fama-French with liquidity model and 32.56% for the Fama-French-Carhart-Pastor-Stambaugh model. The outcomes of the equity motivated factors regressed on the commodity futures returns underline the incapability equity factors have on describing commodity futures returns and is in line with previous research (Erb & Harvey, 2006; Daskalaki, Kostakis & Skiadopoulos, 2014). According to Cochrane (2005) if a factor is verifiable and acknowledged to successfully price a specified market both theoretically and empirically, the same factor should be able to price other markets as well (Daskalaki, Kostakis & Skiadopoulos, 2014). The low explanatory power and rejection of all risk premiums in the equity motivated factor models shows the equity factors low ability to price commodities futures and our finding give support for the belief of segmentation between equities and commodity futures markets.

Earlier views on the segmentation between commodity futures and equities markets are divided. Our results are in line with the ones of Bessembinder (1992) and Daskalaki, Kostakis and Skiadopoulos (2014) who presents results in support of segmentation between the markets. Our results do however differ in the sense that our models in general produce a better fit for the data and the value and liquidity factor produce higher t-statistics. This may be due to the results presented by Tang and Xiong (2012) who found that given commodities and commodity indices increased influence as an investment vehicle for large asset managers, pension funds and other financial institutions, the asset class is becoming more "financialized" recent years and henceforth is likely to integrate the equities and the commodity futures markets to a larger extent. As our data includes futures returns up until 2017, this may be the reason for the increased goodness of fit of our models in comparison with earlier research and might give an indication of increasing integration of the two markets.

Table 4 Equity Motivated Factor Models

	FF3	FF4	FF3+L	FF4+L
Constant	0.003	0.004	0.003	0.003
t-stat	*1.608*	*1.608*	*1.324*	*1.277*
Market	0.002	0.002	0.007	0.005
t-stat	*0.162*	*0.140*	*0.549*	*0.405*
Size	-0.009	-0.009	-0.005	-0.004
t-stat	*-0.989*	*-0.977*	*-0.677*	*-0.542*
Value	0.004	0.004	0.004	0.004
t-stat	*0.489*	*0.504*	*0.480*	*0.588*
Momentum		-0.002		-0.006
t-stat		*-0.234*		*-0.583*
Liquidity			0.011	0.012
t-stat			*0.756*	*0.794*
R^2	38.64%	38.67%	53.63%	56.64%
$Adj. R^2$	21.91%	14.14%	35.09%	32.56%

Note: Results for the equity factor models studied in this research. We assess the Fama–French three factor model (FF3), Carhart four factor model (FF4), the liquidity factor model (FF3+L) and the Fama-French-Carhart-Pastor-Stambaugh (FF4+L). We use the Fama–MacBeth (1973) method to estimate the risk premiums for the models. Presented in the table is the constant, risk premiums, t-statistics, R^2 and adjusted R^2.The test assets are the 15 separate commodity futures studied in this research from the time-period January 1989–December 2017.

4.2.3 Commodity specific factors

Table 5 shows the descriptive statistics of the constructed commodity specific-factor mimicking portfolios. When reviewing the annualized performance of a portfolio based on the hedging pressure hypothesis and consequently going long in each commodity future contract with a positive hedging pressure and short in each commodity contract with a negative hedging pressure, the portfolio fails to capture the risk premium of commodity future returns as it on average returns a negative return of 1.09% on a yearly basis. The performance of the long portfolio based on the hedging pressure are recorded at 4.47% and the short portfolio yields a return of 5.47% on average annually. Analyzing the standard deviation of the two portfolios, the average annualized standard deviation of the long-short portfolio, 19.31%, is noticeably higher than for the long-only portfolio which is noted for an average annualized standard deviation of 15.97%. This is not in line with the hedging pressure hypothesis as defined in this research, as the longs (shorts) in a portfolio offer a restricted hedge against the risk that the long positions (short positions) could depreciate (appreciate). Hence, as this research aims to research the risk premia of the futures excess returns, any statistical test including this factor would be hard to argue in favor of as the HML_{HP} portfolio does not offer a risk premium and therefore we choose to exclude the hedging pressure factor from the Fama-Macbeth regressions conducted in this section.

The result of the HML_{HP} portfolio is in line with Keynes (1930) concept of normal backwardation, which provides a rationale for only having long positions in the commodity futures markets. Hedgers make use of commodity futures to hedge against commodity price risk, this infers the presence of a risk premium of commodities. In his theory, Keynes (1930) argues that the existence of commodity futures gives companies with exposure to the underlying commodity an opportunity to hedge against the risk of fluctuations in the prices of said commodity. Since hedging can be seen as a type of insurance, in a world of risk-averse hedgers and investors, hedgers should provide investors with a long commodity futures position a risk premium as "payment for insurance".[8] Hence, investors with a long position in commodity futures should be paid a risk premium and consequently this motivates a reasoning for a long only portfolio consisting of commodity futures should be a useful way to distribute capital. With the arguments above, Keynes (1930) theory argues that an HML portfolio should not offer a risk premium of the excess return of commodity futures. Support in favor of this argument is weak in empirical research and rather only a limited selection of studies supports the Keynesian hypothesis. However, our research that shows that a long-short portfolio performs worse than a long-only or short-only does support the view of Keynes.

Even though the hedging pressure factor in our test is insignificant, previous research has stressed the importance of taking hedging pressure into account when capturing the risk premium in commodity futures markets. Not doing this might lead to misleading conclusion about the risk premiums existence in commodity futures markets (Basu & Miffre, 2013). The low explanatory power of the hedging pressure factor might be a result of the low correlation between excess returns in the commodity futures contracts in our sample. Important to note,

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8 A commodity fabricator as Royal Dutch Shell, with a business model which compels the company to have a long position in oil, can decrease their exposure to variation in oil prices by shorting oil futures. As this can be seen as an insurance by Royal Dutch Shell, the company is ready to sell oil futures with an expected loss. Thus, market participant obtains a risk premium for having a long position in oil futures.

our result of the nonexistence of a risk premium for the hedging pressure factor based on hedgers open interest does not reject the conclusions of researchers such as Basu and Miffre (2013). Neither do we argue against that the risk premium is present in individual commodity contract, in line with the findings of Daskalaki, Kostakis and Skiadopoulos (2014).

Table 4 also show the descriptive statistics associated with the HML_B portfolio based on the basis. The average annualized futures return based on a portfolio going long in futures that have a positive basis and short in futures that have a negative basis is 1.18%. This portfolio also has a lower standard deviation than the long-only and short-only portfolios. Evident from the data presented, the theory of storage is supported as the long-short portfolio produce positive returns on average over the sample period. In table 6, the risk premium for the basis factor is hardly positive and insignificantly different from zero and the model presents an adjusted R^2 of 1.29%. Hence, the factor based on the theory of storage and therefore the basis does not give any valuable information about the cross-section of the commodity futures risk premiums. The reason behind this poor performance of both the long-short portfolio and the basis factor can be to begin with that basis risk is straightforward, well known and easy to understand for market speculators and hedgers. Also, a well-known fact in commodity research is that spot prices generally mean-revert (Bessembinder, et al., 1995; Chaves & Viswanathan, 2016). Hence, a bold explanation for the poor performance and low pricing ability of the HML_B portfolio is that market participants easily can project the reversion in spot-prices and therefore adjusts the futures prices, thus the basis, on commodity futures to remove any apparent arbitrage possibilities which in turn results in lower returns and as a result non-significant risk premia. Previous research in favor of the existence or nonexistence of a risk premia related to the basis factor is to some extent inconclusive. Chaves and Viswanathan (2016) and their research about mean-reversion in spot and future commodity markets, came up with a similar result as our research, stating that market participants investing in commodity futures do not gain any financial profits from the mean-reversion related to spot-prices as these expectations is already accounted for in the futures prices through the basis. In contradiction, Yang (2013) shows that a “slope” factor over maturities constructed on the basis of a portfolio of commodity futures actually do explain the cross-sectional variation in the risk premiums for commodity futures. Furthermore, Szymanowska et al., (2014) argues that a long-short portfolio based on sorting from the basis factor, explains the cross-section of spot risk premia while Daskalaki, Kostakis and Skiadopoulos (2014) found that a long-short portfolio based on the basis had low explanatory power and an insignificant risk premia of the cross section of commodity futures returns. The simplest and most obvious reason for the different and inconclusive results and the low explanatory power of the basis risk premia in terms of describing the returns of the commodity futures in our sample is the sorting criteria and sample selection among commodity futures contracts, or that a risk premia simply is not present. We will in section 4.3 make a more comparative research by sorting the commodities in subsectors dependent on their types and characteristics.

The descriptive statistics of the factor constructed on commodity specific momentum as described in section 3.2 is presented in table 5. The momentum strategy is superior to the other portfolios constructed on the hedging pressure and the basis in terms of annualized average return as the long-short portfolio returns 3.58%. Table 6 present the result of the Fama Macbeth regression for the HML_M commodity specific factor model and it is evident that the model has a decent explanatory power with an adjusted R^2 of 19.81%. However, the model yields an insignificant risk premia. Cross-section momentum strategies benefit from high correlation of the underlying asset and are therefore more appropriate for trading assets that are homogenous. As the return of a long-short portfolio sorted on the momentum strategy is influenced by the change among individual commodity futures trends, the strategies outcome becomes extremely uncertain when there is a low correlation between the underlying assets of interest (Jusselin, 2017). In appendix A, we present the correlation between the commodity futures in our portfolio, where it is clear that correlation among the commodities is weak, possibly explaining the insignificance of the momentum risk premia of our set of commodity futures.

As described in section 2.3.3 Gorton, Hayashi and Rouwenhorst (2012) argues that momentum in the commodity futures market is related to the basis and therefore the theory of storage. This is also the conclusion of Miffre and Rallis (2007) who finds that a momentum strategy generally buys contracts where the future price is below the spot price, which is what we refer to as the basis in this study. This suggest that momentum and the basis are related, thus these two strategies should take similar positions. In our sample, this hypothesis is highlighted as the high momentum mimicking portfolio and high basis mimicking portfolios has a correlation coefficient of 70%. Clearly, the strategies are associated and can be seen as a compensation for bearing risk during periods when storage levels are below normal.

However, our result of an insignificant risk premia for momentum is in line with Daskalaki, Kostakis and Skiadopoulos (2014) and highlights the possible heterogenous structure of commodity futures.

Table 5 Commodity Specific Factor Mimicing Portfolios

	Mean	St. deviation
HP factor		
Long portfolio	4.47%	15.97%
Short portfolio	5.47%	20.35%
Long-Short portfolio	-1.09%	19.31%
Basis Factor		
Long portfolio	5.11%	17.2%
Short portfolio	3.87%	16.66%
Long-Short portfolio	1.18%	15.84%
Commodity momentum factor		
Long portfolio	8.02%	18.39%
Short Portfolio	4.56%	20,00%
Long-Short portfolio	3.58%	22.38%

Note: Mean and standard deviation of the returns of the commodity specific factor mimicking portfolios for the time-period January 1989–December 2017. The factor mimicking portfolios are the hedging pressure, the basis, and the past twelve-months return for commodities (skipping the most recent month).

Table 6 Commodity Specific Factor Models

	Basis Factor	Commodity momentum
Basis factor		
Constant	0.003	
t-stat	*1.484*	
Basis factor	0.000	
t-stat	*0.055*	
Commodity momentum factor		
Constant		0.003
t-stat		*1.210*
Commodity momentum		0.008
t-stat		*0.778*
R^2	7.83%	25.54%
$Adj. R^2$	1.29%	19.81%

Note: Results for the commodity specific factor models studied in this research. We assess the basis and commodity momentum. We use the Fama–MacBeth (1973) method to estimate the risk premiums for the models. Presented in the table is the constant, risk premiums, t-statistics, R^2 and adjusted R^2.The test assets are the 15 separate commodity futures studied in this research from the time-period January 1989–December 2017.

4.3 Subsector analysis

In this section, we divide the commodity futures in our sample into subsectors depending on their subsector based on the theory in section 2.4 and perform the Fama Macbeth regression on the commodity specific factors, HML_B and HML_M, again. In our sample, we can divide the commodities in two different subsectors; speculative which comprise seven commodities (Gold, Silver, Palladium, Platinum WTI-oil, heating oil and natural gas) and one agricultural sector containing seven commodities (Coffee, Cacao, Sugar, Corn, Cotton, Soybeans, Wheat). Although the energy subsector alone would be interesting to test, we are limited by the sample at hand and would not have robust and feasible results in this subsector as asset pricing tests conducted with less than five commodities are not reliable due to low degrees of freedom. The result for the subsector analysis is presented in table 7 and contains the constant, risk premia and the corresponding adjusted R^2 from the Fama-Macbeth regression on the agricultural and speculative commodities.

In table 7, the risk premia for both sectors are insignificant for both the macro, equity and commodity specific factor asset pricing models. In addition, there are low adjusted R^2 for all models. The theory of storage puts emphasizes on the sign of the futures basis and consequently on the relation between the convenience yield and the inventory level. The speculative subsector is subject to a basis that on average is negative, which in turn means that this sector of commodities generally has a low convenience yield and high inventory level. Also, the annualized standard deviation for the metals basis is low, which suggests that the inventory level for these commodities is relatively easy to estimate. However, inventory levels for the oil industry is often extremely uncertain and are driven by supply, demand and political decisions. With the same reasoning, the inventory level for the agricultural level differs somewhat between the commodities and the annualized standard deviation of the basis for the individual commodities in the agricultural sector is high. This suggests that the inventory level deviates a lot and that the inventory level is extremely hard to predict and estimate. The agricultural sector is generally described as a sector which possess a high level of unpredictability of production and producers have difficulties in forecasting with certainty the quantity their harvest will yield. There might be various reasons for these observations, the most likely and obvious reasons are the impact of external and unpredictable variables such as natural disasters as well as other weather conditions, diseases and seasonal effects.

One would expect that the commodity momentum factor would offer a risk premia due to the speculative nature in the speculative subsector, as the reasoning for momentum discussed above is generally seen as a result of overreaction to news. This suggests that investors in the commodity market investing in speculative futures should be compensated for bearing the risk associated with for example an overreaction on news from a decision by OPEC to produce more oil. However, the risk premia are insignificant for both the agricultural sector and the speculative sector.

The above results suggest a nonexistence of a risk premia for any of the commodity specific factors in the cross-section of commodity futures divided into subgroups. Even though one would assume that commodities in these subsector would occur to be more homogenous, we discovered no evidence of the existence of a risk premia in the cross-section of these commodities either. A final word is in order on the fact that we are researching the cross-section of all of the commodity futures as well as the cross section of the agricultural and speculative commodities. We do not reject the possibility that there may be a significant risk premia for other subgroups in the commodities futures universe or during a different time period. Nor do we reject the possibility of the existence of a significant risk premium for individual commodities in a time series setting.

Table 7 Sub Sector Analysis

(a)	Agricultural									
	Macro models				Equity models				Commodity specific models	
	CAPM	CCAPM	MCAPM	MCCAPM	FF3	FF4	FF3+L	FF4+L	Basis	Commodity momentum
Constant	0.001	0.007	0.001	0.007	0.002	0.002	0.001	0.001	0.001	0.001
t-stat	*0.620*	*0.481*	*0.566*	*0.498*	*0.616*	*0.615*	*0.617*	*0.605*	*0.675*	*0.632*
Market factor	0.003		0.003		0.002	0.002	0.002	0.002		
t-stat	*0.242*		*0.207*		*0.176*	*0.143*	*0.185*	*0.187*		
Consumption growth		0.002		0.002						
t-stat		*0.351*		*0.331*						
Money Growth			0.000	0.000						
t-stat			*-0.065*	*-0.057*						
Size factor					0.001	0.001	0.001	0.003		
t-stat					*0.104*	*0.107*	*0.112*	*0.160*		
Value Factor					0.008	0.008	0.008	0.007		
t-stat					*0.279*	*0.275*	*0.279*	*0.273*		
Momentum factor						-0.004		-0.008		
t-stat						*-0.187*		*-0.202*		
Liquidity factor							0.000	0.003		
t-stat							*0.025*	*0.124*		
Basis factor									-0.002	
t-stat									*-0.124*	
Commodity momentum										-0.003
t-stat										*-0.121*
R^2	21.13%	24.00%	25.35%	26.96%	39.54%	41.03%	40.35%	49.13%	8.17%	7.93%
Adj. R^2	5.36%	8.80%	12.90%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

(b)	Speculative									
	Macro models				Equity models				Commodity specific models	
	CAPM	CCAPM	MCAPM	MCCAPM	FF3	FF4	FF3+L	FF4+L	Basis	Commodity momentum
Constant	0.005	0.010	0.002	0.010	0.004	0.004	0.004	0.003	0.005	0.003
t-stat	*1.617*	*0.936*	*0.846*	*0.940*	*1.576*	*1.544*	*1.278*	*1.043*	*1.708*	*0.800*
Market factor	0.000		0.006		0.006	0.002	0.007	0.000		
t-stat	*-0.013*		*0.381*		*0.362*	*0.109*	*0.467*	*-0.008*		
Consumption growth		0.002		0.001						
t-stat		*0.907*		*0.290*						
Money Growth			-0.001	-0.003						
t-stat			*-1.24*	*-0.522*						
Size factor					-0.016	-0.017	-0.014	-0.013		
t-stat					*-1.089*	*-1.287*	*-1.347*	*-1.271*		
Value Factor					0.003	0.005	0.003	0.009		
t-stat					*0.341*	*0.496*	*0.364*	*0.983*		
Momentum factor						-0.007		-0.013		
t-stat						*-0.522*		*-1.056*		
Liquidity factor							0.006	0.012		
t-stat							*0.335*	*0.639*		
Basis factor									0.021	
t-stat									*0.837*	
Commodity momentum										0.017
t-stat										*0.668*
R^2	0.00%	44.63%	26.78%		34.54%	53.12%	75.80%	26.36%	31.38%	37.58%
Adj. R^2	0.00%	33.56%	7.85%		15.66%	25.31%	27.41%	6.43%	14.65%	25.10%

Note: Results for the agricultural (a) and the speculative subsector (b) on all asset pricing models in the study. We assess the macro, equity and commodity specific models. We use the Fama–MacBeth (1973) method to estimate the risk premiums for the models. Presented in the table is the constant, risk premiums, t-statistics, R^2 and adjusted R^2.The test assets are the 7 speculative and 7 agricultural subsector commodity futures studied in this research from the time-period January 1989–December 2017.

4.4 Heterogeneous structure of the commodity futures market

In addition to the segmentation argument between commodity futures and equity markets, our results of the nonexistence of a risk premium in the cross section of commodity futures for all of the models in table 1 can likewise be assigned to a potential insignificance of the factor betas estimated from the first step of the Fama Macbeth regression and in addition it can also be due to a heterogeneous cross section of the commodity futures or a combination of them both. To further investigate this question, we scrutinize the estimated betas attained from the time series approach and can conclude that these are significant in several cases. Thus, the nonexistence of a risk premia for the cross section of commodity futures in our sample are not likely to be due to insignificant time series betas.

Kat and Oomen (2007) found in their research that correlations in various groupings of commodity futures are small and generally insignificant and that the various groupings do not provide an investor with a risk premia, with an exception from the energy sector. The results in our research emphasize the hypothesis of the heterogeneous structure of individual commodity futures and are also supported in Daskalaki, Kostakis and Skiadopoulos (2014) who studied the hypothesis of a heterogenous structure of commodity futures by assessing single factor time series models for every individual commodity future and finds no factor that is significant for all futures across the sample. Nor do they find any evidence of a subgroup of commodities futures for which all are sensitive against a common factor, underlining the hypothesis of a heterogeneity structure of the excess returns. For further argument in favor of the heterogenous structure, Hirshleifer (1988) and de Roon, Nijman and Veld (2000) argues that the commodity specific factors can lone describe the individual futures solitary in research in the time series. The finding and rejection of all the models and their corresponding risk premiums in our sample, hence the absence of mutual factors in the cross section may be associated to the occurrence of extremely dissimilar drivers behind the returns of all individual commodities, as the risk premia for all factors fails to statistically explain even the agricultural and speculative subsectors.

5 Conclusion

This paper investigates whether there is an identifiable improvement of the performance of asset pricing models with regards to the financialization of commodities over recent years and if there therefore exist a common factor that can significantly price the cross section of subsectors and/or all commodities. The paper questions previous research on commodity futures, as these studies generally studies portfolios of commodity futures (Szymanovska, 2010; Basu & Miffre, 2013; Bakshi, Gao & Rossi, 2013). While this approach is attractive as it reduces the errors in variables problem, our result shows that due to the heterogenous structure of commodity futures returns, tests should be conducted on individual futures. We study the whole sample of fifteen commodities and two additional samples where the commodity futures are divided into subsectors, with a set of different macro, equity and commodity specific factor models to scrutinize whether there exist one or multiple asset pricing models able to price commodity futures in a cross-sectional setting. In our research, all models are relatively bad at explaining the variation in commodity futures returns as the models in general present a low adjusted R^2 along with insignificant risk premiums for both the cross-section of all futures in our sample and the subsectors. The only exception is the models including the consumption factor (CCAPM and MCCAPM) which suggests an adjusted R^2 of 57.19% and 54.21% on quarterly frequency respectively, yet with insignificant risk premiums.

The outcomes of this study suggest that the widespread macro and equity models which are backed by an immense amount of empirical support and evidence to significantly explain the cross-section regarding equities, does not work well for explaining the cross-section of commodity futures. Thus they are not suitable in assessing this asset class which gives rise to the hypothesis of market segmentation between the markets. In addition, the commodity specific factor models fail to price the cross-section of commodity futures, implying that the commodity market is in itself also segmented giving further arguments in favor of the heterogeneity of commodity futures. We find that the absence of common factors for the commodity futures returns is likely to be associated to the heterogenous structure of the underlying commodity per se and the main drivers behind the prices of these seems to be diverse even within subsectors. Consequently, it makes sense that participants in the commodity futures market in general assess commodity contract in separation from each other as our research lays a foundation for that expected returns of futures contracts seems to be exclusively influenced by the individual attributes of the contracts.

Important to note is that we do not reject the hypothesis that there might be significant risk premiums during a specific time period or across other subsectors of commodity futures. We do find a small indication of that the equity and commodity markets as well as the internal structure of commodity futures are becoming more integrated and as our models in general shows an increased performance in terms of higher adjusted R^2 and higher t-statistics than previous research (Jagannathan, 1985; Bessembinder 1992; Daskalaki, Kostakis & Skiadopoulos, 2014). Hence, the result in this research do not discard the suggestion by Tang and Xiong (2012) of the financialization of commodities over the recent years but rather, we believe that a dataset compiling of only commodity futures with recent data might have another outcome than our examination concerning related factors.

5.1 Future Research

To further evaluate the existence of risk premiums in commodity futures, we suggest that further research adopt a smaller dataset consisting of only recent data. This would enable the analysis to evaluate the possible future implications of the weakening of the heterogeneity assumption. Since we employ a large dataset, we are limited to the extent to which we can draw conclusions of the significance of having a commodity market that may be both integrated with equities to a greater extent than today. Adapting smaller datasets might enhance the analysis further. We find this an interesting topic since this will have a great impact on the way commodity futures are evaluated in the future. In hindsight, the authors of this paper are convinced that commodities and the investment in derivative contracts on them is an asset class that will have an increasing significance in the financial climate to come.

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Appendix A

Correlation table Futures

	COFFEE	COCOA	SUGAR	CORN	WHEAT	SOYBEANS	COTTON	GOLD	COPPER	SILVER	PALLADIUM	PLATINUM	HEATING OIL	WTI-OIL	NATGAS
COFFEE	1														
COCOA	0,148119	1													
SUGAR	0,117756	0,133678	1												
CORN	0,171979	0,157171	0,094267	1											
WHEAT	0,183664	0,129393	0,08322	0,608933	1										
SOYBEANS	0,224166	0,143842	0,069398	0,716936	0,496617	1									
COTTON	0,093671	0,160534	0,065122	0,328395	0,204967	0,401111	1								
GOLD	0,156571	0,213489	0,042605	0,160584	0,148635	0,161609	0,068777	1							
COPPER	0,177114	0,127163	0,155467	0,180962	0,223434	0,242065	0,24596	0,22924	1						
SILVER	0,228239	0,236227	0,061533	0,188615	0,14934	0,20065	0,053909	0,740908	0,309453	1					
PALLADIUM	0,131149	0,119882	0,210177	0,171683	0,171726	0,182844	0,177451	0,2966	0,346051	0,408364	1				
PLATINUM	0,205918	0,250176	0,146018	0,198266	0,188413	0,225979	0,248328	0,590837	0,413168	0,608615	0,569824	1			
HEATING OIL	0,040264	0,086823	0,021117	0,076459	0,128333	0,151411	0,121335	0,15595	0,31396	0,139469	0,143193	0,167306	1		
WTI-OIL	0,076852	0,135682	0,076174	0,078293	0,091953	0,15001	0,149851	0,184914	0,33846	0,184237	0,209514	0,235205	0,819307	1	
NATGAS	0,043301	-0,01232	0,019408	0,07366	0,072515	0,082941	0,009445	0,114917	0,050883	0,069262	0,081729	0,102896	0,388086	0,314491	1