EUROZONE STOCK RETURNS AND FOREIGN CURRENCY RISK

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Abstract

This paper investigates stock returns for a large cross section of Eurozone corporations during 2000-2019 through various asset-pricing models. First, we compute Eurozone-specific factors to discuss the size, value, profitability, momentum, and investment effects of stock returns. Subsequently, the paper expands widely-used asset pricing models by introducing a foreign exchange risk factor to evaluate whether foreign currency risk is priced systematically in Eurozone stock returns. The results confirm the importance of various factors used previously by asset-pricing models. Moreover, we find strong evidence for the pricing of foreign currency risk in Eurozone stock returns. We employ factor spanning regressions, asset-pricing tests, and several evaluation metrics to derive and assess our findings.

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1. INTRODUCTION

Over the last 30 years, scholars have developed asset pricing models that can better explain the expected stock returns either for a specific market or international markets. Some of the key asset pricing models in the literature use various risk factors, such as the size, value, momentum, profitability, and investment factors (Fama and French, 1993, 2015, 2018; Carhart, 1997; Hou, Xue, and Zhang, 2015, 2019, 2021; Barillas and Shanken, 2018), along with the market risk premium of the capital asset pricing model (CAPM). Apart from these, a wide range of other factors (*e.g.*, Pástor and Stambaugh, 2003; Cooper et al., 2008; Asness and Frazzini, 2013; Stambaugh and Yuan, 2017; Elyasiani et al., 2020) have been investigated including currency-risk related factors (Kolari *et al.*, 2008; Lustig *et al.*, 2011; Karolyi and Wu, 2020). This study sheds new light on the systematic role of currency risk in explaining stock returns, with an emphasis on the Eurozone market.

The role of currency exchange risk in the operation of both domestic and multinational firms has a long history. Although various facets of currency risk have been studied in the literature, its role in pricing stock returns has been relatively neglected. This topic has recently come to the forefront with the introduction of novel risk factors to measure currency risk (Lustig, et al., 2011, 2014; Verdelhan, 2018). Although these factors have been shown to capture foreign exchange risk exposures, recent work (*e.g.*, Aloosh and Bekaert, 2019; Karolyi and Wu, 2020*)* shows that their importance in stock pricing is not evident. Karolyi and Wu (2020) test the significance of different currency risk factors for a large cross-section of stock returns around the globe and point out that their importance could primarily be affected by the inclusion of emerging markets. While the introduction of currency risk factors has regenerated interest in the pricing of foreign exchange risk, earlier work relying on the sensitivity of stock returns to foreign exchange changes has an important role. For instance, Kolari *et al.* (2008) find that stocks with extreme sensitivity (positive or negative) to currency risk tend to have lower returns than those with lower or no sensitivity. In this paper, we explore how currency risk contributes to pricing Eurozone stock returns using both the more recent currency-risk factors and the more 'traditional' currency sensitivity approaches.

The primary focus of almost all empirical studies on foreign exchange (forex) risk has so far been the US stock market, addressing almost entirely dollar currency risk. Though two decades have passed since the introduction of the euro and the establishment of the Eurozone, little research on Eurozone stock pricing has been carried out. The Eurozone includes some of the most important stock markets globally that share several common characteristics such as a single currency and a central regulatory body (ESMA). The few papers (Schrimpf *et al.*, 2007; Annaert *et al.*, 2013; Eiling *et al.*, 2012) that focus on Eurozone stock markets are mostly confined to the significance of the 3-factor model of Fama and French or the Carhart 4-factor model. Studies concerned with foreign exchange risk focus primarily on all European stock markets (Bartram and Karolyi, 2006; Muller and Verschoor, 2006). There are few Eurozone-specific studies on individual stock markets, such as Germany (Schrimpf *et al.*, 2007; Amel-Zadeh, 2011). No previous study, however, has investigated the applicability of asset pricing models for Eurozone stock markets as a group. This paper fills this gap within a multi-factor asset-pricing model that includes a currency risk factor that has a key role in describing stock returns in the Eurozone.

Research on Eurozone stock returns is important for a number of reasons. Next to the US and UK capital markets, the region contains some of the deepest markets where shares of some of the largest global corporations (especially in consumer goods) are traded. Throughout the last 20 years, the euro has established its position as the second most important currency globally. According to the European Central Bank (2021), in 2019 the share of exports invoiced in euros exceeded that invoiced in dollars (48% vs 40%)[2] and, as of December 2020, the euro was a close second to the dollar in terms of the share of global payments recorded by SWIFT (38% vs 42%). According to the ECB (2021), half of the green bond market, a market that is growing in popularity among investors, is denominated in euros. It is noteworthy that, compared to the Eurozone, the operations of US corporations are primarily domestic: the percentage of the international sales of US corporations (approximately 24%) in 2019 was less than half of the Eurozone's (approximately 53%)[3]. For international investors, Eurozone stock markets allow them to gain exposure to the second most important currency globally. The fact that Eurozone corporations share a common currency (and are thus exposed to the same currency risk) renders it an important region to study the pricing of stock returns and the role played by foreign exchange risk.

The aim of this paper is twofold. First, it provides Eurozone-specific estimates of the widely-used asset pricing models of Fama and French (1993, 2015, 2018). Second, and equally important, it investigates the role of currency risk in explaining stock returns in the Eurozone by extending the Fama and French 3-, 5- and 6-factor models and Carhart (1997) 4-factor model. Currency risk is defined via two approaches: (i) the sensitivity of stock returns to exchange rate changes (*e.g.*, Kolari *et al.*, 2008) and (ii) the more recent approach of Lustig *et al.* (2011) who introduce two currency risk factors, the level factor and slope factors. This is the first paper to provide estimates of currency risk factors for the euro and take the perspective of Eurozone-based investors.

As a preliminary and to motivate discussion of the importance of a currency risk factor in the pricing of Eurozone stock returns, Figure 1 presents monthly values of various factors used in asset

[2] If intra-euro area trade is excluded, the share of exports in euros is approximately 30% and that in dollars 50%.
[3] Refinitiv Eikon Datastream, Direction of Trade Statistics

pricing models in index form for the period January 2000 – December 2019. Figure 1 presents our estimates of Eurozone-specific Fama-French factors and Carhart's momentum factor along with a foreign exchange risk factor.[4] The construction and estimation method for all the Eurozone-specific factors is described and discussed in detail in subsequent sections. The Fama-French factors are those included in the 6-factor model: factors that measure return spreads related to the size effect (*SMB*), value effect (*HML*), profitability effect *(RMW*), investment effect (*CMA*), and momentum effect (*MOM*). The foreign exchange risk factor is a zero-investment portfolio long in portfolios of stocks with very low foreign exchange sensitivity and short in portfolios with extreme foreign exchange sensitivity. Additionally, Figure 1 plots the MSCI EMU index, a broad-based index of stock market performance across the major Eurozone markets.

The figure shows that the MSCI EMU index has provided mostly negative returns for the first decade and especially up to the global financial crisis; by 2009 it was 26% below its initial value. Since then, the index has turned upwards and provided an average return of 0.74% per month between 2009 and 2019. The various Fama-French and momentum factors move together over time and provide a return of between 50% and 100% during the first decade. Since the global financial crisis, higher returns are evident for all factors. The momentum factor yields the highest return over the 2000-2019 period and its monthly-compounded return is 0.61%. The performance of the foreign exchange factor follows that of the other factors during the pre-crisis period, albeit at a somewhat higher level. Since the global crisis, the return of the foreign exchange factor has outstripped the other factors yielding a monthly-compounded rate of return of 0.73% between 2000 and 2019. In sum, corporations with extreme sensitivity (positive or negative) to currency risk experienced lower returns than companies with low to zero sensitivity, and an investment strategy

[4] The figure uses a logarithmic scale to plot index values. The base period is January 2000.

that takes advantage of this has provided superior performance to other factors and the broader market. This result is discussed in detail in the remainder of the paper.

[INSERT FIGURE 1 HERE]

This paper contributes to the literature in several ways. First, it provides Eurozone-specific estimates of Fama and French (2018) factors, discussing their importance in stock pricing. Second, it introduces a Eurozone-specific foreign exchange factor to evaluate the impact of foreign currency risk on stock returns for a large cross-section of Eurozone corporations, in eleven stock markets of member countries for 2000-2019. To our knowledge, this is the first study to attempt this. Combining the Fama-French and exchange risk factors allows for a more thorough evaluation of the factors involved in pricing shares in the Eurozone. Third, our findings show strong evidence of the pricing of currency risk in Eurozone stock returns. To derive and assess the results, our empirical methodology employs panel regressions, factor spanning regressions, asset pricing tests, and several evaluation metrics (*e.g.,* Gibbons/Ross/Shanken (GRS test); Sharpe Ratio; Adjusted R-squared).

The following section reviews the literature on asset pricing as it relates to the determinants of European stock returns, foreign currency risk, and currency risk factors. Section 3 describes the data used in the analysis and the methodology adopted. Section 4 presents the empirical results, while Section 5 provides a robustness analysis. The final section summarizes the conclusions of this study.

2. BACKGROUND LITERATURE

The paper draws on four strands of the literature. The first examines the leading theory and research around Asset Pricing Models, exploring their efficiency and possible development space.

The second focuses on various anomalies and phenomena in the pricing of European and Eurozone stock returns, mainly within the Fama and French framework, commenting on these stocks' behavior. The third strand examines foreign currency risk exposure, its determinants, and whether it is priced in stock returns. Finally, the last one is relatively new since it focuses on currency risk factors, a recent addition to the academic literature.

2.1 Asset Pricing Theory

Sharpe (1964) and Lintner (1965) prove that considering the market risk and economic conditions is essential for investors' decisions, combined with how sensitive their positions are. The work produced by these academics influenced the development of the capital-asset-pricing model (CAPM) which is the first theoretical asset pricing model connecting the expected return of an asset with its market systematic risk. Fama and French (1992) using a cross-sectional analysis show the inefficiency of CAPM’s beta to explain stock returns, while the combination of size and book-to-market ratio in the model weakens the impact of leverage and E/P ratio on average stock returns. Fama and French (1993) identify five risk factors that can explain the returns of stocks and bonds. For the stock market they indicate two additional risk factors that can improve the simple CAPM and increase its efficiency in explaining stocks' pricing. In this paper, they introduce *small-minus-big (SMB)* and *high-minus-low (HML)* risk factors, and thus the widely used Fama-French 3-factor model. Carhart (1997) proves that stocks with high performance one year back keep their high average expected returns for the following year, suggesting a stock level *momentum (MOM)* factor. Fama and French (2015) show that the *investment* and *profitability* factors improve substantially their 3-factor model (FF3).

Fama and French (2018) investigate whether *cash profitability* is a better proxy for developing the profitability factor than *operating profitability*. According to their findings, the *cash* *profitability* factor performs better in some tests, but the two factors yield similar results. Moreover, they examine how effective the addition of a *momentum* factor is to the analysis. The *momentum* factor is an important addition to the model, thus suggesting the 6-factor model (FF6). However, an asset pricing model without the momentum factor continues to perform relatively well.

A number of papers investigate Fama-French's factor-efficiency and propose some alternative and more efficient factors through their analysis. Hou *et al.* (2014) propose an alternative model to Fama-French's 3-factor model and show that adding to the analysis of stock pricing an *investment* and a *profitability* factor increases the model's efficiency. In addition to that, in Hou *et al.* (2019, 2021), they expand their model adding an *expected growth* factor. Asness and Frazzini (2013) develop an alternative *HML* factor based on the traditional one's methodology (Fama and French 1993). They prove that a factor constructed in a more timely manner with more frequent rebalancing is better and more accurate than the traditional one (FF3).

Other studies (Barillas and Shanken 2017; Barillas and Shanken 2018; Barillas *et al.* 2019) combine the factors from different asset pricing models to define the optimal one, assessing the performance of the traditional models too. For instance, Barillas and Shanken (2018) use a Bayesian procedure to find the best asset pricing model for the US market by combining previous research factors. They conclude in a model which contains *the market return* and *SMB* factors from the Fama-French 5-factor model, the *Investment* and *Profitability* factors from the Hou *et al.* (2014) model, the new *HML* factor of Asness and Frazzini (2013), and Carhart's *MOM* factor. They compare it with various alternatives and traditional models (FF3, FF5), and still, their new model outperforms them. Fama and French (2015, 2017) claim that their 5-factor model, even if it performs better than the 3-factor model, still fails to correctly capture the behavior of small stocks that make high investments even if profitability is low. Pástor and Stambaugh (2000) support that no specific model could be characterized as the most optimal since investors' choices and beliefs affect the results.

2.2 European/ Eurozone Asset Pricing Studies

Despite a large number of existing studies in the asset pricing literature, there is limited investigation of asset pricing models in Europe and Eurozone. Fama and French (2012) examine the application of the 3-factor and 4-factor models on various international markets (North America, Europe, Japan, and Asia-Pacific), using size as an indicator and report the existence of value and momentum in stock returns. Following that, Fama and French (2017) examine the application of their 5-factor model on the same international markets showing once again that their 5-factor model is superior to their 3-factor model. Cakici *et al.* (2016) examine the *size*, *value*, and *momentum* effects in several emerging stock markets, including some European (Hungary, Poland, Turkey, Czech, Russia). They find that the *size* and *momentum* strategies fail to explain stock market variation in emerging markets. At the same time, the *value* effect does exist for the majority of the emerging markets used in their research.

Bauer *et al.* (2010) investigate if the Fama and French 3-factor model is consistent through time and whether it helps eliminate various European stock markets' anomalies. Their results indicate that the *size* effect has a strong presence in the European markets, and also, there is weak evidence of the pricing of *HML* in stock returns. Finally, there are indications of strong variation of factor loadings through time. Elyasiani *et al.* (2020) perform an analysis on the European stock market expanding Carhart's 4-factor model, with volatility, skewness and kurtosis factors. They confirm the presence of a negative volatility premium and a positive skewness premium in the pricing of stocks, and also the presence of a size premium in the European stock market.

Schrimpf *et al.* (2007) investigate the efficiency of conditional asset pricing models in explaining stock returns in the German stock market. Their results indicate that a conditional CAPM can perform as well as the Fama-French 3-factor model. Amel-Zadeh (2011) provides evidence on the existence of the *size* effect in the German stock market which is conditional to the firms past performance.

2.3 Foreign Currency Sensitivity

The role of foreign exchange (forex) risk in stock returns pricing has received considerable attention in the literature without arriving at a consensus. In an early study, Jorion (1990) examines the exposure of a group of US multinational firms to foreign currency risk and finds that the level of exchange rate exposure is positively related to the level of foreign sales. However, Amihud (1994) and Bartov and Bodnar (1994) find no evidence of foreign exchange risk pricing. The first paper considers large US exporting firms and the second firms whose returns were affected negatively by fluctuations of the US dollar's value. Dumas and Solnik (1995) found evidence in favor of the pricing of foreign-exchange risk on returns. De Santis and Gérard (1998) found strong evidence for a multifactor model containing market portfolios and foreign exchange risk factors. Both these papers use data on the excess return on equity and currency holdings from Germany, the United Kingdom, Japan, and the United States. Griffin and Stulz (2001) find weak evidence on the relationship between foreign exchange rate exposure and stock returns. Their focus is on various industries in the USA, Canada, United Kingdom, France, Germany, and Japan.

Muller and Verschoor (2006) in their paper *"European foreign exchange risk exposure"*, examine the relationship between individual European firm's stock returns and fluctuations in the currency values of the EMU's major trading partners. They conclude that a depreciating (appreciating) euro against foreign currencies has a net negative (positive) impact on European stock returns. Kolari *et al.* (2008) find that stocks with extreme sensitivity to currency risk tend to have lower returns, and they construct a new foreign exchange factor to investigate this further. They conclude that foreign exchange risk sensitivity is priced in stock returns and is negative and significant. Similarly, Doidge *et al.* (2006) report evidence that firms exposed to foreign markets tend to gain over periods of large depreciations of currency and lose in periods of large appreciations, proving that exchange rate fluctuations significantly affect firm value.

Bartram and Bodnar (2012) examine the significance of exchange rate exposure on stock returns for 37 countries from July 1994 to December 2006. Their analysis shows that the effect of forex exposure differs significantly among countries. This phenomenon is more significant for companies in emerging markets. Inci and Lee (2014) investigate the relation of stock returns and exchange rate changes for an international sample of firms, taking into account adjustment time of the first to the latter. They identify a significant relation between them. Rendón (2020) examines if currency premiums estimated for five geographical regions explain the foreign stock returns. Extending Carhart’s 4-factor model with the estimated currency premium, he finds that the new factor has a significant impact on the model adding to its explanatory power.

2.4 Currency Risk factors

Currency risk factors are a more recent addition to the literature. Two currency risk factors have been developed for the US dollar by Lustig *et al.* (LRV-2011). The factors are based on currency portfolios sorted according to the interest rate differential between the dollar and foreign currencies. The *level* factor is the average excess return on all foreign currency portfolios. The *slope* factor is "the return on a zero-cost strategy that goes long on the high-interest rate currency portfolio and short in the low-interest-rate currency portfolio".[5] These factors have been shown to be important in measuring the risk associated with changes in the dollar's value relative to foreign currencies. According to their exposure to the *carry trade risk* factor, sorting currencies into portfolios reveals similar trends in interest rates and currency returns. That verifies the first sorting results based on interest rates and shows the common variation in exchange rates. Karolyi and Wu (2020) evaluate whether currency risk is priced in the cross-section of global stock returns by using the LRV currency risk factors. Currency risk factors importance is not evident since the carry-trade factor gives significant results, but the dollar risk factor doesn't. For that reason, they point out that even though currency risk factors seem promising, other determinants must be taken into account in order to obtain a more distinct outcome. Additionally, they note that these results could primarily be affected by the inclusion in the sample of emerging markets.

Opie and Riddiough (2020) show that taking advantage of currency return probability through the concept of currency portfolios will allow for higher returns and better diversification compared to conventional investment strategies. Aloosh and Bekaert (2019) find that the relations between currencies based on factor structure are inversely related to countries' physical distances. They use three new currency factors based on currency co-movements, commodities, and trading volumes and use the concept of currency baskets in their estimation. Brusa *et. al* (2014) argue that international investors are indeed compensated for bearing currency risk. They combine the World

[5] In addition to these two factors, these authors developed four more that will be discussed in the following sections. Because the level and slope factor have received almost exclusive attention in the literature we will focus on them.

CAPM model plus two currency risk factors, the *dollar* and *carry risk* factors to introduce the International CAPM Redux and subsequently, they compare its performance with World CAPM, F&F multifactor model, and International CAPM. The results show that the International CAPM Redux outperforms the other models, proving that currency factors are significant.

Overall the existing literature (*e.g.*,Pástor and Stambaugh, 2000; Fama and French, 2015; Hou *et al.*, 2015; Barillas and Shanken, 2018; Hou *et al*., 2021; *etc*) on asset pricing models leaves room for further research in investigating the choice of optimal asset pricing models for specific countries/regions since additions to well-established models such as the 3- and 5-factor models of Fama and French have been shown to be an improvement. Moreover, there is additional value from evaluating the applicability of various widely-used asset-pricing models for Eurozone and to extend these with the addition of a currency risk factor that is potentially crucial for stock markets where corporations have significant exposure –especially sales exposure– to foreign exchange risk.

3. DATA AND METHODOLOGY

This section describes the data and methodology for constructing the factors used in the subsequent empirical analysis. We begin with the data sources and sample construction. Subsequently, we describe several asset pricing models for Eurozone stock returns widely used in the literature. We then discuss the issue of foreign exchange risk concerning asset pricing in the Eurozone. Finally, we present average excess returns of double sorted portfolios to explore the importance of various factors that previous research on the area has shown to be significant in terms of stock pricing and to suggest an additional factor capturing the effect of currency risk.

3.1 Data Sources and Sample Construction

Our sample includes all publicly listed firms in the principal stock exchanges of the Eurozone with available monthly market data in Refinitiv Eikon Datastream and annual accounting data in Refinitiv Worldscope. The data set excludes firms with average annual market price below 1 euro and firms with fewer than 40 consecutive monthly observations.[6] Following the literature (*e.g.*, Fama and French, 1993; Hou *et al.*, 2014; Hou *et al.*, 2019; Karolyi and Wu, 2020), we exclude financial corporations.[7] Our sample firms have their primary listing in eleven Eurozone stock exchanges: Vienna Stock Exchange, Euronext Brussels, Nasdaq Helsinki, Euronext Paris, Deutsche Borse, Athens Stock Exchange, Euronext Dublin, Italian Stock Exchange (Milan), Euronext Amsterdam, Euronext Lisbon, and Madrid Stock Exchange. The stock exchanges included are those of the ten countries that adopted the euro at its launch, plus Greece that adopted the euro in 2001 (and its sample starts in January 2001). The Luxembourg stock exchange is excluded from the analysis due to its heavy reliance on financial firms. The stock exchanges of the other seven members of the Eurozone (Cyprus, Estonia, Latvia, Lithuania, Malta, Slovakia, and Slovenia) are excluded because they correspond to lesser markets with relatively thin trading; moreover, these countries adopted the euro at later stages, and there is insufficiently long time-series data for most firms.

Our sample covers the period January 2000 – December 2019 and consists of 417,727 firm-month observations, corresponding to 3,426 primary stocks, of which 617 have data for the entire period.

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[6] The sample includes observations from firms with average annual market price above one euro. If a firm's average annual price falls below one euro in a specific year, observations from that point onwards are excluded. The requirement for 40 consecutive monthly observations is necessary to maintain an adequate number of observations for the rolling regressions performed in our subsequent analyses.

[7] This corresponds to industry 30 of the ICBIC code, the code used by Refinitiv Eikon Datastream to allocate firms into various industries according to their operations.

The firms cover a wide range of industries, as shown in Table A2 in Appendix. Our data set with the highest total market capitalization in December 2019 is listed in France (over €2trillion) and Germany (over €1trillion). Consumer Discretionary and Industrials are the two industries with the highest total market capitalization for the same period (over €1 trillion each), and Telecommunications and Real estate with the lowest (less than €300 billion and €200 billion respectively). All accounting and market data are in euros.

To construct several asset pricing factors that will be explained in the following subsection, we use accounting and market data. We match these two by lagging annual accounting data four months from each firm's fiscal-year end date to preclude look-ahead bias. The fiscal-year end date of each firm is from Refinitiv Worldscope (code *WC05350*). This process ensures that accounting data are available to market participants before market data (market capitalization, stock prices) are determined and allows us to exploit each firm's information dynamically. Also, to avoid any sensitivity of our results to extreme observations, we winsorized the top and bottom 1% (1^{st} and 99^{th} percentiles) of all accounting variables.

In addition to accounting and market data, we use foreign exchange market data to construct currency-related factors. End-of-month spot and forward exchange rates for the euro against twenty-six currencies are collected from WM/Refinitiv. These are used to estimate currency risk factors and an index of the euro nominal effective exchange rate (described in the following sub-sections). For the construction of the euro effective exchange rate, data for the exports/imports of each Eurozone partner are from the *Direction of Trade Statistics* of the International Monetary Fund.

3.2 Asset Pricing Models

In this sub-section, we discuss several asset pricing models that, according to Barillas and Shanken (2018), are widely used in the literature: the Fama and French (F&F) 3-factor, 5-factor, and 6-factor models, and Carhart's 4-factor (C4) model. We also discuss extended versions of the Fama and French 3-factor model suggested by Karolyi and Wu (2020) that include the currency risk factors of Lustig *et al.* (2011). Finally, we introduce and discuss a foreign exchange factor (*FX*) that is especially relevant for pricing stock returns in the Eurozone. This factor draws on previous literature on the pricing of foreign exchange risk. It revolves around the sensitivity of stock returns to changes in the foreign exchange value of the euro.

3.2.1 The Fama and French models

The first asset pricing model is the well-known arbitrage pricing theory model (APT) of Fama and French (1993), the 3-factor model. The 3-factor model includes the market risk premium (*MRP*) and the small-minus-big (SMB_{3F}), and the high-minus-low (*HML*) factors. The market risk premium is measured by subtracting the risk-free rate (the 3-month German Government Benchmark yield) from the MSCI EMU stock index return.[8] To construct the SMB_{3F} and *HML* factors, first, stocks are sorted into ten portfolios according to market capitalization (*ME*)[9]. As Fama and French (2017) proposed, stocks in the top and lowest 10% of the sample are considered portfolios of big and small stocks. These two (big and small portfolios) are further sorted into three portfolios based on the book-to-market equity ratio (*B/M*) using the 30th and 70th percentile as high and low breakpoints. Finally, we consider the intersections of the two size portfolios and the three

[8] The MSCI EMU Index is a broad stock index for the Eurozone, containing 237 stocks from 10 member countries: Austria, Belgium, Finland, France, Germany, Ireland, Italy, the Netherlands, Portugal and Spain. The total market capitalization of the index in February 2021 was approximately €4,243 billion . An alternative index is the EURO STOXX 50 which also includes firms from the Eurozone but is narrow – includes only 50 firms from 8 Eurozone countries. Other indexes such as the STOXX 600 Europe are also broad indexes but they include stocks from other European markets and are not limited to Eurozone companies.

[9] Market Capitalization is defined as stock price multiplied by common shares outstanding.

B/M portfolios to create six portfolios of stocks: *SL* (small corporations with low breakpoints for *B/M* ratio), *SM* (small corporations with medium breakpoints for *B/M* ratio), *SH* (small corporations with high breakpoints for *B/M* ratio), *BL* (big corporations with low breakpoints for *B/M* ratio), *BM* (big corporations with medium breakpoints for *B/M* ratio), and *BH* (big corporations with high breakpoints for *B/M* ratio). Subsequently, monthly value-weighted returns on these six portfolios are calculated.

The *HML* factor is the average return on the *SH* and *BH* portfolios minus the average return on the *SL* and *BL* portfolios, *i.e.*, the average return on the two value portfolios (high *B/M* breakpoint) minus the average return on the two growth portfolios (low *B/M* breakpoint). The SMB_{3F} factor is the average return on the three small portfolios (*SL*, *SM*, *SH*) minus the average return on the three big portfolios (*BL*, *BM*, *BH*).

In the Fama and French framework, portfolios are rebalanced annually at the end of June each year. In this study, however, we follow a more flexible approach and rebalance portfolios at the end of each month to include each firm's most recent (annual) financial results. Fama and French (1993) suggest that the accounting variables used in the computation of the factors are from each company's fiscal period ending. We use Refinitiv Eikon Datastream to find each company's fiscal-period end date. Rather than rebalancing annually, however, as mentioned in the previous subsection, we match accounting and market data by lagging annual accounting data four months from each firm's fiscal-year end date to preclude look-ahead bias. This process ensures that accounting data are available to market participants when determining market variables, and, therefore, we exploit the information available from each firm dynamically.

Fama and French (2015) introduce two additional factors to their 3-factor model, the investment *(CMA)* and the profitability (RMW_{OP}) factors, to what has become known as the 5-factor model.

First, we sort stocks into ten portfolios based on ME as in the 3-factor model to define this model's factors. The 5-factor model suggests an alternative method for computing the small-minus-big (SMB_{5F}) factor that combines information from the computation of *HML*, along with RMW_{OP} and *CMA*. As for the 3-factor model, the small and big portfolios are further sorted with breakpoints at the 30th and 70th percentiles for *B/M* and also use the same breakpoints for operating profitability (*OP*) and investment (*INV*).

The process for computing the *HML* factor in the 5-factor model is the same as for the three-factor described above: the average return on portfolios of small corporations with high breakpoints for *B/M* ratio and big corporations with high breakpoints for *B/M* ratio minus the average return on portfolios of small corporations with low breakpoints for *B/M* ratio and big corporations with low breakpoints for *B/M* ratio. For the computation of the RMW_{OP} factor, the procedure is the same as for *HML*. Still, instead of the three portfolios sorted according to the *B/M* ratio, the three portfolios are sorted by *OP*. Taking the intersection of the two size portfolios and the three *OP* portfolios, we create six portfolios. The RMW_{OP} factor is defined as the average return of the portfolios of small stocks with high *OP* and of big stocks with high *OP* minus the average return on the portfolios of small stocks with low *OP* and big stocks with low *OP*, *i.e.*, is the average return on the two most robust (high) operating profitability portfolios minus the average return on the two most weak (low) operating profitability portfolios. Operating profitability is calculated as revenues minus cost of goods sold, selling, general and administrative expenses, and interest expense as a percentage of each corporation's book equity value.

The conservative minus aggressive (*CMA*) factor relates to investment. It is computed using the same method as for *HML*, but instead of the *B/M* ratio, stocks are sorted according to investment (*INV*). We consider the two size portfolios' intersection with the three *INV* portfolios and create six portfolios of stocks. *CMA* is the average return on portfolios of small stocks with low *INV* and big stocks with low *INV* minus the average return on the portfolios of small stocks with high *INV* and big stocks with high *INV*. It is the average return on the two most conservative investment portfolios (low investment) minus the average return on the two most aggressive investment portfolios (high investment). Investment is measured as the change in total assets between the end of fiscal year *t*-1 and fiscal year *t*, divided by *t*-1 total assets. Finally, the SMB_{5F} factor of the Fama-French 5-factor model is the average return on the nine small stock portfolios generated from estimating the three previously mentioned factors *(HML,* $RMW_{OP,}$ *CMA)* minus the average return on the nine big portfolios.

Fama and French (2018) introduce the 6-factor model by adding a momentum (*MOM*) factor (see next section) and also suggest two alternatives to their previous robust-minus-weak and small-minus-big factors. The alternative Robust minus Weak factor (RMW_{CP}) and Small minus Big factor (SMB_{6F}) use cash profitability (*CP*) instead of operating profitability. For the RMW_{CP} factor, the process is the same as for the RMW_{OP} factor. The two portfolios containing the 10% stocks with the lowest and highest *ME* and their intersection with three portfolios sorted based on *CP* are used to create six stocks portfolios. RMW_{CP} is defined as the average return of the portfolios of small stocks with high *CP* and of big stocks with high *CP* minus the average return on the portfolios of small stocks with low *CP* and big stocks with low *CP*, *i.e.*, is the average return on the two most robust (high) cash profitability portfolios minus the average return on the two most weak (low) cash profitability portfolios.

The SMB_{6F} is the average return on the nine small stock portfolios from the estimation process of *HML,* $RMW_{CP,}$ *and CMA* minus the return on the nine big portfolios similar to the Fama and French

(2015) procedure. The difference is that instead of using the three small portfolios and the three big portfolios from the formation of RMW_{OP}, we use those RMW_{CP}.

In the computation of all factors, we follow Fama and French (2018) and include only firms with all the required data. We exclude firms with negative book equity for sorts on *B/M*, operating, and cash profitability. Additionally, all variables used in the sorting process and the ones used for their estimations are lagged one month.

3.2.2 Carhart's 4-factor model

Carhart (1997) introduced a momentum factor (*MOM*) as an addition to the Fama-French 3-factor model. The momentum factor is the return on equal-weighted, zero investment portfolios formed by sorting firms based on average stock returns from month *t*-11 to *t*-1. The factor is the value-weighted average returns of firms within the highest 30 percent minus the value-weighted average returns of firms within the lowest 30 percent. Returns are re-calculated monthly.

3.3 Foreign Currency Risk

An important issue in the pricing of stock returns concerns whether and the extent to which foreign currency risk is priced. There is extensive literature on the pricing of foreign exchange risk that was reviewed in the previous section. As indicated, there are two general empirical approaches to the pricing of foreign currency risk: the exposure of stock returns to changes in exchange rates and, more recently, the construction of currency risk factors. A significant component of the literature has focused on the foreign exchange risk faced by US corporations. The exposure of Eurozone firms (and European firms in general) has been relatively neglected, especially by the currency risk factor literature.

In this paper, we provide a comprehensive investigation of the role of foreign exchange risk in the pricing of Eurozone shares. Eurozone firms share a common currency and, thus, are exposed to similar foreign currency risks. Moreover, they rely to a greater extent on foreign (non-Eurozone) sales than US firms. Foreign currency risk is likely to play an important role in addition to the domestic factors described previously. In the remainder of this sub-section, we outline the two approaches to foreign exchange risk and present empirical results from the two methods for Eurozone stock returns.

3.3.1 Foreign Exchange Sensitivity

The literature has gauged the importance of foreign exchange risk by estimating the sensitivity ('beta') of stock returns to foreign exchange returns. The literature is differentiated by how foreign exchange returns are measured and the underlying model for estimating stock returns' foreign currency exposure. For instance, some studies use bilateral exchange rates while others effective exchange rates. Additionally, some studies build their own models or employ the CAPM model that includes only the market premium and foreign exchange returns. In contrast, others expand the CAPM to include asset pricing factors. These are the most usual ways in which currency risk has been studied (Dumas and Solnik, 1995; De Santis and Gérard, 1998; Griffin and Stulz, 2001; Muller and Verschoor, 2006; Kolari, Moorman, and Sorescu, 2008; Bartram and Bodnar, 2012). In this study, we measure foreign exchange returns by the return on an index of the effective exchange rate and employ several asset pricing models.

To compute an effective exchange rate (*EER*) for the euro, we use end-of-month spot exchange rates between the euro and twenty-six currencies obtained from the WM/Refinitiv database. The currencies we consider are: Australian dollar, Canadian dollar, Czech koruna, Danish krone, Hong Kong dollar, Hungarian forint, Indian rupee, Indonesian rupiah, Japanese yen, Kuwait dinar, Malaysian ringgit, Mexican peso, New Zealand dollar, Norwegian krone, Philippine peso, Polish zloty, Saudi riyal, Singapore dollar, South Africa rand, South Korean won, Swedish krona, Swiss franc, Taiwan dollar, Thai baht, British pound and US dollar.[10] The EER is a geometrically weighted average of the twenty-six currencies, and the weights represent total trade between the Eurozone and each trading partner. Data on exports and imports between the Eurozone and each trading partner are from the *Direction of Trade Statistics* of the International Monetary Fund. The euro EER is computed as

$$EER_t^{€} = \prod_{k=1}^{k=N_k} (S_{k,t}^{€})^{w_k} \tag{1}$$

where $EER_t^{€}$ is the euro effective exchange rate at time *t*, $S_{k.t}^{€}$ is the spot exchange rate between currency *k* and the euro (expressed as units of foreign currency per euro) at time *t*, w_k is the weight of currency k in the *EER* index and $k = 1, \dots, N_k$ are the trading partners included in the construction of the index. The weight w_k is calculated as the share of country *k's* trade in the total trade (exports plus imports) of the Eurozone averaged over 1996-2019.[11] The base period for the *EER* index is February 1999.

We estimate several asset pricing models that supplement the various factors described previously with the return on the euro *EER*. The estimated models are:

$$\left(R_{i,t} - R_{f,t}\right) = a_i + \beta_{i,M}(R_{M,t} - R_{f,t}) + \sum_{j=1}^{j=F_N} \beta_{i,j} F_{j,t} + \beta_{i,EER}\Delta\ln EER_t + v_t \tag{2}$$

[10] The currencies (and trading partners) included in the computation of EER are those for which forward exchange rates are available from WM/Refinitiv because these data are necessary for the computation of currency risk factors (see next subsection) and so results from the two methods are comparable. The currencies included are, however, those of the most important trading partners of the Eurozone. They accounted for 65% of the Eurozone's total trade (considering trade outside EMU) in 2019 (*Direction of Trade Statistics*). As a robustness check on our results, we also employed an effective exchange rate for the euro computed by the European Central Bank (that includes an additional 14 currencies to the 26 currencies included here). The results are very similar.

[11] While we use time invariant weights for the computation of the EER, we also checked our results with weights that vary across time and confirm that the results are not sensitive to the choice of weights.

where $(R_{i,t} - R_{f,t})$ is firm *i*'s excess stock return (net of the risk-free interest rate), $(R_{M,t} - R_{f,t})$ is the excess return on the equity market portfolio denominated in euro, F_j is asset pricing factor j, F_N are the factors included in the estimated model, and $\Delta \ln EER_t = \ln EER_t - \ln EER_{t-1}$ is the return on the *EER* computed as described previously. The market return is the MSCI EMU total return index. The number of factors included in the model (F_N) corresponds to the number in the relevant asset pricing model (*e.g.*, 3-factor model, *etc*.). The estimate of the parameter $\beta_{i,EER}$ is each firm's foreign exchange sensitivity or exposure to foreign currency changes. The model in *Eq.* (2) is estimated for each stock i via rolling regressions with a 24-month window.

One strand of the literature attempts to explain the determinants of exchange rate sensitivities (the estimated betas, $\beta_{i,EER}$ across firms (Choi and Jiang 2009; Krapl 2020). Another strand of the literature investigates whether stock returns vary systematically across the estimated betas (*e.g.*, Kolari *et al.*, 2008; Bartram and Bodnar, 2012). We also examine this issue, intending to develop a factor-like variable similar in spirit and structure to the previously outlined factors. We estimate the model in *Eq.* (2) that corresponds to the Fama-French 6-factor model ($F_N = 6$), the most comprehensive F&F asset pricing model. Subsequently, we employ the estimates of $\beta_{i,EER}$ to sort stocks into 25 portfolios, portfolio 1 having stocks with the lowest sensitivities while portfolio 25 containing stocks with the highest sensitivities. A foreign exchange (*FX*) risk factor uses monthly value-weighted returns to create a zero-investment portfolio that is long in the middle portfolios and short in the extreme portfolios. To compute the *FX* factor, we subtract the average return of the extreme sensitivity portfolios (1 and 25) from the three middle portfolios' average returns (12, 13, and 14).[12] Stocks are re-assigned into portfolios each month.

[12] The *FX* factor is in the spirit of Kolari et al. (2008). Whereas their factor takes the difference between the average return of all (23) middle portfolios minus the average of the two extremes (1 and 25), we consider an alternative

[Please insert here Table 1]

Table 1 presents the results. The first four columns show the number of observations, the average estimate of $\beta_{i,EER}$, the percent of the positive coefficients and the percent that are significant for each portfolio. The fifth column shows the size of each portfolio computed as the number of shares multiplied by their price. The final column of Table 1 presents the average annual value-weighted returns for each of the 25 portfolios from January 2000 to December 2019. The extreme portfolios (*i.e.*, 1 and 25) have the lowest average annual value-weighted returns (-1.96% and -0.88%, respectively), while returns are substantially higher for the middle portfolios.[13] The return difference between the average of the middle three exchange rate sensitivity portfolios (*i.e.*, 12th to 14th portfolios) and extreme sensitivity portfolios (1st and 25th portfolios) is positive (8.78%) and statistically significant at the 5% level.

The foreign exchange currency risk factor we use in this paper considers differences in average returns between the three middle and two extreme-sensitivity portfolios. Sensitivities are estimated based on the Fama-French 6-factor model, for reasons stated earlier. However, we would like to note that variations in the definition of the FX risk factor produce similar results to what is presented in this paper. For example, we computed risk factors based on other Fama-French models (*e.g.*, 3-, 4-, and 5-factor) and the international CAPM model that includes only the market excess return and $\Delta \ln EER$ in *Eq.* (2). In addition, we considered the difference in average returns

measure that looks at the difference in average returns between only three middle portfolios (12, 13, and 14) and the two extremes. We believe this to be a preferred method for computing a foreign exchange risk factor that is more feasible as an investment strategy and is associated with substantially lower transactions costs. .

[13] The inverse-U shaped pattern with respect to foreign exchange rate sensitivities is also observed for U.S. stock returns by Kolari et al. (2008) and for developed markets (excluding N. America) by Karolyi and Wu (2017) who construct currency risk factors to conduct their analysis.

between all middle and the two extreme portfolios. The results (reported in Section 5) are entirely consistent regardless of the method used to compute the FX factor.

3.3.2 Currency risk factors

Researchers have recently introduced currency risk factors that aim to capture investment behavior in the foreign exchange market driven by interest differentials across currencies. The currency risk factors are similar in spirit to the other factors in the F&F models in that they relate to investment strategies in the foreign exchange market. The currency risk factors have been shown to explain most of the cross-sectional variation in foreign currency excess returns (Lustig *et al.*, 2011). Brusa *et al.* (2014) introduce currency risk factors into an international asset pricing model and claim that their 3-factor model explains aggregate stock market returns from a broad cross-section of developed and emerging markets. Karolyi and Wu (2020) use a wide range of asset pricing models to evaluate the addition of currency risk factors. They conclude that CRF are promising; still, their suitability in explaining stock returns needs to be studied further. Our paper examines the role played by currency risk in the pricing of Eurozone stock returns. Whereas the previous literature has been entirely devoted to developing currency risk factors for the dollar, we construct currency risk factors for the euro and examine their relevance for the pricing of foreign exchange risk in the Eurozone.

Lustig *et al.* (2011) calculate forward discounts for various currencies vis-à-vis the US dollar and use these to allocate currencies into six portfolios at the end of each month. They include all foreign currencies (both developed and emerging economy currencies) for which forward exchange rate data are available. They use the sorted portfolios to compute two currency risk factors. The *level factor* (or the *dollar risk factor*) is the average excess return on all foreign currency portfolios. The *slope factor* (or the *carry trade risk factor*) is equivalent to the return on a zero-cost strategy that goes long in the high-forward discount portfolio (sixth portfolio) and short in the low-forward discount portfolio (first portfolio).

Lustig *et al.* (2014) introduce two additional factors based on comparing forward discounts between the US and developed countries' currencies. The investment strategy relies on whether the average forward discount on all developed country currencies is positive or negative: the strategy goes long on all forward one-month contracts in the former case. The latter case goes short. The excess return on this strategy is labeled as the *dollar-carry-trade factor*. According to LRV (2014), this factor rewards US investors for the risk they bare, by selling the dollar when the price of risk is high. LRV (2014) introduce a second factor, the *average forward discount (AFD)* factor, which is the differential between the US short-term interest rate and the average short-term interest rate of all other developed countries.

Verdelhan (2018) introduces two additional currency risk factors. He constructs six portfolios of currencies sorted according to their forward discounts (as in LRV 2011). The *dollar factor* is the average change in the exchange rate between the US dollar and the foreign currencies across all portfolios of currencies at each point in time. The *carry factor* is the difference between the average change in the exchange rate between the US dollar and all currencies in the high-forward discount portfolio (sixth portfolio) and the average exchange rate change for currencies in the low-forward discount portfolio (first portfolio). The paper shows that the *dollar factor* and *carry factor* capture a significant part of exchange rate variation, detecting differences regarding firms' forex sensitivity across countries.

All previous studies have addressed and constructed currency risk factors from the perspective of US dollar-based investors. This literature (*e.g.*, Brusa *et al.*, 2014; Aloosh and Bekaert, 2019; Karolyi and Wu, 2020) has identified the first two factors (*Level* and *Slope*) as the relevant factors measuring exchange rate risk and introduced these as a pair. Our paper constructs and analyzes currency risk factors for the euro from a Eurozone investor's perspective. Also, we focus our attention on the first two factors for the euro: we refer to these as the *euro level factor* (or the *euro risk factor*) and the *euro slope factor* (or the *euro carry trade risk factor*).[14] According to LRV (2011), the slope factor captures most of the currency-related exposure of stock returns, and it is entirely affected by common exchange variation between various currencies. The higher the forward discount of the currency, the higher its exposure is to this slope factor. They conclude that these factors capture common variation in exchange rates and measure differences in global risk exposure.

We follow the process in LRV (2011) and calculate the log forward discount of each currency relative to the euro as the difference between the log (mid) spot exchange rate at the end of each month (month *t*) and the log 30-day (mid) forward exchange rate at the end of the previous month. The (forward discounts of) currencies are then sorted into six portfolios, and portfolios are rebalanced each month. The lowest portfolio (portfolio 1) contains the currencies with the lowest forward discounts, while the highest portfolio (6) contains the currencies with the highest forward discounts. Forward and spot exchange rates are all in units of foreign currency per euro. Subsequently, we compute the log currency excess returns for each portfolio, net of bid-ask spreads. We assume that investors sell all foreign currencies in portfolio one and buy the other portfolios' currencies. The net log currency excess return for an investor who goes long in foreign currency k at the end of period $t+1$ is given by:

$$rx_{k,t+1}^{€lg} = f_{k,t}^{€bid} - s_{k,t+1}^{€ask} \qquad (3)$$

[14] We have also computed the other four currency risk factors mentioned and have examined their contribution to the pricing of foreign currency risk in the Eurozone. The results are the same as for the level and slope factor for the euro that we discuss in the next section.

where $f_{k,t}^{€bid}$ is the log 30-day *bid forward exchange rate* between currency *k* and the euro at the end of period *t* and $s_{k,t+1}^{€ask}$ is the log *ask spot exchange rate* between currency *k* and the euro at the end of period *t*+1. By contrast, the net excess return for an investor who goes short in foreign currency *k* at the end of period *t+1* is given by

$$rx_{k,t+1}^{€sh} = -f_{k,t}^{€ask} + s_{k,t+1}^{€bid} \tag{4}$$

where $f_{k,t}^{€ask}$ and $s_{k,t+1}^{€bid}$ are defined similarly. We have complete data on the bid, ask, and mid-forward and spot exchange rates at the end of each month between the euro and the 26 currencies mentioned previously in the discussion of the construction of the EER index for the euro from WM/Refinitiv.

Following LRV (2011), in Table 2, we report several statistics for the six currency portfolios from a Eurozone-based investor's perspective. First, for each portfolio, we calculate the mean change in the log spot exchange rate $\Delta s_{t+1} = s_{t+1} - s_t$, the average log forward discount $(f_t - s_t)$, and the average log gross excess return that includes transaction costs (without bid-ask spreads) as $rx_{t+1} = -\Delta s_{t+1} + (f_t - s_t)$. These means, along with the corresponding standard deviations, are shown in the first three panels of the table. The fourth panel shows the average log excess return net of transaction costs (rx_{t+1}^{net}) that allows for bid-ask spreads as described earlier and shown in Eqs. (3) and (4). The fifth and sixth panels show log currency excess returns on carry trades, where an investor goes long in each of the portfolios 2 to 6 and short in the first portfolio. The fifth-panel shows carry trade gross excess returns (includes transaction costs), and the sixth panel excess returns net of transaction costs. All monthly moments of the returns are annualized (means are multiplied by 12 and standard deviations by $\sqrt{12}$) and are presented as percentages. The annualized standard error (*SE*) is shown in parentheses below each mean. Panels also show the Sharpe ratio (*SR*) as the annualized mean divide by the annualized standard deviation.

[Please insert here Table 2]

According to uncovered interest rate parity, on average, the expected forward discount on a currency (second panel) should equal the average expected rate of depreciation (first panel) so that the average log excess return (third panel) is zero. The average forward discount on currencies in the first portfolio is -1.23%. However, instead of appreciating, they depreciate on average by 0.66%, generating an average log currency excess return of −1.89%. Similarly, currencies in the sixth portfolio are expected to depreciate on average 6.68%, whereas they depreciate by 2.11%, yielding an average excess return of 4.57%. As shown in the third panel, the average gross excess return is significantly different from zero for portfolios 4 and 6. LRV (2011) reports similar findings for the dollar regarding the excess returns, but the averages are higher than the euro. After considering bid-ask spreads in the fourth panel, the net average excess return on the first portfolio is zero. Excess returns on other portfolios are, as expected, lower than gross excess returns. The sixth portfolio's net return is 1.91%, reducing 2.66% from the gross return. More importantly, none of the six euro portfolio net excess returns is significantly different from zero. The euro net excess returns are also lower than those for the dollar. Finally, the Sharpe ratio for the euro portfolios is low, and the highest is 0.28 (in absolute value).

The fifth and sixth panels report returns on zero-cost strategies that go long in currencies in each portfolio 2 to 6 (high forward discount) and short in the first portfolio (low forward discount) gross and net of transaction costs, respectively. In the fifth panel, all the differences (all strategies) yield positive and significant returns, increasing from portfolio 2 to 6. However, in the sixth panel, not all continue to generate positive returns net of transaction costs. Moreover, the resulting return is not significantly different from zero for any of the long-short strategies. This differs from estimates for the dollar, showing that all strategies (except for portfolio 2) yield significant positive returns, increasing from portfolio 3 to 6. The slope factor is the difference between the net returns on the first and the last portfolio and is 1.91% for the euro. This is lower than the corresponding strategy for the dollar (4.54%). This high-minus-low strategy yields a Sharpe ratio of 0.15, a ratio that is lower than the 0.50 for the dollar.

The last panel reports the frequency by which each portfolio is met through the period considered. As one can see, more or less, all portfolios have the same appearance through the sample. However, portfolio 1 has a marginally stronger presence.

3.4 Average Excess returns on portfolios of 5 x 5 sorts

In a series of papers, Fama and French (1993, 1996, 2012, 2015, 2017) use a double-sorted portfolio analysis to investigate how the various variables, *B/M*, *OP*, *CP*, and *INV* (a description of these variables and their measurement is in Appendix Table A1), vary across different levels of market capitalization (size).[15] This approach is used widely in the literature (Karolyi and Wu, 2020; Lustig *et al.*, 2011; Lutzenberger, 2015). For instance, Fama and French (2015) sort stocks into five-size portfolios and five (independent) portfolios based on *B/M, OP*, *CP*, and *INV,* respectively, leading thus into 25 (5×5) portfolios where their value-weighted returns are calculated. We perform the same analysis to investigate the interconnection between size and the other drivers (*B/M*, *OP*, *CP*, and *INV*) since it has not been done before for the Eurozone.

[15] Market Capitalization (*ME*) is defined as price times common shares outstanding. Operating profitability (*OP*) is calculated as revenues minus cost of goods sold, selling, general and administrative expenses, and interest expense as a percentage of each corporation's book equity value. Cash profitability (*CP*) is equal to operating profitability minus the effect of accruals. Investment (*INV*) is defined as the change in total assets between the end of fiscal year *t*-1 and fiscal year *t*, divided by *t*-1 total asset

Table 3 presents average value-weighted excess returns for 5x5 sorts based on *Size-B/M*, *Size-OP*, *Size-CP*, *Size-INV*, and size-foreign exchange sensitivity (*FXS*) we report results for Eurozone stock returns. In Part I, the table presents average value-weighted excess returns for 5x5 sorts based on *Size-B/M*, *Size-OP*, *Size-CP,* and *Size-INV*. Panel A of Table 3 shows average monthly excess returns for 25 value-weighted portfolios from two independent sorts, one on *ME* and the other on *B/M*. In every *ME* quintile, average return increases with *B/M*, *i.e.*, in Eurozone value stocks (high *B/M ratio*) perform better than growth stocks (low *B/M ratio*). The value effect is more prevalent among small stocks and weaker among big stocks, a characteristic observed by Fama and French (2015, 2017). For example, the average excess return for the first size quintile rises from 0.08% for the lowest *B/M* portfolio to 0.99% for the highest. On the other hand, the average excess return increases from 0.22% to 0.65% for the biggest stocks. Moreover, we examine whether a size effect exists when the smallest stocks' average excess returns are higher than those of the biggest stocks. There is no size effect for the first three *B/M* quintiles. There is, however, more distinct evidence of a size effect for Eurozone stock returns from the other sorts in Table 3.

Panels B, C, and D show excess returns for sorts on three other variables (or drivers) *OP*, *CP*, *INV*. For every size quintile, shares with the highest operating profitability or cash profitability display higher average returns than the lowest profitability, lending evidence to the importance of profitability. There is evidence for the size effect for every *OP/CP* quintile, but it is weaker for the higher *OP/CP* quintiles. In panel D, for every size quintile, the average return of the lowest investment portfolio is higher than the average return of the highest portfolio, evidence of an investment effect. There is a size effect in the three middle *INV* quintiles. In sum, the results for Eurozone stock returns regarding these effects are consistent with the findings of Bauer *et al.*

(2010), Fama and French (2015), and Lutzenberger (2015). We confirm the importance of size, value, profitability, and investment in Eurozone stock returns.

[Please insert here Table 3]

In addition, Panel E of Table 3 includes the stocks sorted on size and *FXS* that is the driver of a factor we regard as important in light of our discussion in the previous subsection. We present average excess returns for portfolios sorted on size and *FXS* by way of investigating its behavior concerning size. Foreign exchange sensitivity is the primary variable for computing a foreign exchange factor, discussed in the previous section, distinguishing between portfolios of stocks sensitive to *FX* returns (high or low sensitivity portfolios) and those that are not (middle portfolios). For this reason, instead of looking at the high-minus-low difference as in previous panels (Panel A-D), we focus on the difference between the average value-weighted returns of the middle sensitivity portfolios minus the average value-weighted return of the two extreme portfolios. The mid portfolios' returns for each size quintile are higher than the two extreme portfolios' returns. They also point to the inverse-U pattern of excess returns for exchange rate sensitivity discussed in the previous subsection. In the following section, we will discuss the importance of the F&F factors for the pricing of Eurozone stock returns and the pricing of foreign exchange risk in the Eurozone. For the former, we will use F&F factors calculated for Eurozone stock returns discussed here. For the latter, we will examine a factor based on foreign exchange rate sensitivity as well as foreign currency risk factors, both of which were described and discussed in the previous subsection.

4. EMPIRICAL ANALYSIS

This section presents the empirical analysis of the evaluation of various asset pricing models' ability to determine Eurozone stock returns. We evaluate the various Fama-French factors but focus our attention on the pricing of foreign currency risk. We begin with a discussion of the factors used in the evaluation of asset pricing models. We continue with the analysis of excess returns derived from double-sorted portfolios (5 × 5) based on key variables used to define the various asset pricing factors. Finally, we present results from spanning regression and multifactor tests, of the addition of foreign exchange risk factors to several baseline asset pricing models.

4.1 Fama-French Factors and Foreign Exchange Risk in Eurozone Stock Returns

Table 4 presents summary statistics for the APT models' main factors, reporting monthly means, standard deviations, Sharpe ratios, and Newey-west *t*-statistics for Eurozone stock returns. *HML* returns are positive and significant and are on average 0.38% per month. There is a positive value effect for Eurozone stock market returns. The existence of a value effect is consistent with the findings of a number of academic papers which identify it for the European and Easter European markets, such as Annaert *et al.* (2013), Lutzenberger (2015), Zaremba and Czapkiewicz (2017), and Foye (2018), but also with Fama and French (2017) results for Europe that show mean *HML* equal to 0.32% between 1990 and 2015.[16] There is a positive and significant momentum effect for Eurozone stock returns equal to 0.61%. The average monthly momentum effect is the highest amongst the various F&F factors. This finding is consistent with Lutzenberger (2015) and Karathanasis *et al.* (2010), who also find a positive and significant momentum in the European

[16] Fama and French (2017) do not report results for the Eurozone alone but for 16, European stock markets that include, in addition to the 11 Eurozone members considered here, the United Kingdom, Switzerland, Norway, Sweden, and Denmark.

market. Lutzenberger (2015) 's estimation for momentum provides the highest estimate among all factors, like our analysis (excluding *Forex* factor).

Profitability premiums are substantial and different from zero: both *RMW* factors (RMW_{OP}, RMW_{CP}) are positive and significant (0.05 level), with means 0.41% (RMW_{OP}) and 0.34% (RMW_{CP}). The investment premium is also significant (p-value < 0.01), with a mean value of 0.42%. This shows that stocks of low investing activity have higher average returns than those with high investing activity. This finding aligns with Titman *et al.* (2004) and Cooper *et al.* (2008), who found a negative relation between asset growth and stock returns. In addition to this, Fama and French (2017) also point out a significant profitability and investment premium for the European market with mean factor returns of 0.41% and 0.20%, respectively.

Finally, the size effect does not seem to exist for Eurozone stock markets. *SMB* factor returns are insignificant regardless of the F&F model (3-, 5- or 6-factor) underlying the computation of this factor. This result is consistent with Fama and French (2012, 2017), Cakici and Tan (2014) and Karathanasis *et al.* (2010), who also report an insignificant size effect for European markets. In conclusion, results from various factor returns are consistent with findings from Table 3, where we also identified a value, profitability, and investment effect but could not find evidence for the size effect.

Table 4 also presents country-specific factors.[17] Country-specific factors are generally insignificant, mainly due to the limited number of firms with available data for individual Eurozone stock markets. Notable exceptions are the pricing of size in stock returns in the Spanish

[17] Factors are presented for nine of the eleven Eurozone members considered in this study because for two of these (Ireland and Portugal) there is insufficient data to compute a continuous time series for the different factors.

and French stock markets (regardless of the calculation method of the *SMB* factor). Also, a significant profitability and investment effect is evident for the German stock market and a significant momentum effect for the Austrian and French stock markets.

The final factor in Table 4 is the FX_{FCT} described in the previous section. It is positive and significant with a mean of 0.73% per month (p-value ≤ 0.05). This indicates that foreign exchange exposure sensitivity is priced in Eurozone stock returns, and stocks with low sensitivity tend to have higher returns than those with extreme (positive or negative) sensitivity. This outcome is similar to previous studies showing that foreign exchange risk has a considerable impact on stock returns (Muller and Verschoor, 2006; Doidge *et al.*, 2006; Kolari, Moorman, and Sorescu, 2008; Inci and Lee, 2014).

[Please insert here Table 4]

Table 5 shows the correlation coefficients between factors. The correlations are generally low except between various methods for the computation of the same factor (*e.g.*, the three methods for computing the size factor for the 3-, 5- and 6-factor models).

[Please insert here Table 5]

4.2 Asset Pricing Tests

In this section, we compare the performance of the Fama-French models. We use regressions to explain excess returns on the portfolios from the 5x5 sorts on *SIZE-BM, OP, CP, INV,* and *FXS*. Using time-series regressions, we regress the value-weighted returns of the 25 portfolios on the factors of each APT model. If an asset pricing model explains expected returns, the intercept is indistinguishable from zero when regressing excess returns on the model's factors.

Table 6 shows performance measures on test assets for the most well-known asset pricing models, *i.e.*, Fama-French 3-, 5, and 6-factor models *(FF3/5/6)* and the Carhart 4-factor model (*C4*) . In addition, we present the Fama-French 6-factor model in its extended version that includes FX_{FCT} as an additional factor.

To compare model efficiency and identify the model that best matches average returns of portfolios formed using Eurozone data, we employ various widely-used asset pricing tests. First, we use GRS-statistic (Gibbons, Ross, and Shanken 1989). Second, we present the average absolute intercept of each model, $A|\alpha_i|$, that shows the average returns left unexplained by a model. Third, we offer estimates of the proportion of the dispersion in average returns that remains unexplained that is attributable to sampling error, $\frac{As^2(\alpha i)}{A\alpha^2 i}$The numerator is the average squared standard error of the intercept and the denominator the average square intercept. A higher value of this metric is preferred to a lower because it indicates that a higher proportion of the dispersion of the intercepts is sampling error as opposed to the dispersion of the true intercepts. Along with these metrics, we present the average adjusted-R^2 (AR^2)and the maximum squared Sharpe ratio of the intercept, $SR^2(\alpha)$, which is the core of the GRS statistic

$$SR^2(\alpha) = \boldsymbol{\alpha_i}' \boldsymbol{\Sigma_\iota^{-1}} \boldsymbol{\alpha_\iota}$$

where $\boldsymbol{\alpha_i}$ is the vector of estimated intercepts, and $\boldsymbol{\Sigma_\iota}$ is the estimated residual covariance matrix. The Sharpe ratio of an investment reveals the connection of the return of an asset to the risk it bears, so the greater it is, the more attractive the investment. By definition, the highest the Sharpe ratio is, the lowest the Sharpe ratio of the intercept (Fama and French, 2018). So, a lower value of the maximum-squared Sharpe ratio of the intercept is preferred. The advantage of the maximum squared Sharpe ratio as a metric is that it uses both the regression intercepts with the covariance matrix of the regression residuals that is an indicator of the accuracy of the alphas.

As in Fama and French (1993), we assume that all factors represent zero-investment strategies, and under the null hypothesis, the intercept of a model must be zero. Taking this into account, the GRS test is an *F*-statistic multiplied *(T-N-K)/(NT)* to the Wald test:

$$W = T\frac{SR^2(\alpha)}{1 + SR^2(F)}$$

where $SR^2(F)$ is the maximum squared Sharpe ratio over portfolios of the factors, *T* is the number of months, *N* is the number of assets, and *K* is the number of factors. The connection of GRS statistic with the two Sharpe ratios ($SR^2(F)$, $SR^2(\alpha)$), is the reason we seek the lowest value in this subsection.

Extensive comparisons of the different models of Fama-French have been carried out previously in the literature. Here we confine our discussion to the Fama-French 6-factor model (*FF*6) in its base version and the extended version augmented by the foreign exchange sensitivity factor to highlight the importance of foreign currency risk in the pricing of Eurozone stock returns. For the 25 *SIZE-BM* sorts, the performance of the base and extended models is similar. The extended model produces a slightly lower GRS-statistic, but the statistic is highly significant (0.01 level) for both versions. The extended model's adjusted-R^2 is slightly higher. The mean absolute intercept is not significantly different between the two versions. The maximum squared Sharpe ratio of the intercept is lower for the base model and the $\frac{As^2(\alpha i)}{A\alpha^2 i}$ ratio is higher, indicating a higher percentage of average returns' unexplained dispersion due to sampling error.

The 25 *size-OP -CP*, *-INV*, and *-FXS* sorts produce very similar results for the two versions. Both versions of the *FF6* model have a statistically significant GRS statistic (0.01 level), and their average absolute intercepts and adjusted-R^2 are similar. The base model has a higher $As^2(\alpha_i)/ A\alpha^2_i$ ratio, while the extended model has a lower maximum Sharpe ratio of the intercept.

The results in Table 6 from 25 *size- BM*, *OP*, *CP*, *INV*, *FXS* sorts do not provide conclusive evidence regarding the two alternative versions of the *FF6* model. The following sub-section performs spanning regressions to investigate this issue further and examine whether the foreign exchange factor contributes effectively to the description of Eurozone average returns.

[Please insert here Table 6]

4.3 Spanning Regressions

In this section, we present results from factor-spanning tests. Spanning regressions investigate whether a factor is important; if regressed on other factors, the intercept is non-zero, which indicates the factor under investigation (shown in the first column of Table 7) is significant in explaining the time variation of expected stock returns. In Panel A of Table 7, we report the intercept (α), the slope coefficients of the other factors, the *t*-statistic of the intercept *t*(α), the αdjusted-R^2, $\bar{R}^2$, and the maximum squared Sharpe ratio of the intercept. In Panel B, we present results from the GRS statistic that compares a baseline model against an augmented model that includes factors capturing foreign exchange risk.

In the time-series regressions (Panel A), the dependent variable is the monthly return of the candidate risk factor. The independent variables are the monthly returns of all other factors of a specific asset pricing model. We evaluate the F&F 3-, 5- 6-factor models and the Carhart 4-factor model augmented by the foreign exchange sensitivity factor explained in section 3.3. We also assess the F&F 6-factor model augmented by the two currency risk factors (level and slope) of Lustig *et al.* (2011). . When the foreign exchange sensitivity factor is added to the F&F factors, the market risk premium (*MRP*) continues to contribute significantly to the description of Eurozone average stock returns for the *FF3, FF6 and C4* models The *HML* and *SMB* factors are significant for all models confirming the importance of value and size effects in the pricing of stocks in the Eurozone after accounting for other factors included in the regressions In the *HML* regressions for the *FF5* and *FF6* models*,* a large part of the *HML* average return is absorbed by the slopes of *RMW* and *CMA* factors. The *CMA* slopes are positive, consistent with value firms being more conservative in their investment policy, and the RMW slopes are negative, consistent with value stocks being less profitable (Fama and French, 2015). As for the *RMW* and *CMA* factors, there is no evidence from the spanning regressions that the inclusion of these two improves a model's ability to describe average stock returns. The results regarding the *HML*, *RMW*, and *CMA* factors' importance are consistent with the spanning regression results of Fama and French (2017) for Europe. On the other hand, our findings for *SMB* in the spanning regressions are opposite to the ones found in the paper of Fama-French since their analysis for Europe shows it as insignificant. The *MOM* factor was examined only in Fama and French (2018), which considers only the US market; nevertheless, it is positive and significant.

Next, we turn to the pricing of foreign exchange risk. The foreign exchange sensitivity factor (FX_{FCT}) is significant (0.01 level) for all models. This indicates that other factors used as independent variables fail to explain returns on the FX_{FCT} factor. These results are confirmed by the maximum squared Sharpe ratio of the intercept for FX_{FCT}, which is, if not the highest, among the highest in each model, indicating that the factors used as independent variables fail to price the

FX_{FCT}. This result confirms the importance of foreign exchange risk in explaining Eurozone stock returns.

The inclusion of the Lustig *et al.* currency risk factors (*CRF*) in the *FF*6 model (last section of Panel A) shows that neither of the two *CRF* (level or slope) factors has a statistically significant impact on the model. This result shows that the two CRF factors are not significant in explaining Eurozone stock returns. In their extensive investigation of the contribution of currency risk factors Karolyi and Wu (2020) also question the ability of these two currency risk factors to explain global stock returns jointly.

Panel B presents multifactor tests to compare several baseline models with models augmented to include the pricing of foreign currency risk. The GRS test statistic evaluates whether the factors included in the augmented model improve the explanation ability of the factors included in the baseline model. We consider four baseline models: the *FF 3*, *FF5*, *FF6* factor models, and the Carhart 4-factor model. We provide two sets of results for the augmented models: one includes both the *CRF* - slope and level - factors, and the other includes the FX_{FCT}. The results confirm those from the spanning regressions. The inclusion of the foreign exchange sensitivity factor improves the performance of all models (p-value < 0.01 in all cases). On the other hand, the inclusion of both *CRF* factors does not contribute significantly to any of the models' ability to explain Eurozone stock returns (p-value > 0.10 in all cases). In sum, we find evidence that a factor estimated using *FXS* of stock returns is important for describing average stock returns in the Eurozone. The excess returns built on zero-investment portfolios generated from this FX_{FCT} are comparable; indeed they exceed, the excess returns generated by the more 'traditional' Fama-French pricing factors.

[Please insert here Table 7]

5. ROBUSTNESS ANALYSIS

In this section, we perform a robustness analysis to evaluate how sensitive our main results for the Eurozone stock markets are to modifications of the underlying empirical methodology. This allows us to understand the pricing of currency risk in equity markets and provides additional support to our findings.

5.1 European Fama-French factors and Eurozone specific factors

This subsection provides a comparison between the ability of asset pricing models based on the European factors calculated by Fama and French and our Eurozone-specific factors to describe Eurozone average stock returns. The Fama-French European factors are not Eurozone specific but cover the whole continent and include returns from stock markets in the United Kingdom, Switzerland, Norway, Sweden, and Denmark.

We make use of the same metrics described in subsection 4.2, *i.e.*, the GRS-statistic, the average absolute intercept from the regressions, $A|\alpha_i|$, average adjusted-R^2 (AR^2), the maximum squared Sharpe ratio of the intercepts, $SR^2(\alpha)$, the proportion of the dispersion in average returns that remains unexplained that is attributable to sampling error, $\frac{As^2(\alpha i)}{A\alpha^2 i}$, and the average of the standard errors of the intercepts.

[Please insert here Table 8]

Table 8 presents the descriptive statistics of European Fama-French factors and Eurozone-specific factors and their difference. The two sets of factors do not differ widely: indeed, a statistical test for the significance of the mean difference between the two cannot reject the equality of means for any of the factors. Table 9 shows the performance measures on test assets for *FF3/5/6* and *C4*, using either Fama-French European factors or Eurozone factors. Considering each metric, the

GRS-statistic is statistically significant for both versions of each model, and the average of the standard errors of the intercepts is the same in all cases. The maximum squared Sharpe ratio of the intercepts, $SR^2(\alpha)$, provides mixed results since for sorts on *SIZE-BM*, *OP* is lower for the Eurozone models, while for sorts on *SIZE-INV/FXS*, it is lower for the European models. The other two metrics $\frac{As^2(\alpha i)}{A\alpha^2 i}$ and the adjusted-R^2, also give mixed results. The performance of the two versions of the models seems similar.

The important conclusion from Table 9 concerns the average absolute intercept from the regressions, $A|\alpha_i|$. For the *FF3* model, the average values of the intercept are almost the same between the two versions. However, for all other cases (*C4, FF5, FF6)*, the models based on Eurozone-specific factors generate much lower mean alphas than the models with the European factors. This would indicate that the Eurozone-specific models are a better fit for our sample.

[Please insert here Table 9]

5.2 Spanning Regressions

In this subsection, we present results from factor-spanning tests similar to those shown in subsection 4.3. We employ three alternative approaches to estimating the foreign exchange sensitivity factor to test the robustness of our methodology. Spanning regressions investigate whether a factor is important in explaining the time variation of expected stock returns when regressed on other factors; the intercept is significantly different from zero. In Panel A of Tables 10, 11, and 12, we report the intercept (α), the slope coefficients of the other factors, the *t*-statistic of the intercept *t*(α), the adjusted - R^2, $\bar{R}^2$, and the maximum squared Sharpe ratio of the intercept. In Panel B, we present results from the GRS statistic that compares a baseline model against an augmented model that includes factors capturing foreign exchange risk.

5.2.1 Using Model Specific Foreign exchange risk factors

The foreign exchange factor has been estimated using the *FF6* model. However, a factor generated using a single model has an explanatory power adjusted to that specific model and might not be suitable for use in other APT models. In this subsection, we estimate a factor separately for each model (*FF3/5/6, C4)*. We estimate each model (*FF3/5/6, C4)* using the methodology described in subsection 3.3.1. Then, we follow the same methodology as before to compute the foreign exchange sensitivity factor. When this alternative foreign exchange sensitivity factor is added to the F&F factors in Table 10, the market risk premium (*MRP*), *HML,* and *SMB* factors continue to contribute significantly to the description of Eurozone average stock returns, confirming the importance of value and size effects in the pricing of stocks in the Eurozone. *RMW* and *CMA* factors provide no significant results that their addition improves a model's ability to describe stock returns in our sample. However, importantly, the FX_{Fct} is significant (0.01 level) for all models. This indicates that other factors used as independent variables fail to price the foreign exchange factor. Panel B presents multifactor tests to compare several baseline models with models augmented to include the pricing of foreign currency risk. The results confirm those from the spanning regressions.

[Please insert here Table 10]

5.2.2 Alternative measure of effective exchange rate for the Euro

In this subsection, we use an alternative measure of the effective exchange rate for the Euro calculated by the European Central Bank. This alternative measure (*EER42*) is the most comprehensive measure of the euro effective rate provided by the ECB and uses bilateral exchange rates and trading patterns for 42 Eurozone trading partners. We follow the same methodology described in subsection 3.3.1 but substitute our estimate of the *EER* with the *EER42* from the ECB.

Adding the foreign exchange sensitivity factor to the F&F factors in Table 11, the market risk premium (*MRP*), *HML*, and *SMB* factors do not lose their strength and continue generating significant intercepts. *RMW* and *CMA* factors do not provide precise results regarding their significance in pricing stock returns in Eurozone. The most substantial result is that the FX_{Fct} continues to be significant (0.01 level) for all models, emphasizing its importance. Panel B results confirm those from the spanning regressions.

[Please insert here Table 11]

5.2.3 Using a different portfolio combination to estimate a foreign exchange risk factor

In this subsection, we choose to use an alternative approach as in Kolari *et al.* (2008). Their foreign exchange factor for the dollar uses the 4-factor model to estimate exchange rate sensitivity. It then takes the difference between the average return of all (23) middle portfolios minus the average of the two extremes (1 and 25).

When the foreign exchange sensitivity factor is added to the F&F factors in Table 12, this foreign exchange factor yields significant intercepts (0.01 level) in all spanning regressions. We have opted for the calculation of a foreign exchange risk premium that is based on a more comprehensive model (FF 6-factor model) and is based on zero-cost arbitrage strategies on a small number of portfolios (five) instead of all the portfolios generated by sorting stocks according to the estimates of foreign exchange sensitivity. In sum, the robustness section results reinforce the importance of the foreign currency risk factors in asset pricing models for describing Eurozone stock returns.

[Please insert here Table 12]

6. CONCLUSION

This study investigates the asset pricing models in Eurozone market by emphasizing on the systematic role of currency risk in explaining stock returns. In particular, this paper first discusses the size, value, profitability, investment and momentum effects in Eurozone, providing Eurozone-specific estimates of the factors used in the various seminal asset pricing models of Fama and French (1993,2015, 2018). Subsequently, it expands these asset pricing models by suggesting a foreign exchange factor to evaluate the impact of foreign currency risk on stock returns for a large cross-section of Eurozone corporations for 2000-2019.

Our findings provide evidence regarding the significance of foreign exchange risk in the pricing of stock returns in the Eurozone. We also confirm the existence of value, profitability, and investment effects in the Eurozone market, and also the importance of momentum. From the spanning regression, we gain statistically significant indications for the size, value, and foreign exchange factors, regardless of the APM used, and for the momentum factor for Carhart's 4-factor model and Fama-French 6-factor model, which use it. Foreign exchange factor's significance confirms the important role of currency exchange risk asset pricing models. Also, the results lead us to the conclusion that value firms in Eurozone seem to be more conservative in their investment policies and less profitable (Fama and French, 2015). The outcomes of this study can be viewed as evidence of the pricing of currency risk in stock returns and confirm the significance of factors discussed in the literature by reporting solid indications about the presence of the value, profitability, investment, and momentum effects in the Eurozone. At the same time, the size effect is absent, which is consistent with other studies (*e.g.,* Fama and French, 2012/2017; Cakici and Tan, 2014; Karathanasis *et al.*, 2010).

Our study offers avenues for future research on asset pricing models for the Eurozone by considering other systematic factors that can be driven by the same forces (*i.e.*, exposure to foreign currency risk) as the foreign exchange factor. Such factors could be related to firms' foreign sales, foreign corporate diversification, or foreign investments.

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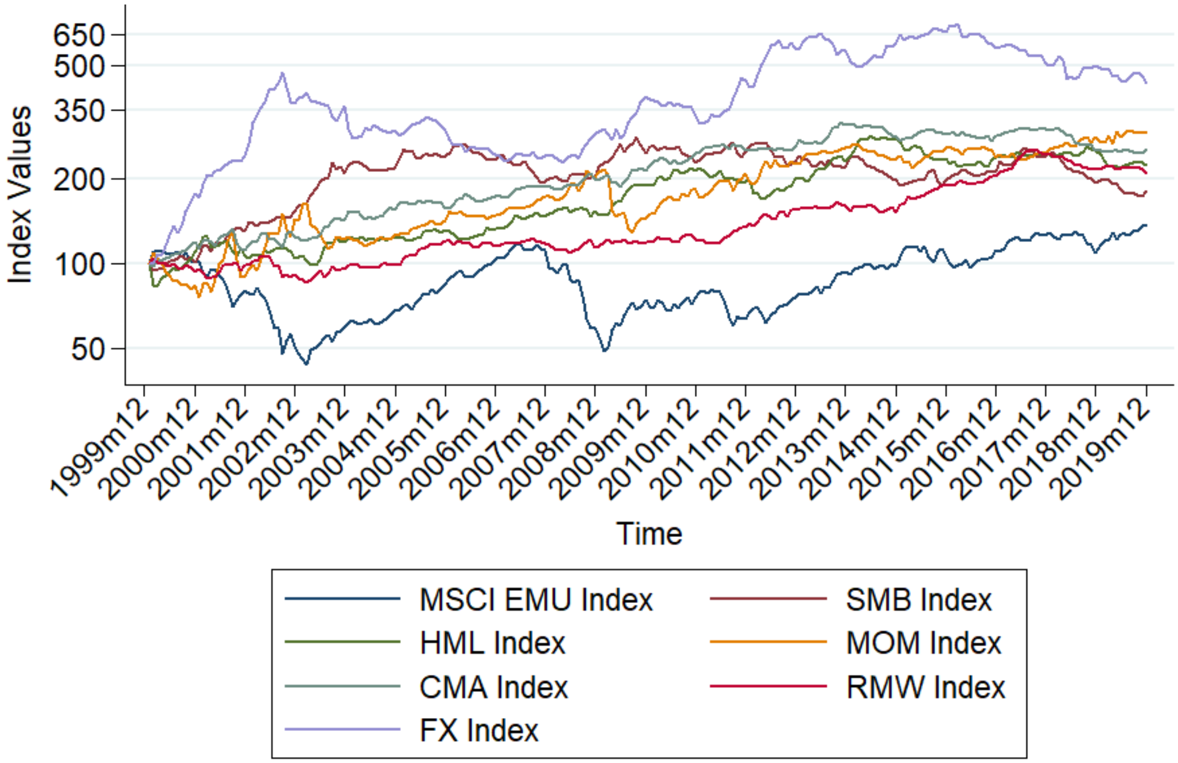
FIGURE

Figure 1: The figure shows how the performance of factor portfolios changed through time, using as base month Jan 2000.



TABLES

Table 1

Foreign exchange sensitivity portfolios

This table presents the value-weighted returns of 25 portfolios formed on foreign exchange sensitivity: January 2000 to December 2019
From 2000 to 2019, 25 portfolios are formed every month based on the sensitivity of Eurozone stock returns to effective exchange rate changes. The zero investment portfolio in the last row of the table is the value-weighted monthly return of stocks in portfolios 12 through 14 minus stocks in portfolios 1 and 25. The coefficient measures sensitivity on Δln*EER* from the estimation of the specification in Eq (2) :

$$\left(R_{i,t} - R_{f,t}\right) = a_i + \beta_{i,M}\left(R_{M,t} - R_{f,t}\right) + \sum_{j=1}^{j=F_N} \beta_{i,j}\, F_{j,t} + \beta_{i,EER}\Delta\ln EER_t + v_t$$

where $(R_{i,t} - R_{f,t})$ is firm *i*'s excess stock return (net of the risk-free interest rate, $(R_{M,t} - R_{f,t})$ is the excess return on the equity market portfolio denominated in euro, F_j is asset pricing factor j, F_N are the factors included in the estimated model, and $\Delta\ln EER_t = \ln EER_t - \ln EER_{t-1}$ is the return on the *EER* in this analysis. The market return $(R_{M,t})$ is the MSCI EMU total return index and (R_{ft}) is the Germany Government Benchmark Bid Yield 3 Month. The number of factors included in the model (F_N) corresponds to the number in the relevant asset pricing model, in this case, the 6-factor model (HML_t, SMB_{6Ft}, RMW_{CPt}, CMA_t, and MOM_t Eurozone-specific factors obtained from this analysis). The estimate of the parameter $\beta_{i,EER}$ is each firm's foreign exchange sensitivity or exposure to foreign currency changes.

The table shows portfolio averages for size, the coefficient on Δln*EER*, and returns. Size is calculated as price times the number of shares outstanding at the end of each month for each portfolio. Annual returns are average value-weighted monthly returns multiplied by 12.

Foreign Exchange sensitivity portfolio	Number of observations	Coefficient on ΔlnEER_t			Size ('000)	Average annual VW return
		Estimate	Percent positive	Percent significant at 10% level		
1	15,136	-5.891	0%	50.3%	535114	-1.96%
2	15,028	-3.236	0%	37.4%	1130415	11.17%
3	15,021	-2.452	0%	26.8%	1616282	11.47%
4	15,030	-1.956	0%	20.0%	2197737	7.94%
5	14,993	-1.599	0%	13.8%	2493933	8.61%
6	15,039	-1.317	0%	9.0%	2592327	10.01%
7	15,025	-1.080	0%	5.6%	2792278	5.73%
8	15,037	-0.868	0%	3.3%	2995702	4.72%
9	15,010	-0.676	0%	2.1%	3010854	5.97%
10	15,000	-0.499	2%	1.2%	3112720	7.18%
11	15,057	-0.331	11%	0.9%	3175413	7.30%
12	15,016	-0.165	27%	0.5%	3073450	9.08%
13	15,024	-0.003	44%	0.6%	3444383	8.31%
14	15,016	0.159	76%	0.6%	3031970	4.67%
15	15,011	0.323	96%	1.0%	2911949	7.54%
16	15,047	0.496	100%	1.4%	2840427	5.34%
17	15,009	0.679	100%	2.1%	2805253	5.11%
18	15,037	0.875	100%	4.0%	2719770	6.88%
19	15,025	1.093	100%	6.3%	2522799	5.82%
20	14,993	1.342	100%	8.9%	2057297	5.47%
21	15,039	1.640	100%	14.7%	1987158	9.18%
22	15,031	2.013	100%	21.4%	1553357	6.48%
23	15,020	2.519	100%	29.6%	1362636	2.69%
24	15,028	3.346	100%	38.4%	860670	3.30%
25	14,906	6.155	100%	52.1%	351550	-0.88%
(12U..14) - (1U25)						8.78%
						NW-t= 1.93
						p-value = 0.05

<u>Table 2</u>

Currency Portfolios for Eurozone Investors

This table reports, for each portfolio, the average change in log spot exchange rates, the average log forward discount, the average gross excess return (without bid-ask spreads), the average net excess return (with bid-ask spreads), and the average return on the long-short strategy (high-minus-low with and without bid-ask spreads). Log currency excess returns are computed as $rx_{t+1} = -\Delta s_{t+1} + f_t - s_t$. Means, standard deviations are annualized and reported as percentage points. Standard errors (SE) are reported in parentheses below the mean. The table also reports Sharpe ratios (*SR*) computed as annualized means divided by annualized standard deviations.

The portfolios are constructed by sorting currencies into six groups at time *t* based on the one-month-forward discount at the end of period $t-1$. The first portfolio contains currencies with the lowest forward discounts, and the last portfolio includes currencies with the highest forward discounts. The sample period is 01/2000–12/2019.

Portfolio	1	2	3	4	5	6
	Spot Exchange Rate Changes					
Mean	0.66%	0.36%	0.28%	-0.82%	3.04%	2.11%
Std. Dev.	6.10%	6.98%	5.59%	5.80%	6.75%	8.48%
	Forward Discounts					
Mean	-1.23%	0.03%	0.78%	1.76%	3.39%	6.68%
Std. Dev.	0.32%	0.23%	0.22%	0.17%	0.23%	0.45%
	Gross Excess Return					
Mean	-1.89%	-0.33%	0.50%	2.58%	0.35%	4.57%
	(0.014)	(0.016)	(0.013)	(0.013)	(0.015)	(0.019)
Std. Dev.	6.12%	7.00%	5.61%	5.81%	6.72%	8.50%
SR	-0.308	-0.047	0.089	0.444	0.052	0.537
	Net Excess Return:					
Mean	0.00%	-1.94%	-1.45%	0.56%	-1.86%	1.91%
	(0.014)	(0.016)	(0.013)	(0.013)	(0.015)	(0.019)
Std. Dev,	6.13%	6.99%	5.60%	5.80%	6.77%	8.52%
SR	0.000	-0.277	-0.259	0.097	-0.275	0.224
	High-minus-Low: Gross					
Mean		1.56%	2.39%	4.47%	2.24%	6.46%
		(0.011)	(0.011)	(0.011)	(0.015)	(0.018)
Std. Dev.		5.11%	4.84%	4.93%	6.79%	7.89%
SR		0.306	0.494	0.907	0.330	0.818
	High-minus-Low: Net					
Mean		-1.94%	-1.45%	0.56%	-1.86%	1.91%
		(0.027)	(0.024)	(0.024)	(0.024)	(0.028)
Std. Dev.		12.11%	10.69%	10.87%	10.94%	12.56%
SR		-0.160	-0.136	0.051	-0.170	0.152
	Frequency					
	0.19	0.16	0.16	0.18	0.16	0.15

Table 3:

Average value-weighted excess returns for 5x5 sorts

This table reports average monthly percent excess returns for portfolios formed on Size and B/M, Size and OP, Size and CP, Size and Inv and Size and foreign exchange sensitivity,

Every month stocks are allocated to five *Size* groups (Small to Big) based on market capitalization. Also, stocks are assigned independently to five groups based on *B/M* or *OP* or *CP* or *Inv* or *foreign exchange sensitivity*. Foreign exchange sensitivity is estimated from an expanded Fama-French 6-factor model as explained in Table 1.

The table shows average monthly returns in excess of the risk-free rate (German Government Benchmark 3-month Bid Yield). The sample period is 01/2000–12/2019.

Panel A: Size and B/M portfolios					
	1-Low	2	3	4	5-High
1-Small	0.08%	0.24%	0.16%	0.71%	0.99%
2	-0.17%	0.17%	0.16%	0.53%	0.57%
3	-0.07%	0.33%	0.41%	0.68%	0.89%
4	0.05%	0.49%	0.62%	0.75%	0.99%
5-Big	0.22%	0.36%	0.57%	0.51%	0.65%
Panel B: Size and OP portfolios					
	1-Low	2	3	4	5-High
1-Small	0.30%	0.68%	0.55%	0.67%	0.57%
2	0.00%	0.42%	0.52%	0.26%	0.25%
3	0.20%	0.38%	0.61%	0.46%	0.55%
4	0.37%	0.26%	0.69%	0.63%	0.61%
5-Big	0.09%	0.18%	0.28%	0.43%	0.54%
Panel C: Size and CP portfolios					
	1-Low	2	3	4	5-High
1-Small	0.26%	0.84%	0.64%	0.71%	0.38%
2	-0.11%	0.53%	0.59%	0.46%	0.39%
3	0.08%	0.47%	0.92%	0.64%	0.75%
4	0.23%	0.47%	0.72%	0.88%	0.79%
5-Big	0.11%	0.36%	0.17%	0.39%	0.51%
Panel D: Size and Inv portfolios					
	1-Low	2	3	4	5-High
1-Small	0.41%	0.71%	0.58%	0.66%	0.04%
2	-0.01%	0.45%	0.60%	0.44%	-0.17%
3	0.42%	0.68%	0.70%	0.34%	0.10%
4	0.64%	0.78%	0.71%	0.58%	0.05%
5-Big	0.63%	0.46%	0.37%	0.22%	0.33%
Panel E: Size and Foreign Exchange Sensitivity					
	1-Low	2	3	4	5-High
1-Small	0.44%	0.74%	0.61%	0.38%	0.43%
2	0.26%	0.50%	0.30%	0.42%	0.02%
3	0.54%	0.62%	0.58%	0.58%	0.13%
4	0.59%	0.77%	0.52%	0.65%	0.34%
5-Big	0.38%	0.39%	0.49%	0.28%	0.39%

Table 4

This table presents summary statistics of the Fama-French factors, Carhart's momentum factor, and of the Forex factor for the period Jan 2000 to Dec 2019, 240 months

Fama-French factors & Carhart's momentum factor: Each month, stocks are assigned to two Size groups using their Market capitalization. Stocks are allocated independently to three B/M groups using 30^{th} and 70^{th} percentile breakpoints. The MV and B/M sorts intersections produce six portfolios, which we use to compute monthly value-weighted returns for each portfolio. We construct spread factors for small and big stocks, and eventually, the HML factor is the average of the small and big spread factors. The investment factor CMA, and the profitability factors, RMW_{op} and RMW_{cp}, are constructed like HML. For CMA, the second sort is on Investment, the annual growth rate of total assets (low to high). The second sort for RMW_{op} is on operating profitability (net of interest expense and scaled by book equity), while for RMW_{cp} is on cash profitability (operating profits minus the effect of accruals) divided by book equity. For the momentum factor, we take the equal-weighted average of firms within the highest 30 percent 11-months returns lagged one month, minus the equal-weighted average of firms with the lowest 30 percent eleven-month returns lagged one month. The portfolios are formed monthly, and the MOM factor is returns on value-weighted, zero investment portfolios for one-year momentum in stock returns (Carhart 1997). The 2x3 sorts used to construct HML, RMW_{op}, $RMW_{cp,}$ and CMA generate four size factors SMB_{bm}, SMB_{op}, SMB_{cp}, and SMB_{inv}. Considering SMB_{3f}, this is the average of the three small stock portfolio returns minus the three big stock portfolio returns from the MV- B/M sorts. SMB_{5f} is the average of SMB_{bm}, $SMB_{op,}$ and SMB_{inv}. SMB_{6f} is the average of SMB_{bm}, $SMB_{cp,}$ and SMB_{inv}.

Forex factor (FX_{Fct}): Using Fama-French's 6-factor model, we estimated the foreign exchange exposure sensitivity coefficients, performing a rolling regression with a window of 24 months, keeping it to a minimum of 24. Using the estimated betas, we sort stocks into 25 portfolios; portfolio 1 has stocks with the smallest sensitivities while portfolio 25 contains stocks with the highest sensitivities. After the above, we proceed with constructing a foreign exchange risk factor (*Forex factor).* We create a zero-investment portfolio using the monthly value-weighted returns that longs stocks within the two extreme sensitivity portfolios (1 and 25) and shorts portfolios in the middle portfolios (12…14).

	HML			**RMW_{OP}**			**RMW_{CP}**			**CMA**			**MOM (Carhart)**		
Mean		**0.38%**			**0.41%**			**0.34%**			**0.42%**			**0.61%**	
Std Dev		0.032			0.025			0.025			0.028			0.052	
Sharpe R.		0.080			0.120			0.090			0.110			0.100	
NW *t*-stat		1.770			2.570			2.550			2.450			1.850	
	Mean	**Std Dev**	**t-statistic**	**Mean**	**Std Dev**	**t-statistic**	**Mean**	**Std Dev**	**t-statistic**	**Mean**	**Std Dev**	**t-statistic**	**Mean**	**Std Dev**	**t-statistic**
AT	0.005	0.152	0.256	-0.018	0.135	-0.761	-0.011	0.167	-0.332	-0.024	0.114	-1.314	**0.009**	**0.063**	**2.193**
BE	**0.021**	**0.066**	**2.245**	0.001	0.080	0.094	-0.012	0.074	-1.398	-0.001	0.061	-0.123	0.005	0.057	1.455
DE	0.001	0.057	0.304	**0.009**	**0.051**	**2.786**	**0.009**	**0.050**	**2.759**	**0.007**	**0.059**	**1.846**	0.004	0.076	0.716
ES	-0.006	0.066	-0.824	-0.001	0.056	-0.253	0.003	0.067	0.513	0.001	0.074	0.206	0.006	0.060	1.485
FI	0.005	0.080	0.844	-0.010	0.085	-1.355	-0.001	0.084	-0.162	-0.001	0.094	-0.161	0.008	0.080	1.543
FR	0.001	0.054	0.295	**0.007**	**0.053**	**1.957**	-0.001	0.049	-0.442	0.000	0.045	0.077	**0.010**	**0.059**	**2.569**
GR	0.000	0.081	0.042	**0.017**	**0.082**	**2.611**	**0.018**	**0.085**	**2.413**	-0.003	0.064	-0.485	0.001	0.082	0.201
IT	0.004	0.069	0.874	0.000	0.081	-0.064	-0.005	0.081	-0.935	-0.005	0.051	-1.507	0.003	0.062	0.779
NL	-0.003	0.104	-0.265	-0.008	0.098	-1.164	**-0.020**	**0.074**	**-3.695**	-0.008	0.112	-0.957	0.000	0.071	0.022

	SMB_{5F}			SMB_{6F}			SMB_{3F}			FX_{FCT}		
Mean		0.35%			0.34%			0.25%			**0.73%**	
Std Dev		0.036			0.036			0.037			0.048	
Sharpe R.		0.070			0.070			0.040			0.130	
NW t-stat		1.480			1.450			1.020			1.930	
	Mean	**Std Dev**	**t-statistic**	**Mean**	**Std Dev**	**t-statistic**	**Mean**	**Std Dev**	**t-statistic**	**Mean**	**Std Dev**	**t-statistic**
AT	-0.034	0.073	-1.401	-	-	-	-0.006	0.132	-0.371	-0.004	0.117	-0.543
BE	0.011	0.011	1.388	**-0.030**	**0.054**	**-1.762**	**-0.015**	**0.054**	**-2.003**	0.005	0.066	1.233
DE	0.004	0.060	0.910	0.003	0.056	0.829	0.002	0.062	0.474	0.007	0.069	1.537
ES	**0.014**	**0.056**	**1.681**	**0.017**	**0.059**	**1.786**	**0.012**	**0.064**	**1.699**	0.007	0.070	1.620
FI	0.003	0.067	0.362	0.003	0.066	0.334	-0.0003	0.071	-0.056	**0.008**	**0.071**	**1.726**
FR	**0.010**	**0.051**	**3.121**	**0.007**	**0.048**	**2.189**	**0.009**	**0.057**	**2.370**	-0.002	0.067	-0.399
GR	0.011	0.098	1.055	0.011	0.096	1.017	0.003	0.107	0.275	0.004	0.089	0.720
IT	-0.007	0.055	-1.486	**-0.009**	**0.050**	**-2.267**	-0.006	0.062	-1.423	**0.008**	**0.071**	**1.689**
NL	0.012	0.091	1.118	0.010	0.084	0.950	0.008	0.083	1.086	0.004	0.085	0.717

Table 5: **Cross-Correlations**

	MRP	HML	RMW_{OP}	RMW_{CP}	CMA	MOM	SMB_{5F}	SMB_{6F}	SMB_{3F}	$Level_{FCT}$	$Slope_{FCT}$	FX_{FCT}
MRP	1.00											
HML	0.11	1.00										
RMW_{OP}	0.04	-0.24	1.00									
RMW_{CP}	0.05	-0.22	0.50	1.00								
CMA	0.01	0.13	0.08	0.16	1.00							
MOM	-0.48	-0.18	0.18	0.23	0.02	1.00						
SMB_{5F}	-0.30	-0.07	0.00	-0.16	0.12	-0.06	1.00					
SMB_{6F}	-0.30	-0.04	-0.04	-0.15	0.16	-0.06	0.99	1.00				
SMB_{3F}	-0.31	-0.26	0.02	-0.13	0.15	-0.03	0.97	0.96	1.00			
$Level_{FCT}$	0.07	0.01	0.01	-0.05	-0.09	-0.01	-0.10	-0.10	-0.09	1.00		
$Slope_{FCT}$	0.09	0.03	0.05	0.05	-0.07	-0.01	-0.14	-0.14	-0.14	0.84	1.00	
FX_{FCT}	-0.32	0.00	0.06	0.13	-0.05	0.21	-0.12	-0.12	-0.13	0.09	0.08	1.00

Summary Asset Pricing tests for portfolios from 5x5 sorts: January 2000 to December 2019, 240 months						
Model factos	GRS	p(GRS)	A|αi|	As2(αi)/ Aα2i	Sh2(a)	AR2
25 *Size-B/M*						
FF 3- Factor model	3.414	0.000	0.003	0.292	0.414	0.769
Carhart 4- Factor model	3.011	0.000	0.003	0.360	0.381	0.770
FF 5-Factor model	3.034	0.000	0.003	0.292	0.389	0.775
FF 6- Factor model	2.769	0.000	0.003	0.361	0.361	0.780
FF 6- Factor model (Extended)	2.659	0.000	0.003	0.351	0.360	0.783
25 *Size-OP*						
FF 3- Factor model	3.043	0.000	0.002	0.510	0.369	0.774
Carhart 4- Factor model	2.802	0.000	0.002	0.590	0.355	0.775
FF 5-Factor model	2.616	0.000	0.002	0.458	0.336	0.784
FF 6- Factor model	2.608	0.000	0.002	0.511	0.340	0.785
FF 6- Factor model (Extended)	2.564	0.000	0.002	0.393	0.347	0.788
25 *Size-CP*						
FF 3- Factor model	5.125	0.000	0.003	0.268	0.621	0.771
Carhart 4- Factor model	4.639	0.000	0.003	0.315	0.587	0.772
FF 5-Factor model	4.605	0.000	0.003	0.250	0.591	0.780
FF 6- Factor model	4.537	0.000	0.003	0.266	0.592	0.787
FF 6- Factor model (Extended)	4.248	0.000	0.003	0.256	0.574	0.790
25 *Size-Inv*						
FF 3- Factor model	4.591	0.000	0.003	0.295	0.556	0.768
Carhart 4- Factor model	4.297	0.000	0.003	0.354	0.544	0.770
FF 5-Factor model	4.513	0.000	0.003	0.272	0.579	0.782
FF 6- Factor model	4.217	0.000	0.003	0.319	0.550	0.786
FF 6- Factor model (Extended)	3.939	0.000	0.003	0.291	0.533	0.789
25 *Size-Forex Sensitivity*						

FF 3- Factor model	2.790	0.000	0.002	0.452	0.338	0.770
Carhart 4- Factor model	2.552	0.000	0.002	0.520	0.323	0.772
FF 5-Factor model	2.630	0.000	0.002	0.415	0.337	0.775
FF 6- Factor model	2.409	0.000	0.002	0.469	0.314	0.783
FF 6- Factor model (Extended)	2.312	0.001	0.002	0.376	0.313	0.786

Table 7: Factor Time-series tests
This table shows the spanning regression results (Panel A) and GRS statistic of Gibbons, Ross, and Shanken (1989) (Panel B). In Panel A, we test whether the factor under investigation (shown in the first column) is significant in explaining the time variation of expected stock return, *i.e.*, whether it has a non-zero intercept when regressed on the other factors reported in each row. We report the intercept (a), the slope coefficients of the other factors, the t-statistic of the intercept, the Adjusted $R^{2,}$ and the maximum squared Sharpe ratio. In Panel B, we present the GRS statistic that tests whether the currency risk factors jointly or the Forex factor explain a baseline model.

PANEL A: Spanning Regressions (Augmented Models)

	α	MRP	HML	SMB_{3F}	SMB_{5F}	RMW_{OP}	CMA	SMB_{6F}	RMW_{CP}	MOM	$Slope_{FCT}$	$Level_{FCT}$	FX_{FCT}	$t(\alpha)$	$\bar{R}^2$	$Sh^2(a)$
MRP	0.52%	-	0.025	-0.492	-	-	-	-	-	-	-	-	-0.383	1.76	0.215	0.014
HML	0.45%	0.012	-	-0.235	-	-	-	-	-	-	-	-	-0.013	2.16	0.061	0.021
SMB_{3F}	0.48%	-0.259	-0.255	-	-	-	-	-	-	-	-	-	-0.185	2.24	0.194	0.022
FX_{FCT}	0.87%	-0.371	-0.027	-0.341	-	-	-	-	-	-	-	-	-	3.00	0.147	0.039
MRP	0.77%	-	-0.112	-0.528	-	-	-	-	-	-0.438	-	-	-0.285	2.94	0.401	0.039
HML	0.55%	-0.068	-	-0.276	-	-	-	-	-	-0.145	-	-	-0.011	2.68	0.097	0.033
SMB_{3F}	0.61%	-0.343	-0.293	-	-	-	-	-	-	-0.183	-	-	-0.171	2.88	0.243	0.038
MOM	0.85%	-0.550	-0.298	-0.353	-	-	-	-	-	-	-	-	0.013	2.89	0.289	0.038
FX_{FCT}	0.86%	-0.364	-0.023	-0.336	-	-	-	-	-	0.013	-	-	-	2.90	0.144	0.038
MRP	0.43%	-	0.165	-	-0.493	0.180	0.031	-	-	-	-	-	-0.383	1.42	0.215	0.009
HML	0.41%	0.078	-	-	-0.044	-0.333	0.181	-	-	-	-	-	0.045	1.98	0.080	0.018
SMB_{5F}	0.41%	-0.255	-0.048	-	-	0.016	0.159	-	-	-	-	-	-0.169	1.88	0.141	0.017
RMW_{OP}	0.39%	0.054	-0.209	-	0.009	-	0.102	-	-	-	-	-	0.056	2.34	0.064	0.025
CMA	0.30%	0.012	0.140	-	0.112	0.125	-	-	-	-	-	-	-0.021	1.65	0.029	0.013
FX_{FCT}	0.80%	-0.373	0.092	-	-0.318	0.182	-0.057	-	-	-	-	-	-	2.70	0.143	0.033
MRP	0.59%	-	0.082	-	-	-	0.067	-0.548	0.393	-0.442	-	-	-0.281	2.28	0.435	0.025
HML	0.43%	0.053	-	-	-	-	0.202	-0.027	-0.324	-0.087	-	-	0.048	2.06	0.093	0.020
SMB_{6F}	0.46%	-0.364	-0.028	-	-	-	0.186	-	0.187	-0.194	-	-	-0.163	2.19	0.218	0.023
RMW_{CP}	0.22%	0.153	-0.193	-	-	-	0.129	0.109	-	0.074	-	-	0.052	1.38	0.115	0.009
CMA	0.25%	0.033	0.154	-	-	-	-	0.139	0.165		-	-	-0.019	1.35	0.053	0.009
MOM	0.71%	-0.579	-0.175	-	-	-	0.130	-0.382	0.249	-	-	-	0.007	2.41	0.300	0.027
FX_{FCT}	0.81%	-0.382	0.101	-	-	-	-0.052	-0.333	0.181	0.007	-	-	-	2.70	0.140	0.034
MRP	0.40%	-	0.069	-	-	-	0.085	-0.497	0.397	-0.493	0.003	0.182	-	1.45	0.369	0.010
HML	0.47%	0.040	-	-	-	-	0.207	-0.030	-0.334	-0.084	0.073	-0.181	-	2..27	0.092	0.024
SMB_{6F}	0.40%	-0.318	-0.033	-	-	-	0.186	-	0.180	-0.197	-0.152	0.252	-	1.82	0.176	0.016

RMW_{CP}	0.26%	0.136	-0.198	-	-	-	0.135	0.096	-	0.073	0.073	-0.255	-	1.63	0.115	0.013
CMA	0.21%	0.037	0.158	-	-	-	-	0.128	0.173	-	-0.002	-0.159	-	1.14	0.053	0.006
MOM	0.74%	-0.584	-0.171	-	-	-	0.122	-0.364	0.253	-	-0.011	0.118	-	2.51	0.294	0.029
$Slope_{FCT}$	0.19%	0.043	0.033	-	-	-	-0.085	-0.106	0.007	0.015	-	-	-	0.78	-0.001	0.003
$Level_{FCT}$	-0.02%	0.016	0.001	-	-	-	-0.032	-0.019	-0.017	0.007	-	-	-	-0.28	-0.007	0.000

PANEL B: Multi-factor Tests

RHS returns (Base Model)	LHS returns (Augmented factors)	GRS	p-value
FF3	Both CRFs	2.275	0.105
Carhart	Both CRFs	2.180	0.115
FF5	Both CRFs	1.670	0.190
FF6	Both CRFs	1.803	0.167
FF3	FX_{FCT}	8.964	0.003
Carhart	FX_{FCT}	8.364	0.004
FF5	FX_{FCT}	7.213	0.008
FF6	FX_{FCT}	7.251	0.008

<u>Table 8:</u>
This table presents the descriptive statistics of European & Eurozone Fama-French factors: Jan 2000 to Dec 2019, 240 months

		European (FF)	Eurozone	Difference
HML	Mean	0.40%	0.38%	0.01%
	StdDev	0.026	0.032	0.029
	NW-stat; t-stat	1.870	1.770	0.038
SMB_{5F}	Mean	0.23%	0.35%	-0.12%
	StdDev	0.020	0.035	0.029
	NW-stat; t-stat	1.780	1.480	-0.465
RMW_{5F}	Mean	0.32%	0.41%	-0.10%
	StdDev	0.017	0.025	0.021
	NW-stat; t-stat	2.750	2.570	-0.498
CMA	Mean	0.30%	0.42%	-0.13%
	StdDev	0.019	0.028	0.023
	NW-stat; t-stat	1.930	2.450	-0.598
MOM	Mean	0.77%	0.61%	0.16%
	StdDev	0.043	0.052	0.048
	NW-stat; t-stat	2.570	1.850	0.370

Table 9: Summary Asset Pricing tests for portfolios from 5x5 sorts using Eurozone and European Fama-French factors

This table reports the Summary Asset Pricing tests for portfolios from 5x5 sorts using Eurozone and European Fama-French factors: January 2000 to December 2019, 240 months

The table shows performance measures on test assets for the Carhart 4-factor model and Fama-French 3/5/6-factor models *(FF3/5/6)*. For the *FF6* model, we use the operating profitability factors instead of the cash profitability ones. All models are presented using either Fama-French's European factors or Eurozone-specific factors estimated using our sample. The asset pricing tests considered are: (1) GRS-statistic (Gibbons, Ross, and Shanken 1989), presenting its p-value, (2) the average absolute intercept, (3) estimates of the proportion of the dispersion in average returns that remains unexplained, that is attributable to sampling error, $As^2(\alpha_i)/ A\alpha^2_i$, (4) Adjusted R_2 (5) the maximum Sharpe ratio of the intercept, and (6) the average standard error of the intercept. We aim to compare the factors and to examine their additional explanatory power. For that reason, we chose to use as MRP the variable provided by Kenneth French's website.

Model factos	GRS	p(GRS)	$A\|\alpha_i\|$	$As^2(\alpha_i)/ A\alpha^2_i$	$Sh^2(a)$	AR^2	ASE(a)
25 *Size-B/M*							
FF3 - Eurozone	2.075	0.003	0.25	0.668	0.253	0.608	0.002
FF3 – Europe	2.433	0.000	0.23	0.752	0.297	0.615	0.002
Carhart 4- Eurozone	1.871	0.010	0.27	0.563	0.238	0.629	0.002
Carhart 4- Europe	2.118	0.002	0.37	0.293	0.276	0.655	0.002
FF5 - Eurozone	1.740	0.020	0.23	0.825	0.224	0.612	0.002
FF5 – Europe	1.867	0.010	0.35	0.351	0.265	0.640	0.002
FF6 - Eurozone	1.627	0.035	0.25	0.688	0.216	0.634	0.002
FF6 – Europe	1.922	0.007	0.44	0.214	0.277	0.663	0.002
25 *Size-OP*							
FF3 - Eurozone	2.030	0.004	0.17	1.272	0.247	0.611	0.002
FF3 – Europe	2.316	0.001	0.19	1.073	0.282	0.612	0.002
Carhart 4- Eurozone	2.034	0.004	0.22	0.809	0.258	0.634	0.002
Carhart 4- Europe	2.410	0.000	0.35	0.303	0.315	0.653	0.002
FF5 - Eurozone	1.623	0.036	0.14	2.086	0.209	0.618	0.002
FF5 – Europe	1.948	0.006	0.35	0.341	0.276	0.638	0.002
FF6 - Eurozone	1.715	0.022	0.18	1.153	0.228	0.641	0.002
FF6 – Europe	2.171	0.002	0.44	0.207	0.313	0.662	0.002

25 *Size-CP*							
FF3 - Eurozone	3.420	0.000	0.24	0.669	0.416	0.617	0.002
FF3 - Europe	3.193	0.000	0.25	0.629	0.389	0.612	0.002
Carhart 4- Eurozone	3.203	0.000	0.29	0.446	0.407	0.637	0.002
Carhart 4- Europe	3.212	0.000	0.38	0.256	0.419	0.648	0.002
FF5 - Eurozone	3.023	0.000	0.21	0.877	0.390	0.622	0.002
FF5 - Europe	2.541	0.000	0.35	0.351	0.360	0.628	0.002
FF6 - Eurozone	2.909	0.000	0.26	0.567	0.386	0.643	0.002
FF6 - Europe	2.725	0.000	0.43	0.222	0.393	0.652	0.002
25 *Size-Inv*							
FF3 - Eurozone	2.968	0.000	0.24	0.698	0.361	0.604	0.002
FF3 - Europe	2.848	0.000	0.23	0.753	0.347	0.615	0.002
Carhart 4- Eurozone	3.044	0.000	0.27	0.545	0.387	0.624	0.002
Carhart 4- Europe	2.951	0.000	0.37	0.275	0.385	0.653	0.002
FF5 - Eurozone	2.821	0.000	0.23	0.781	0.364	0.616	0.002
FF5 - Europe	2.071	0.003	0.37	0.308	0.293	0.642	0.002
FF6 - Eurozone	2.943	0.000	0.25	0.624	0.391	0.637	0.002
FF6 - Europe	2.387	0.000	0.44	0.200	0.344	0.664	0.002
25 *Size-Forex Sensitivity*							
FF3 - Eurozone	3.011	0.000	0.19	1.036	0.368	0.604	0.002
FF3 - Europe	2.063	0.003	0.21	0.916	0.252	0.596	0.002
Carhart 4- Eurozone	2.696	0.000	0.24	0.659	0.343	0.623	0.002
Carhart 4- Europe	1.995	0.005	0.35	0.304	0.260	0.632	0.002
FF5 - Eurozone	2.664	0.000	0.18	1.313	0.344	0.606	0.002
FF5 - Europe	1.803	0.014	0.34	0.371	0.256	0.613	0.002
FF6 - Eurozone	2.443	0.000	0.21	0.853	0.325	0.626	0.002
FF6 - Europe	1.867	0.010	0.42	0.231	0.269	0.636	0.002

Table 10: Factor Time-series tests using Model Specific Currency Risk factors for Eurozone: Jan 2000 to Dec 2019, 240 months

This table shows the spanning regression results (Panel A) and GRS statistic of Gibbons, Ross, and Shanken (1989) (Panel B). In Panel A, we test whether the factor under investigation (shown in the first column) is significant in explaining the time variation of expected stock return, *i.e.*, whether it has a non-zero intercept when regressed on the other factors reported in each row. We report the intercept (a), the slope coefficients of the other factors, the t-statistic of the intercept, the Adjusted $R^{2,}$ and the maximum squared Sharpe ratio. Panel B presents the GRS statistic, which tests whether the Forex factor provides an additional explanation to a baseline model.

PANEL A: Spanning Regressions (Augmented Models)

	a	MRP	HML	SMB_{3F}	SMB_{5F}	RMW_{OP}	CMA	SMB_{6f}	RMW_{CP}	MOM	FX_{FCT}	t(a)	AR²	$Sh^2(a)$
MRP	0.50%	-	0.025	-0.491	-	-	-	-	-	-	-0.405	1.73	0.243	0.013
HML	0.45%	0.012	-	-0.228	-	-	-	-	-	-	-0.011	2.19	0.059	0.021
SMB_{3F}	0.51%	-0.275	-0.255	-	-	-	-	-	-	-	-0.188	2.34	0.198	0.024
FX_{FCT}	0.78%	-0.421	-0.023	-0.349	-	-	-	-	-	-	-	2.67	0.173	0.031
MRP	0.76%	-	-0.105	-0.517	-	-	-	-	-	-0.450	-0.271	2.90	0.399	0.038
HML	0.55%	-0.064	-	-0.264	-	-	-	-	-	-0.142	-0.005	2.70	0.094	0.033
SMB_{3F}	0.63%	-0.346	-0.290	-	-	-	-	-	-	-0.184	-0.169	2.97	0.240	0.040
MOM	0.90%	-0.566	-0.293	-0.346	-	-	-	-	-	-	-0.033	3.10	0.287	0.043
FX_{FCT}	0.83%	-0.369	-0.011	-0.345	-	-	-	-	-	-0.036	-	2.71	0.123	0.033
MRP	0.60%	-	0.138	-	-0.500	0.167	0.003	-	-	-	-0.419	1.98	0.237	0.019
HML	0.43%	0.068	-	-	-0.053	-0.329	-0.181	-	-	-	0.015	2.04	0.077	0.020
SMB_{5F}	0.48%	-0.264	-0.057	-	-	0.012	0.145	-	-	-	-0.185	2.20	0.148	0.023
RMW_{OP}	0.38%	0.051	-0.206	-	0.007	-	0.104	-	-	-	0.046	2.26	0.060	0.024
CMA	0.34%	0.001	0.139	-	0.103	0.127	-	-	-	-	-0.046	1.81	0.033	0.016
FX_{FCT}	1.15%	-0.400	0.030	-	-0.334	0.143	-0.116	-	-	-	-	3.95	0.172	0.072
MRP	0.59%	-	0.082	-	-	-	0.067	-0.548	0.393	-0.442	-	-	-0.281	2.28
HML	0.43%	0.053	-	-	-	-	0.202	-0.027	-0.324	-0.087	-	-	0.048	2.06
SMB_{6f}	0.46%	-0.364	-0.028	-	-	-	0.186	-	0.187	-0.194	-	-	-0.163	2.19
RMW_{CP}	0.22%	0.153	-0.193	-	-	-	0.129	0.109	-	0.074	-	-	0.052	1.38
CMA	0.25%	0.033	0.154	-	-	-	-	0.139	0.165	0.049	-	-	-0.019	1.35
MOM	0.71%	-0.579	-0.175	-	-	-	0.130	-0.382	0.249	-	-	-	0.007	2.41
FX_{FCT}	0.81%	-0.382	0.101	-	-	-	-0.052	-0.333	0.181	0.007	-	-	-	2.70

PANEL B: Multi-factor Tests

RHS returns (Base Model)	LHS returns (Augmented factors)	GRS	P-value
FF3	FXFct	7.115	0.008
Carhart	FXFct	7.294	0.007
FF5o	FXFct	15.531	0.000
FF6c	FXFct	9.476	0.002

Table 11: Factor Time-series tests (Forex factor estimated using EER42 from ECB): Jan 2000 to Dec 2019, 240 months

This table shows the spanning regression results (Panel A) and GRS statistic of Gibbons, Ross, and Shanken (1989) (Panel B). In Panel A, we test whether the factor under investigation (shown in the first column) is significant in explaining the time variation of expected stock return, *i.e.*, whether it has a non-zero intercept when regressed on the other factors reported in each row. We report the intercept (a), the slope coefficients of the other factors, the t-statistic of the intercept, the Adjusted $R^{2,}$ and the maximum squared Sharpe ratio. Panel B presents the GRS statistic, which tests whether the Forex factor provides an additional explanation to a baseline model.

PANEL A: Spanning Regressions (Augmented Models)

	a	MRP	HML	SMB_{3F}	SMB_{5F}	RMW_{OP}	CMA	SMB_{6f}	RMW_{CP}	MOM	FX_{FCT}	t(a)	AR²	$Sh^2(a)$
MRP	0.59%	-	-0.020	-0.499	-	-	-	-	-	-	-0.396	1.97	0.225	0.017
HML	0.50%	-0.010	-	-0.253	-	-	-	-	-	-	-0.069	2.42	0.069	0.026
SMB_{3F}	0.51%	-0.264	-0.275	-	-	-	-	-	-	-	-0.195	2.39	0.201	0.025
FX_{FCT}	1.00%	-0.388	-0.138	-0.361	-	-	-	-	-	-	-	3.46	0.164	0.052
MRP	0.80%	-	-0.141	-0.531	-	-	-	-	-	-0.430	-0.287	3.06	0.402	0.043
HML	0.59%	-0.086	-	-0.291	-	-	-	-	-	-0.142	-0.060	2.91	0.104	0.039
SMB_{3F}	0.63%	-0.344	-0.310	-	-	-	-	-	-	-0.177	-0.176	2.98	0.246	0.040
MOM	0.82%	-0.540	-0.293	-0.343	-	-	-	-	-	-	0.039	2.78	0.290	0.036
FX_{FCT}	0.97%	-0.366	-0.127	-0.346	-	-	-	-	-	0.040	-	3.28	0.162	0.049
MRP	0.51%	-	0.112	-	-0.504	0.132	0.036	-	-	-	-0.392	1.68	0.223	0.013
HML	0.47%	0.054	-	-	-0.065	-0.325	0.178	-	-	-	-0.020	2.24	0.077	0.024
SMB_{5F}	0.45%	-0.261	-0.070	-	-	-0.004	0.159	-	-	-	-0.182	2.07	0.150	0.020
RMW_{OP}	0.42%	0.040	-0.205	-	-0.002	-	0.100	-	-	-	0.018	2.50	0.055	0.029
CMA	0.30%	0.013	0.137	-	0.114	0.122	-	-	-	-	-0.016	1.63	0.029	0.013
FX_{FCT}	0.99%	-0.388	-0.041	-	-0.348	0.059	-0.043	-	-	-	-	3.32	0.155	0.051
MRP	0.62%	-	0.051	-	-	-	0.069	-0.552	0.377	-0.435	-0.280	2.41	0.434	0.028
HML	0.48%	0.033	-	-	-	-	0.200	-0.045	-0.316	-0.087	-0.005	2.27	0.088	0.025
SMB_{6f}	0.49%	-0.365	-0.046	-	-	-	0.186	-	0.178	-0.188	-0.169	2.31	0.222	0.025
RMW_{CP}	0.23%	0.147	-0.188	-	-	-	0.129	0.105	-	0.073	0.035	1.43	0.110	0.010
CMA	0.25%	0.034	0.152	-	-	-	-	0.140	0.164	0.050	-0.017	1.35	0.052	0.009
MOM	0.68%	-0.567	-0.174	-	-	-	0.131	-0.371	0.246	-	0.035	2.31	0.301	0.025
FX_{FCT}	0.94%	-0.379	-0.011	-	-	-	-0.046	-0.346	0.122	0.036	-	3.14	0.157	0.046

PANEL B: Multi-factor Tests

RHS returns (Base Model)	LHS returns (Augmented factors)	GRS	P-value
FF3	FXFct	11.930	0.001
Carhart	FXFct	10.677	0.001
FF5o	FXFct	10.971	0.001
FF6c	FXFct	9.793	0.002

Table 12: Factor Time-series tests (Forex factor estimated by subtracting the two extreme portfolios from all middle portfolios): Jan 2000 to Dec 2019, 240 months

This table shows the spanning regression results (Panel A) and GRS statistic of Gibbons, Ross, and Shanken (1989) (Panel B). In Panel A, we test whether the factor under investigation (shown in the first column) is significant in explaining the time variation of expected stock return, *i.e.*, whether it has a non-zero intercept when regressed on the other factors reported in each row. We report the intercept (a), the slope coefficients of the other factors, the t-statistic of the intercept, the Adjusted R^{2}, and the maximum squared Sharpe ratio. Panel B presents the GRS statistic, which tests whether the Forex factor provides an additional explanation to a baseline model.

PANEL A: Spanning Regressions (Augmented Models)

	a	MRP	HML	SMB_{3F}	SMB_{5F}	RMW_{OP}	CMA	SMB_{6f}	RMW_{CP}	MOM	FX_{FCT}	t(a)	AR²	$Sh^2(a)$
MRP	0.49%	-	0.026	-0.484	-	-	-	-	-	-	-0.361	1.63	0.183	0.012
HML	0.45%	0.012	-	-0.235	-	-	-	-	-	-	-0.017	2.17	0.061	0.021
SMB_{3F}	0.47%	-0.247	-0.258	-	-	-	-	-	-	-	-0.184	2.20	0.188	0.021
FX_{FCT}	0.82%	-0.299	-0.029	-0.299	-	-	-	-	-	-	-	3.00	0.113	0.039
MRP	0.78%	-	-0.119	-0.528	-	-	-	-	-	-0.459	-0.287	2.95	0.394	0.039
HML	0.56%	-0.072	-	-0.279	-	-	-	-	-	-0.146	-0.022	2.73	0.098	0.034
SMB_{3F}	0.61%	-0.339	-0.297	-	-	-	-	-	-	-0.192	-0.180	2.90	0.242	0.038
MOM	0.89%	-0.568	-0.300	-0.371	-	-	-	-	-	-	-0.045	3.06	0.290	0.042
FX_{FCT}	0.85%	-0.321	-0.042	-0.314	-	-	-	-	-	-0.041	-	3.06	0.111	0.042
MRP	0.41%	-	0.162	-	-0.484	0.165	0.027	-	-	-	-0.358	1.31	0.181	0.008
HML	0.42%	0.074	-	-	-0.047	-0.331	0.182	-	-	-	0.041	2.00	0.079	0.019
SMB_{5F}	0.40%	-0.243	-0.052	-	-	0.008	0.157	-	-	-	-0.163	1.84	0.132	0.016
RMW_{OP}	0.39%	0.047	-0.208	-	0.005	-	0.103	-	-	-	0.048	2.39	0.061	0.026
CMA	0.31%	0.009	0.140	-	0.110	0.126	-	-	-	-	-0.034	1.69	0.031	0.013
FX_{FCT}	0.78%	-0.298	0.074	-	-0.271	0.140	-0.080	-	-	-	-	2.77	0.106	0.035
MRP	0.60%	-	0.074	-	-	-	0.064	-0.547	0.386	-0.463	-0.279	2.29	0.425	0.025
HML	0.44%	0.048	-	-	-	-	0.202	-0.032	-0.321	-0.085	0.038	2.09	0.091	0.021
SMB_{6f}	0.47%	-0.359	-0.032	-	-	-	0.184	-	0.181	-0.203	-0.167	2.22	0.215	0.023
RMW_{CP}	0.23%	0.148	-0.192	-	-	-	0.130	0.106	-	0.076	0.044	1.42	0.112	0.010
CMA	0.26%	0.031	0.154	-	-	-	-	0.137	0.166	0.048	-0.028	1.39	0.053	0.009
MOM	0.75%	-0.595	-0.171	-	-	-	0.126	-0.397	0.256	-	-0.046	2.56	0.301	0.031
FX_{FCT}	0.82%	-0.332	0.071	-	-	-	-0.067	-0.302	0.138	-0.043	-	2.91	0.105	0.039

PANEL B: Multi-factor Tests

RHS returns (Base Model)	LHS returns (Augmented factors)	GRS	P-value

FF3	FXFct	8.925	0.003
Carhart	FXFct	9.310	0.003
FF5o	FXFct	7.602	0.006
FF6c	FXFct	8.393	0.004

Table A1: Definitions of variables used in the analysis

Variable	Definition	Data source
Market value	Market value is defined as price times common shares outstanding	Refinitiv Eikon Datastream code: MV
Market to Book value ratio	Market to Book Value ratio. 1/MTBV will produce Book to Market ratio	Refinitiv Eikon Datastream code: MTBV
Operating Profitability	Revenues minus [COGS + Interest Expense + SGA Expenses] divided by lagged Common shareholders equity	· Revenues (Worldscope code: WC01001) · COGS (Worldscope code: WC01051) · Interest Expense (Worldscope code: WC01251) · SGA Expenses (Worldscope code: WC01101) · Common shareholders equity (Worldscope code: WC03501)
Total Assets	---	Worldscope code: WC02999
Cash profitability	Operating Profitability minus the effect of accruals. Accruals are estimated following Sloan (1996).	· Total Current assets (Worldscope code: WC02201) · Cash & short term investments (Worldscope code: WC02001) · Total Current Liabilities (Worldscope code: WC03101) · Short Term Debt & Current Portion of Long Term Debt (Worldscope code: WC03051) · Income taxes (Worldscope code: WC01451) · Depreciation, depletion & amortization (Worldscope code: WC01151)
Return on Equity	Net Profit divided by Common Shareholders Equity	· Net Profit (Worldscope code: WC01551) · Common Shareholders Equity (Worldscope code: WC03501)
Forward & Spot Exchange rates	Units of Foreign currency to the Euro	Refinitiv Eikon Datastream
Exports/ Imports	Expressed in Euro	Direction of Trade Statistics (IMF)

Table A2: Frequency Table of Industries included in the analysis, Jan 2000 – Dec 2019		
Industry	**Frequency (No of Companies)**	**Percentage of the total sample**
Basic Materials	230	6.71
Consumer Discretionary	758	22.12
Consumer Staples	303	8.84
Energy	91	2.66
Health Care	231	6.74
Industrials	785	22.91
Real Estate	283	8.26
Technology	502	14.65
Telecommunications	115	3.36
Utilities	128	3.74