The effect of macroeconomic variables on the robustness of the traditional Fama–French model. A study for Mexico using different portfolios

Received 23 March 2021
Revised 24 May 2021
Accepted 24 May 2021

Eduardo Saucedo
EGADE Business School, Tecnologico de Monterrey, Monterrey, Mexico, and
Jorge Gonzalez
Instituto Econofinanzas, Monterrey, Mexico

Abstract

Purpose – Fama–French model (FFM) has been successful in helping to predict the financial markets, but investors have been interested in creating more sophisticated models to better predict the performance of the stock market. The objective of the extended version is to create a more robust econometric model to better predict the performance of the Mexican Stock Market.

Design/methodology/approach – The study divides the Mexican Stock Market into six different portfolios. The criteria to build those portfolios are the same one used in Fama–French (1992). The study comprises 78 stocks listed in the Mexican Stock Market that are analyzed monthly during 1997–2018. The study analyzes the period before and after the 2008–2009 financial crisis to identify whether there are important changes. The estimation applies the traditional and an extended version of the FFM that include macroeconomic variables such as country risk, economic activity, inflation rate, and exchange rate and some financial variables recommended in the literature.

Findings – Results indicate that classic FFM variables are statistically significant in most cases, but relevant macroeconomic variables such as the interest rate, exchange rate and country risk stand out for being weakly relevant in most of the portfolios. However, it is noticed that some of these macroeconomic variables became relevant for different portfolios only after the 2008–2009 crisis, especially in portfolios which include small market capitalization firms.

Research limitations/implications – The study includes the stocks listed in the Mexican Stock Market. One limitation is the small number of stocks available, which reduces the possibility of creating well diversified portfolios. This study includes 78 stocks. The stocks removed from the sample are from firms that were not listed during six consecutive months or whose market capitalization did not change in the same period. Outlier data were removed from the sample to capture in better way the general performance of the stock market.

Practical implications – The objective of the extended version is to create a more robust econometric model than the traditional model. It is expected that such estimations can be helpful to investors to make better decisions when they try to predict performance in the stock market.

Social implications – An extended version of the FFM can be helpful to investors to make better decisions when they try to predict performance in the stock market.

Originality/value – To the best of our knowledge there are no more studies in the literature of the Mexican financial market that apply the same methodology.

Keywords Fama–French model, Extended Fama–French model, Mexican Stock Market, Macroeconomic variables

Paper type Research paper

JEL Classification — C58, G11, G14, G15

Journal of Economics, Finance and Administrative Science
Emerald Publishing Limited
2077-1886
DOI 10.1108/JEFAS-03-2021-0010

1. Introduction

The Fama–French Model (1992) (FFM) is a well-known asset pricing model in finance that uses size, book-to-market equity and other variables such as beta (market size), leverage and earning-price ratios to capture the stock return of different companies. In the original study, the authors claim that beta has little or even no ability to explain cross-sectional variation in equity returns, but variables such as book-to-market value and market firm capitalization (firm size) can explain such variation.

Empirical evidence suggests that, in some cases, FFM has been successful in helping to predict the financial markets, but investors have been interested in creating more sophisticated models to better predict the performance of the stock market. Therefore, in the last few years, some extensions of the FFM have emerged. Besides the traditional variables included in the FFM, Fama–French extensions comprise the inclusion of variables related to either macroeconomic conditions or firm performance, such as momentum, profitability, dividends, fundamentals, etc. Studies by Bali *et al.* (2015), Aretz *et al.* (2005), Adcock *et al.* (2019) and Bergbrant and Kelly (2016) are good examples of Fama–French extensions that include macroeconomic conditions, while studies by Roy and Shijin (2018) and Djamaluddin and Roffi (2017) are extensions that include variables related to firm performance.

Regarding the literature about Mexico on this matter, only a few research studies have applied either the traditional or an extension of the FFM to analyze the performance of the Mexican Stock Market. Most of such literature centers its analysis on the FFM and just adds the interest rate as an additional explanatory variable, as found in Velarde (2004) and Treviño (2011). To the best of our knowledge, there are no other research studies that apply an extended version of the FFM to analyze the performance of the Mexican Stock Market across different periods. The objective of this study is to provide some new evidence that contributes to the literature and at the same time provides important signals that can be helpful for investors interested in the Mexican Stock Market.

The study divides the Mexican Stock Market into different portfolios, according to specific characteristics that are explained in the following sections, and then applies the traditional FFM and an extended version of the same, which include some macroeconomic and financial variables recommended in the literature. The purpose of the extended version is to explore if the inclusion of economic fundamentals is helpful in creating a more robust econometric model to better predict stock market returns in Mexico. To explore how the 2008–2009 financial crisis affected local markets, the sample has been divided into two periods, one of them without the effect of the crisis. The study uses a database that spans from June 1997 to January 2018 and creates portfolios using Mexican stocks, according to the amount of the returns generated by firms in previous periods, as in Fama and French (1992).

The structure of the study is as follows: Section 2 analyses relevant literature regarding the FFM applied to Mexico and international markets. Section 3 presents the methodology and econometric model implemented in this study. Results are presented in Section 4 and, lastly, Section 5 includes the discussion and conclusion parts of the research.

2. Literature review

This study is based on Fama and French (1992), which uses different portfolios classified according to market book value and the market capitalization of each firm. Different literature, such as O'Brien (2007) and Blanco (2012), supports the idea that by incorporating firms according to market firm capitalization and market book equity, FFM becomes more robust than the traditional Capital Asset Pricing Model (CAPM). One characteristic that makes FFM preferable to CAPM is that the latter incorporates only the market risk premium and disregards whether portfolios are made up of small or large firms or according to market value books.

2.1 FFM in the Mexican Stock Market and other markets

Velarde (2004) works on an extension of the FFM and develops an analysis with additional variables, such as unexpected inflation, exchange rate, long-and-short interest rate spreads, spreads between corporative and government bonds to identify if these risk variables help to explain returns in the Mexican Stock Market. The author concludes that those variables do not explain Mexican Stock Market behavior, since most of them are not statistically significant. Valencia-Herrera (2015) also implements the FFM and analyzes the performance of the Mexican Sustainability Index during the period from 1995 to 2012. Results indicate that such an index generated not only smaller returns but also smaller risk than the entire Mexican Stock Market. Results also indicate that market risk premium, beta market capitalization and year momentum beta are all statistically different from zero.

Gómez (2006) analyzes the effect of local and external factors in the returns of different Mexican portfolios from 1995 to 2003. The author finds that the exchange rate is relevant to explain market returns, while country risk does not have any effect on them. Similarly, Treviño (2011) examines the determinants of the Mexican Stock Market returns from 1994 to 2010. The author constructs Fama–French portfolios and finds that the exchange rate has a clear impact on risk returns. Trejo-Pech *et al.* (2012) analyze the Mexican Stock Market from 1991 to 2010 and implement the FFM. The study includes nine portfolios, and their results are aligned with stock market returns. However, when 25 portfolios are created, the model is no longer functional to predict stock market returns due to the small sample size in each portfolio.

Regarding the literature about Latin America, Sanvicente *et al.* (2017) examine the Brazilian stock market from 2004 to 2014. The authors find that country risk is not statistically significant to explain stock returns. Duarte *et al.* (2013), in a study for Colombia during the period from 2004 to 2012, use a CAPM model to explain whether the firm size is relevant to determine the size premium in local stock markets. Their results indicate that size premium is not relevant; thus, the market does not award any premium for investing in either small or big companies.

In the case of the United States (US), Aretz *et al.* (2010) develop an extended version of the FFM and incorporate additional variables to the traditional FFM model. They include macroeconomic variables such as economic expectations, unanticipated inflation rate, and changes in the spread between short- and long-term interest rates. They conclude that portfolios constructed according to book market value are overly sensitive to changes in economic fundamentals, while portfolios created according to firm capitalization value are more sensitive to changes in interest rate and exchange rate. Later, Fama and French (2015) developed a different study for the US stock market, from 1963 to 2013, where besides the variables from their seminal model, they include additional variables related to profitability and investment patterns. They create three portfolios and find that this new extended model explains between 71 and 94%, respectively, of the total variance generated by these portfolios.

Among the relevant FFM literature that has been developed about Asia, Chiang *et al.* (2017) analyze nine Asian stock markets from 1995 to 2015 and compare those using different variations of the traditional FFM. The authors include profitability, investment, momentum, P/E ratio and dividend yield variables. They find that FFM with eight explanatory variables is more effective to explain the performance of the stock market than the traditional FFM.

Manjuantha and Mallikarjunappa (2018) use data from 1996 to 2010 to test the FFM in the Indian Stock Market. They find that portfolios composed of medium and high book value firms are well explained by the FFM, but portfolios composed of small book value firms only respond to market premium and not to the other two explanatory variables included in the model. Lastly, Chowdhury (2017), in an analysis for Bangladesh during 2010–2014, uses the Fama–French three-factor model. The main finding is that stocks with a small market

capitalization value perform better than those with a large capitalization value. Results also indicate that big firms have an ambiguous effect on portfolio returns.

3. Methodology and econometric model

This study includes the stocks listed in the Mexican Stock Market. One limitation of this study is the small number of stocks available in the Mexican market, which reduces the possibility of creating well-diversified portfolios. This study includes 78 stocks [1], a number obtained after eliminating financial stocks, as well as the least liquid stocks listed in the stock market [2] (the stocks removed from the sample are from firms that were not listed during six consecutive months or whose market capitalization did not change in the same period). The database used in this study comprises monthly data from June 1997 to January 2018 [3]. The stock market data are obtained from Bloomberg and already include dividends. After robustness and residual tests in each regression, outlier data were removed from the sample when the results changed significantly between periods, or when residuals were located outside the confidence interval threshold. This allowed us to capture the general performance of the Mexican Stock Market in a better way.

The study includes the financial risk environment prevailing in the country as an explanatory variable called country risk. Such variable is used to capture the exposure of the stock market to the country's risk factors. The country risk variable is expressed as the difference between the long-term Mexican bonds categorized in dollars and the long-term US treasury bonds. The long-term premium variable is included afterward and is obtained from the difference between the 10-year Mexican bond return and the 91-day CETE (CETE means Certificado de la Tesoreria, which is a treasury government bond equivalent to the US 3-month Treasury bill). The information for each of these instruments is obtained from Mexico's Central Bank (Banxico) website.

The econometric model also includes fundamental macroeconomic variables, such as exchange rate, an indicator of the economic activity at a country level (IGAE) and the inflation rate. The exchange rate is available daily on Banxico's website and was calculated using the average value in the entire month. The economic activity index, *Indicador Global de la Actividad Economica* (IGAE) and the inflation rate (INPC) are available monthly at the National Institute of Statistics and Geography (INEGI). Lastly, the study also includes the SPY500 variable, which measures the performance in the US stock market and was obtained from Bloomberg.

The construction of the six portfolios included in this study starts with the Fama and French (1992) methodology. This process consists of sorting the stocks according to market firm capitalization and then dividing them into two categories: B (Big) and S (Small). The category for each firm is obtained considering the average value in the Mexican Stock Market Index during the analyzed period. For example, if a company is among the 50% most capitalized companies in the Mexican Stock Market, then it is considered as a big company, otherwise, it is considered a small company [4]. This exercise allows modifications if market capitalization changes across participant firms. As a result, the portfolios for small and big companies could be consisted of different companies every year.

Once the stocks are separated according to firm capitalization (small and big), they are divided according to the book-to-market ratio of each analyzed company. Fama and French (1992) in their study organize the stocks by high, medium and low categories, where the abbreviation H stands for high, M for medium and L for low. It is important to mention that H represents 30% of the company stocks with the highest book-to-market ratio among all the 78 stocks included in the analysis, L stands for the companies with the 30% lowest ratio and M takes the remaining 40% of the stocks in the sample. The book-to-market ratio information comes from the financial statements reported in December from the previous year. Similarly,

portfolios are rebalanced each year to allow for changes if any stock suffers a modification in its book value during the analyzed period. Due to sample size, we did not split the estimations into quintiles, as is presented in the original Fama and French (1992) study. The six portfolios constructed for this study are shown in Table 1. These portfolios are regressed against the traditional variables included in the Fama and French (1992), and then in a second model, they are regressed against the traditional variables plus some additional relevant macroeconomic variables supported by the literature.

This process is then followed by the construction of the SMB (Small Minus Big) variable, which is the average return of the three portfolios composed of small-capitalization companies in the Mexican Stock Market (50% smallest market capitalization companies) minus the average yield of the three biggest portfolios (50% biggest market capitalization companies). That is, SMB = [1/3 (S/L + S/M + S/H)] – [1/3 (B/L + B/M + B/H)]. SMB refers to the firm size premium and is expected to have a positive sign for small firm returns because in the short run small firms traditionally generate larger returns than big firms to compensate by size risk.

Next, the HML variable is constructed. HML, which stands for High Minus Low, is the average yield of the two portfolios together with the highest book-to-market ratio (S/H and B/H) minus the average yield of the two portfolios with the smallest ratio (S/L, B/L). That is, HML = [½ (S/H + B/H)] – [½ (S/L + B/L)]. The HML coefficient is expected to be positive for the portfolios with the highest ratio, granting higher profitability and value. In this sense, the stocks with the highest valuation are expected to provide higher returns for investors. Therefore, if the portfolio consists of high valuation stocks, then an increase in the return in this kind of stock leads to a better performance of the portfolio. The market return (RM) is constructed by weighting the monthly stock returns listed according to their respective size. We subtract the market risk-free government bond (91-day CETE bond) from the stock market return during the same period. Such difference is called the market risk premium, which is a yield obtained for investing in stocks rather than investing in assets without any risk, such as government bonds.

Descriptive statistics are shown in Table 2. The whole period indicates that the B/H portfolio shows the highest returns among all portfolios constructed in this study, while the B/L portfolio shows the smallest returns. Moreover, when the sample is split among the 1997–2010 period (to capture the effect of economic crisis) and 2010–2018 (without crisis), the average return for all portfolios is, in general, higher for the pre-crisis period than for the after-crisis period, except for the S/L and SMB portfolios, which show opposite results.

Table 2 also shows that when the average return between big-capitalization (BL, BM, BH) and small-capitalization (SL, SM, SH) portfolios is contrasted, a clear dominance cannot be stated among them. Table 2 also indicates that volatility during the period after the financial crisis is smaller than the period before the crisis. This happens for almost all portfolios, regardless of the stock composition in the portfolio. Lastly, Market Risk Premium (MRP) is small, but positive for all samples, indicating that the average return in the financial stock market is not higher than risk-free instruments such as government bonds (CETES). The second period shows practically zero returns for a market premium; such results could be explained due to a local monetary tightening policy and a weak performance in the Mexican

	Market capitalization	
Book value	Small	Big
Low	Small/Low (S/L)	Big/Low (B/L)
Medium	Small/Medium (S/M)	Big/Medium (B/M)
High	Small/High (S/H)	Big/High (B/H)

Source(s): Own estimations using data from Bloomberg

Table 1. Portfolios created for this study

Table 2.
Descriptive statistics

	Whole period June 1997 to January 2018				Before and during financial crisis June 1997 to May 2010				After financial crisis June 2010 to January 2018			
	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.	Mean	Max	Min	Std. dev.
Big firms												
B/H	1.45	24.87	−38.33	7.38	1.66	24.87	−38.33	9.28	1.09	11.67	−9.01	4.42
B/M	0.81	18.96	−32.58	6.62	1.02	18.96	−32.58	7.88	0.45	7.41	−9.09	3.61
B/L	0.71	19.54	−44.08	7.53	0.97	19.54	−44.08	8.84	0.26	13.27	−23.67	4.52
Small firms												
S/H	0.97	45.83	−38.53	8.81	0.98	45.83	−38.53	10.60	0.97	11.12	−10.85	4.39
S/M	1.44	22.55	−30.62	6.79	1.59	22.55	−30.62	8.13	1.17	9.21	−8.43	3.52
S/L	0.90	14.51	−30.55	5.92	0.81	14.51	−30.55	6.98	1.04	9.67	−6.37	3.50
SMB, HML and market risk premium												
SMB	0.11	13.27	−15.26	4.52	−0.09	13.27	−15.26	5.37	0.46	7.15	−6.50	2.49
HML	1.13	29.26	−38.64	7.38	1.26	29.26	−38.64	8.99	0.91	14.40	−9.23	5.35
MRP	0.21	14.26	−32.20	6.39	0.34	14.26	−32.20	7.71	−0.01	7.59	−11.01	3.17

Source(s): Authors' estimations using data from Bloomberg. MRP is equal to $RM_t - rf_t$, that is, market risk minus risk-free interest rate

Stock Market. Table 3 shows the correlation matrix and indicates that correlation among portfolios is not a relevant problem.

The base model for this study is an adaptation from the Fama and French model (1992) with the inclusion of factors, such as credit and macroeconomic variables, as presented by Simpson and Ramchander (2008).

$$r_{it} - \mathrm{rf}_t = \alpha_i + \beta_1(\mathrm{RM}_t - \mathrm{rf}_t) + \beta_2 \mathrm{SMB}_t + \beta_3 \mathrm{HML}_t + \gamma_1 \mathrm{Term}_t + \gamma_2 \mathrm{Country\ Risk}_t + \delta_1 \mathrm{ExcRate}_t + \delta_2 Y_t + \delta_3 \pi_t + \phi_1 \mathrm{SPY}_t + \varepsilon_{it} \quad (1)$$

Where, SMB refers to a portfolio composed of small-minus big-capitalization companies and HML refers to a portfolio with high minus low book-to-market ratio companies. Both generated variables are consistent with the Fama–French methodology. The variable RM in Eqn 1 refers to the average market return of the 78 stocks in this study. The 91-day CETE is a proxy for the risk-free rate of return, this variable is denoted as rf_t; then, $(\mathrm{RM}_t - \mathrm{rf}_t)$ and refers to excess returns or market risk premium. The $r_{it} - \mathrm{rf}_t$ is the dependent variable and refers to the excess return of each of the portfolios constructed in this study (S/L, S/M, S/H, B/L, B/M, B/H). Note that $\boldsymbol{\beta}$ is estimated for the common FFM variables.

Then, we focus on the long-term risk premium variable, which is obtained throughout the estimation of the spread of the 10-year Mexican Treasury bond and the 91-day Treasury bond (CETE). The structure term reflects the expectations of market participants about future changes in interest rate. Another variable included in the model is called country risk, which refers to the spread between the long-term Mexican bonds in US dollars and the long-term US Treasury bond. An increase in country risk reflects a higher risk to invest in Mexico; therefore, investors need to be compensated with a higher premium in returns to be willing to invest. For these variables (further to FFM model), it is estimated $\boldsymbol{\gamma}$, which refers to how each portfolio reacts to changes in the interest environment.

Now, $\boldsymbol{\delta}$ measures the impact of three macroeconomic variables (Exc Rate, $\boldsymbol{Y}$ and $\boldsymbol{\pi}$) that refer to exchange rate, economic activity and the local inflation rate. According to results obtained in the literature, a depreciation of the Mexican peso is expected to lead to fewer portfolio returns (Adcock *et al.*, 2019; Aretz *et al.*, 2010). A similar effect on each portfolio return is expected to be generated by increases in the inflation rate (Kelly, 2003; Zhang *et al.*, 2009). Lastly, an increase in economic activity is also expected to increase returns across portfolios (Kelly, 2003; Zhang *et al.*, 2009). Then, ϕ is estimated to capture the impact that the US stock market index (S&P 500) is having on domestic portfolios. A positive relationship between the US and Mexico stock markets is expected, due to the positive cycles between both economies. Lastly, the $\varepsilon_{i,t}$ term refers to the traditional error term that is expected to have a normal distribution with a zero mean and variance, σ^2.

	BH	BM	BL	SH	SM	SL	SMB	HML	RMP
B/H	1.00								
B/M	0.64	1.00							
B/L	0.57	0.65	1.00						
S/H	0.47	0.42	0.41	1.00					
S/M	0.69	0.61	0.60	0.60	1.00				
S/L	0.57	0.64	0.48	0.45	0.63	1.00			
SMB	−0.31	−0.36	−0.42	0.44	0.13	0.13	1.00		
HML	0.77	0.32	0.14	0.66	0.49	0.21	0.09	1.00	
RMP	0.52	0.61	0.64	0.48	0.51	0.50	−0.17	0.29	1.00

Source(s): Authors' estimations with data obtained from Bloomberg

Table 3. Correlation between portfolio returns

One of the main purposes of this study is to identify whether the macroeconomic variables included in the model are influencing the stock returns in each of the six portfolios. Variables such as momentum and profitability, among others included in the literature (Fama and French, 2015; Djamaluddin and Roffi, 2017) are excluded from the analysis to keep enough degrees of freedom, as suggested by Trejo-Pech *et al.* (2012). Additionally, to check the stationarity of the variables used in the model, a table with the unit root test is developed, which is available upon request. Such table shows the Dickey Fuller Extended test with the optimal number lags (according to Schwarz information criterion) and the Phillips–Perron test. Results indicate that all variables are $I(1)$, which allow us to regress all variables in the FFM. Lastly, to check heteroskedasticity problems in the regressions estimated in this study, Breusch–Pagan tests are included for each regression. In general, no problems can be seen with heteroskedasticity or autocorrelation in the distribution of errors.

4. Results

4.1 Whole sample period analysis

Two econometric models for each of the portfolios are estimated. The first model refers to the classic FFM, followed by the second model that is an augmented version of the FFM and includes the spread between short- and long-term interest rate, country risk and the macroeconomic variables previously mentioned. Each regression is estimated for the entire analyzed period (June 1997 to January 2018). The study also comprises an analysis for the period before and after the 2008–2009 financial crisis. The reason for dividing the analysis into these two periods is because some relevant changes could be originated in the Mexican Stock Market after the financial crisis.

Table 4 shows the portfolio results for small and big market capitalization firms for the whole period analyzed in this study. Such portfolios are divided into low-, medium- and high-value firms. The table also shows comparatives between the traditional and the extended version of the FFM, which is the main objective of this research paper. Results indicate that coefficients for traditional FFM are all statistically significant and similar to coefficients obtained in the extended FFM.

The traditional FFM includes the market risk, SMB and HML variables. Results indicate that excess return or market risk premium $(RM_t - rf_t)$is positive and significant across all regressions. Such results indicate evidence that the Mexican Stock Market demands a premium for investing in risk assets rather than investing in assets without market risk. However, the coefficient is close to 1, a value aligned with a unitary elasticity, except for the BH portfolio, characterized by big capitalization and value. SMB is positive and statistically significant in the case of all small-capitalization firm portfolios. Such coefficients indicate that the Mexican Stock Market grants a size premium for investing in small-capitalization firms where stock variations are higher than big-firm variations. In the case of portfolios composed of big market capitalization firms, results are negative and statistically significant, indicating that an increase in the return of SMB portfolios creates a negative effect on the portfolio's return since the small portfolios become more attractive with an increase in their returns. In the case of small market capitalization portfolios, the HML coefficient is statistically significant for all portfolios but with mixed signs. It is positive for high and medium book valued firms, but negative for low book valued firms. Findings are relevant because they show a premium for firm size and for firm value. As a result, investors with portfolios composed mainly of small firms could expect to see higher returns than the average market returns; such behavior is replicated for stocks with high books value.

In the case of portfolios with small market capitalization firms, the long-term risk premium variable (which is the difference between the 10-year Mexican bond return and the 91-day CETE bond) is not statistically significant in any portfolio. In the case of big value

Table 4. Results portfolio small- and big-capitalization firms' period: June 1997 to January 2018

	Small						Big					
	High book value (SH)		Med book value (SM)		Low book value (SL)		High book value (BH)		Med book value (BM)		Low book value (BL)	
Variables	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM
C	−0.32	−0.63	−0.37	0.20	−0.01	1.18**	−1.53*	0.73***	−0.04	−0.33	0.49***	0.49
	(0.25)	(0.21)	(0.19)	(0.69)	(0.95)	(0.02)	(0.00)	(0.10)	(0.81)	(0.36)	(0.01)	(0.15)
Risk premium	1.01*	1.05*	0.91*	0.86*	0.99*	0.88*	0.81*	0.67*	1.02*	0.99*	1.05*	1.08*
$RM_t - rf_t$	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SMB	1.31*	1.35*	0.75*	0.69*	0.70*	0.62*	−0.13*	−0.25*	0.01	−0.01	−0.50**	−0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.65)	(0.71)	(0.08)	(0.97)
HML	0.39*	0.41*	0.13*	0.14*	−0.22*	−0.20*	0.51*	0.58*	−0.07*	−0.07*	−0.13*	−0.14*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Long-term risk premium		0.05		0.20		−0.10		0.11		0.25**		−0.29**
		(0.76)		(0.25)		(0.56)		(0.46)		(0.04)		(0.02)
Country risk		0.15		−0.48**		−0.65*		−1.25*		−0.15		0.27***
		(0.49)		(0.04)		(0.00)		(0.00)		(0.36)		(0.08)
IGAE		−0.38		0.00		0.48		−0.06		0.33		−0.25
		(0.18)		(0.99)		(0.11)		(0.80)		(0.12)		(0.20)
Exchange		0.29*		−0.09		−0.19**		−0.03		−0.02		0.09
Rate		(0.00)		(0.33)		(0.04)		(0.65)		(0.74)		(0.12)
Inflation rate		−1.09		0.41		−0.19		0.57		−1.28**		−0.23
		(0.14)		(0.58)		(0.79)		(0.39)		(0.02)		(0.65)
SPY500		−0.02		−0.04		0.05		−0.02		0.03		0.07***
		(0.67)		(0.43)		(0.34)		(0.68)		(0.37)		(0.08)
*R*2	0.91	0.92	0.86	0.87	0.82	0.87	0.90	0.93	0.85	0.93	0.92	0.94
N	248	248	248	248	248	248	248	248	248	248	248	248
Breusch–Pagan test	0.11	0.20	0.05	0.11	0.12	0.75	0.09	0.20	0.04	0.12	0.08	0.40

Note(s): Trad. FFM refers to Traditional FFM and Ext. FFM refers to Extended FFM
Source(s): Authors' estimations with data obtained from Bloomberg. * denotes significance at 1%, ** at 5% and *** at 10%, respectively

companies, results are mixed, while the coefficient is positive for medium book value portfolios, but negative in the case of low book value portfolios. Regarding the country risk variable, results indicate that in the case of small-capitalization firms, the variable is negative and statistically significant. This is consistent with the expected value because an increase in the economic risk level in a country leads to a negative return in these portfolios due to more uncertainty for investments and more risk of default (Stoopen, 2015). In the case of big market capitalization firms, the country risk variable has mixed results, indicating that it cannot be considered a strong predictor to determine the return in big companies. These findings could be relevant for investors, since the country risk is daily data, and big movements for this indicator seem to affect mainly small firms, although returns in big firms could also be affected.

Regarding macroeconomic variables (IGAE, exchange rate and inflation rate), results indicate that, in general, they are all poor predictors to estimate portfolio returns. This is consistent throughout portfolios regardless of whether they are composed of small or big companies. For example, IGAE is not statistically significant for any of the analyzed portfolios, while the inflation rate is just significant for one out of six portfolios, making this variable a poor predictor. The variable exchange rate is positive and statistically significant in the case of small-capitalization firms with high book value, but negative with small book value firms, and is not significant for any portfolio in the case of big firms. This could indicate that portfolios composed of small market firms are more sensitive to exchange rate variations than portfolios composed of big firms. Lastly, the variable SPY500, which stands for the Standard and Poor 500 Index, is not statistically significant for any small market capitalization portfolio. In the case of large market capitalization portfolios, it is statistically significant just in the case of large firms with small book value portfolios.

4.2 Traditional small FFM before, during and after the financial crisis

Table 5 shows the results for the portfolios of small market capitalization firms during the periods before/during and after the 2008–2009 financial crisis. Results indicate that all the conventional variables (MRP, SMB and HML) in the traditional and extended FFM are statistically significant. Such results are consistent across portfolios and for both analyzed periods.

The variables market risk premium and SMB, which refer to the firm size premium, are both positive and statistically significant in all portfolios; such coefficients are somewhat stable for both periods, although there is a reduction in magnitude for the SH portfolios. An analysis of the subsamples identifies the coefficients in FFM that are marginally reduced in the period after the financial crisis, in comparison to the period before the crisis. It is important to mention that S&P BMV IPC (a proxy for our portfolio market performance) goes from 2500 points in 1997 to 32,600 points in 2007 or late 2009. In other words, in nominal terms, the local market grew 13 times in such period. From 2010 to the beginning of 2018, the index went from 34,000 to 50,000 points, not enough to double the market in 8 years. Such reduction in coefficients between both periods can be interpreted as a signal that the Mexican Stock Market has matured in the past few years. Also, the monetary policy was tight during the 2016–2018 period, which, combined with uncertainty in local markets after the US 2016 election, could have reduced the magnitude in such coefficients. Such factor could be a reason to explain the small market premium during the period after the financial crisis in comparison to the previous period. The HML coefficients are statistically significant for all portfolios before and after the crisis, but the coefficients are mixed; positive values are for high and medium book value, while negative for the low book value portfolios. The long-term risk premium and country risk variables are not statistically significant in most of the portfolios either before or after the crisis. However, the expected (negative) sign remains.

Table 5. Results Portfolio small-capitalization firms before, during and after the 2008–2009 financial crisis

	Before and during financial crisis June 1997–May 2010						After financial crisis June 2010–January 2018					
	High book value (SH)		Med book value (SM)		Low book value (SL)		High book value (SH)		Med book value (SM)		Low book value (SL)	
Variables	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM
C	−0.41	−0.74	−0.67	−0.21	−0.36	0.92	−0.38	2.14***	−0.72	−3.39**	−0.72**	0.21
	(0.37)	(0.28)	(0.13)	(0.75)	(0.42)	(0.16)	(0.24)	(0.06)	(0.06)	(0.02)	(0.06)	(0.85)
Risk premium	1.01*	1.03*	0.90*	0.87*	0.98*	0.88*	0.95*	1.12*	0.76*	0.55*	0.76*	1.04*
$RM_t - rf_t$	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SMB	1.34*	1.39*	0.74*	0.68*	0.66*	0.56*	1.09*	1.19*	0.80*	0.56*	0.80*	0.86*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
HML	0.42*	0.42*	0.13*	0.16*	−0.25*	−0.25*	0.31*	0.35*	0.15*	0.12**	−0.15*	−0.06***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.09)
Long-term risk premium		0.14		0.18		−0.17		−0.47***		−0.42		0.04
		(0.54)		(0.43)		(0.47)		(0.03)		(0.12)		(0.84)
Country risk		0.09		−0.40		−0.63**		−0.45		0.11		0.12
		(0.75)		(0.18)		(0.03)		(0.26)		(0.82)		(0.76)
IGAE		−0.61		0.16		0.40		−0.19		−0.10		0.69**
		(0.13)		(0.68)		(0.32)		(0.56)		(0.79)		(0.04)
Exchange rate		0.29**		−0.06		−0.28**		0.37*		−0.28**		−0.21**
		(0.04)		(0.65)		(0.04)		(0.00)		(0.02)		(0.02)
Inflation rate		−0.96		−0.15		−0.86		−1.22		1.99**		−0.13
		(0.38)		(0.88)		(0.44)		(1.11)		(0.04)		(0.86)
SPY500		0.02		−0.11		0.06		−0.16**		0.17**		−0.01
		(0.74)		(0.16)		(0.41)		(0.02)		(0.04)		(0.94)
$R2$	0.92	0.93	0.88	0.88	0.87	0.88	0.81	0.85	0.63	0.64	0.72	0.79
N	156	156	156	156	156	156	92	92	92	92	92	92
Breusch–Pagan test	0.33	0.16	0.08	0.83	0.71	0.21	0.43	0.74	0.31	0.50	0.10	0.11

Note(s): Trad. FFM refers to Traditional FFM and Ext. FFM refers to Extended FFM
Source(s): Authors' estimations with data obtained from Bloomberg. * denotes significance at 1%, ** at 5% and *** at 10%, respectively

In the case of macroeconomic variables such as IGAE, results are positive and statistically significant just for the small book value portfolio during the period after the financial crisis, indicating that an increase in economic activity leads to higher returns for this portfolio during the analyzed period. In the case of the exchange rate, which is another macroeconomic variable, coefficient estimates are statistically significant, but with mixed signs across portfolios indicating no clear effect on them. Nevertheless, portfolios that include small capitalization firms seem to react to this variable. In the case of the inflation rate, results indicate an effect just on the medium book value firm portfolios during the period after the financial crisis. SPY500 is statistically significant just for some of the portfolios. Before the crisis, none of the SPY500 coefficients are statistically significant, but, after the crisis, SPY500 became positive and significant in the medium book value.

4.3 Traditional big FFM before, during and after the financial crisis

Table 6 shows results for portfolios composed of big market capitalization firms in both periods analyzed in this study. The traditional FFM estimates indicate that the market risk premium variable is positive and statistically significant across all portfolios. Such market risk compensation in the case of the BH portfolio is higher during the period before the crisis than in the post-crisis period, while other portfolios show smaller variations. Coefficients are statistically significant only for the BH portfolio, showing the expected sign, i.e. an increase in premium size reduces returns in big firms. The second period analyzed in this study (after the 2008–2009 financial crisis) shows a small reduction in such coefficients; while the other portfolios analyzed in this study display coefficients that are not statistically significant.

In the case of the HML variable, results indicate they are statistically significant in almost all portfolios, and the coefficients are similar between traditional and extended FFM. Portfolios with a higher value react positively to the HML indicator. An increase in the average value leads to fewer returns in BL portfolios and reduces their attractiveness for potential investors. Regarding the long-term risk premium variable, results indicate that it is not statistically significant for the period before the financial crisis, except for the BL portfolio. In the period after the crisis, estimates are mixed indicating no clear pattern across portfolios.

Regarding the country risk variable, results are negative and statistically significant for BH portfolios during the period before the 2008–2009 financial crisis and statistically significant for BM portfolios during the period after the crisis, while all other portfolios are not statistically significant. In other words, not all portfolios react to risk changes, but when they do, the expected movement is a fall in returns.

In the case of the macroeconomic variables such as IGAE and inflation, estimates indicate they are not statistically significant in any of the portfolios, regardless of the analyzed period. In the case of the exchange rate, the coefficient is not statistically significant before the financial crisis, although it is negative in the period after the crisis for portfolios composed of high book value firms. Results indicate the exchange rate creates more changes in small capitalization firm portfolios than in portfolios composed of big market capitalization firms. Such results could be expected because it is more difficult for small firms to hedge the risk created by the exchange rate than big companies, which can easily access hedging instruments. Results also indicate that the Mexican Stock Market at the portfolio level has not been able to clearly capture the effects of economic activity or inflation rate. Lastly, the variable SPY500 is not statistically significant for the period after the financial crisis, while the period before the crisis is positive and statistically significant just for the small book value portfolio.

5. Discussion and conclusions

The main findings indicate that estimated coefficients in the traditional FFM are statistically significant and consistent with expected values. In addition, the traditional FFM coefficients,

Table 6. Results portfolio big-capitalization firms before, during and after the 2008–2009 financial crisis

	Before and during financial crisis June 1997–May 2010						After financial crisis June 2010–January 2018					
	High book value (BH)		Med -book value (BM)		Low book value (BL)		High book value (BH)		Med book value (BM)		Low book value (BL)	
Variables	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM	Trad FFM	Ext FFM
C	−2.41*	0.12	−0.17	−0.95***	0.55**	0.68***	−1.26*	−3.88*	0.26	2.05***	0.44	1.20*
	(0.00)	(0.82)	(0.60)	(0.10)	(0.05)	(0.10)	(0.00)	(0.00)	(0.37)	(0.06)	(0.17)	(0.00)
Risk premium	0.78*	0.63*	1.01*	1.04*	1.05*	1.08*	0.63*	0.53*	1.07*	1.10*	1.05*	1.22*
$RM_t - rf_t$	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SMB	−0.18*	−0.31*	0.02	0.00	−0.04	0.01	−0.07	−0.12**	−0.08	−0.10	−0.08	−0.00
	(0.00)	(0.00)	(0.49)	(0.98)	(0.19)	(0.75)	(0.35)	(0.10)	(0.26)	(0.22)	(0.31)	(0.93)
HML	0.50*	0.58*	−0.06**	−0.10*	−0.11*	−0.13*	0.66*	0.64*	−0.05	−0.03	−0.22*	−0.29*
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.11)	(0.37)	(0.00)	(0.00)
Long-term risk premium		0.07		0.33		−0.30**		0.61*		−0.04		−0.51**
		(0.70)		(0.11)		(0.04)		(0.00)		(0.83)		(0.04)
Country risk		−1.32*		0.13		0.22		0.46		−0.68***		0.34
		(0.00)		(0.59)		(0.23)		(0.20)		(0.08)		(0.45)
IGAE		−0.12		0.16		−0.35		0.41		0.14		−0.15
		(0.71)		(0.63)		(0.15)		(0.17)		(0.65)		(0.68)
Exchange		−0.07		−0.09		0.10		−0.24*		0.00		−0.12
Rate		(0.52)		(0.45)		(0.23)		(0.00)		(0.94)		(0.26)
Inflation rate		0.30		−0.61		−0.43		0.77		−1.02		0.48
		(0.74)		(0.52)		(0.52)		(0.25)		(0.16)		(0.58)
SPY500		−0.05		0.00		0.10*		0.06		−0.09		−0.00
		(0.41)		(0.99)		(0.03)		(0.27)		(0.15)		(0.97)
*R*2	0.92	0.93	0.93	0.91	0.94	0.95	0.86	0.88	0.79	0.81	0.76	0.82
N	156	156	156	156	156	156	92	92	92	92	92	92
Breusch-Pagan-test	0.67	0.61	0.91	0.13	0.95	0.91	0.63	0.27	0.78	0.14	0.20	0.14

Note(s): Trad. FFM refers to Traditional FFM and Ext. FFM refers to Extended FFM
Source(s): Authors' estimations with data obtained from Bloomberg. * denotes significance at 1%, ** at 5% and *** at 10%, respectively

also included in the extended FFM version, are remarkably similar to those obtained when the traditional FFM is estimated alone.

In the case of the market risk premium, the coefficient is always significant and statistically significant, regardless of the portfolio composition or analyzed period. However, the study finds that movements in the short-term interest rate originated by movement in the monetary policy can influence returns originated by stock market portfolios. It is important to note that the returns coefficient is smaller for portfolios composed of big companies with a high book value in comparison to portfolios composed of low book value companies. SMB portfolios, which are composed of small companies, pose a size premium, which vanishes once big companies are included in the portfolio.

HML coefficients are statistically significant for the whole period regardless of the portfolio. In addition, the coefficients for high book value are in general bigger than for medium and low book value portfolios. There is a clear value premium, which could be a helpful hint for investors once they decide where to invest their money. The long-term risk premium and SPY500 variables are not statistically significant for almost any portfolio, and show negative mixed values indicating no clear pattern in the effect of the long-term risk premium on firm returns. In other words, results indicate no evidence that long-term investments generate an additional premium and are consistent across portfolios. The country risk variable has a negative and statistically significant effect on stock returns in the case of the full sample period, but such relationship disappears for the period after the financial crisis. However, there is evidence that changes in country risk values can negatively affect returns in some portfolios. Regarding the macroeconomic variables, results indicate that during the period after the crisis, portfolios composed of small firms seem to respond more accordingly to macroeconomic effects, such as changes in the exchange rate, country risk and inflation rate. In the case of portfolios composed of big firms, such response is less pronounced. In short, portfolios composed of small firms generate higher returns than portfolios composed of big firms. In addition, higher returns are also found in the case of firms that show the highest book-to-market ratio values. Lastly, results also indicate that macroeconomic fundamentals are weakly related to returns in stock portfolios.

As the Mexican stock market matures, it is expected to respond more accordingly to changes in economic fundamentals, as stock markets do in developed economies. For example, in a study about Mexico, Castillo-Ponce *et al.* (2015) find evidence that the stock market has matured and is now responding to economic fundaments. However, there is not enough literature analyzing the determinants of stock returns, and this study contributes as one of the pioneers in examining the relationship between macroeconomic factors and the performance of Mexican firm stocks.

Notes

1. The list of the 78 stocks used in this study is available upon request.
2. The reason why financial stocks are eliminated from this study is because of the leverage level traditionally maintained by these firms. Financial corporations usually have higher levels of leverage (risk) than non-financial firms. This is mentioned and implemented in Fama and French (1992).
3. Due to the monthly frequency data, we decided to begin in 1997 to capture as much data as possible for a time series. Data availability for many firms begins in these years. This year made it possible to dissipate the effect of the 1994–95 crisis, which affected variables such as inflation and interest rates.
4. As a note, each June the portfolios were rebalanced, meaning that the exercise of categorizing small and big companies was repeated every June throughout the period analyzed in the study.

References

Adcock, C., Bessler, W. and Conlon, T. (2019), "Fundamental factor models and macroeconomic risks-An orthogonal decomposition". doi: 10.2139/ssrn.3421394.

Aretz, K., Bartram, S.M. and Pope, P.F. (2005), "Macroeconomic risks and the Fama and French/Carhart model", *EFA 2005 Moscow Meeting*.

Aretz, K., Bartram, S.M. and Pope, P.F. (2010), "Macroeconomic risks and characteristic-based factor models", *Journal of Banking and Finance*, Vol. 34 No. 6, pp. 1383-1399.

Bali, T.G., Brown, S.J. and Tang, Y. (2015), *Macroeconomic Uncertainty and Expected Stock Returns*, Georgetown McDonough School of Business, Research Paper, 2407279, available at: https://pdfs.semanticscholar.org/0e47/b337529c88b8e2cb185cf7a8f565979b5b66.pdf.

Bergbrant, M.C. and Kelly, P.J. (2016), "Macroeconomic expectations and the size, value, and momentum factors", *Financial Management*, Vol. 45 No. 4, pp. 809-844, doi: 10.1111/fima.12140.

Blanco, B. (2012), "The use of CAPM and Fama and French three factor model: portfolios selection", *Public and Municipal Finance*, Vol. 1 No. 2, pp. 61-70.

Castillo-Ponce, R., Rodríguez-Espinosa, M.D.L. and Gaytan-Alfaro, E.D. (2015), "Stock market development and economic performance: the case of Mexico", *Revista de Análisis Económico*, Vol. 30 No. 1, pp. 41-56, doi: 10.4067/S0718-88702015000100003.

Chiang, T., Nelling, E. and Zheng, D. (2017), "Stocks returns and economic fundamentals: evidence from Asian stock market", Unpublished manuscript, available at: http://sfm.finance.nsysu.edu.tw/25thSFM/php/Studys/CompleteStudy/064-1000572812.pdf.

Chowdhury, E.K. (2017), "Functioning of Fama-French three-factor model in emerging stock markets: an empirical study on chittagong stock exchange, Bangladesh", *Journal of Financial Risk Management*, Vol. 6 No. 04, p. 352, doi: 10.4236/jfrm.2017.64025.

Djamaluddin, S. and Roffi, A. (2017), "Fama and French five-factors pricing model testing in Indonesia", *International Journal of Business and Management Invention*, Vol. 6 No. 9, pp. 75-90.

Duarte, J.B., Ramírez, Z.Y. and Mascareñas, J.M. (2013), "Study of the size effect in the stock market of Colombia", *Journal of Economics, Finance and Administrative Science*, Vol. 18 No. S, pp. 23-27, doi: 10.1016/S2077-1886(13)70027-1, SSRN available at: https://ssrn.com/abstract=2358187.

Fama, E.F. and French, K.R. (1992), "The cross-section of expected stock returns", *The Journal of Finance*, Vol. 47 No. 2, pp. 427-465, doi: 10.2307/2329112.

Fama, E.F. and French, K.R. (2015), "A five-factor asset pricing model", *Journal of Financial Economics*, Vol. 116 No. 1, pp. 1-22, doi: 10.1016/j.jfineco.2014.10.010.

Gómez, A. (2006), *Integration of the Mexican Stock Market*, Department of Economics, University of Toronto, manuscript submitted for publication.

Kelly, P. (2003), "Real and inflationary macroeconomic risk in the Fama and French size and book-to-market portfolios", *SSRN Electronic Journal*. doi: 10.2139/ssrn.407800.

Manjuantha, T. and Mallikarjunappa, T. (2018), "Testing of Fama and French factors in Indian capital market", *AIMS International Journal of Management*, Vol. 12 No. 1, pp. 11-23, doi: 10.26573/2018.12.1.2.

O'Brien, M.A. (2007), "Fama and French factors in Australia", Unpublished manuscript, available at: http://www.web.uwa.edu.au/data/assets/pdf_file/0006/33396/OBrienMichaelPhDConf2007.pdf.

Roy, R. and Shijin, S. (2018), "A six-factor asset pricing model", *Borsa Istanbul Review*, Vol. 18 No. 3, pp. 205-217, doi: 10.1016/j.bir.2018.02.001.

Sanvicente, A.Z., Sheng, H.H. and Guanais, L.F.P. (2017), "Are country and size risks priced in the Brazilian stock market?", *BAR-Brazilian Administration Review*, Vol. 14 No. 1, doi: 10.1590/1807-7692bar2017160076.

Simpson, M. and Ramchander, S. (2008), "An inquiry into the economic fundamentals of the Fama and French equity factors", *Journal of Empirical Finance*, Vol. 15 No. 5, pp. 801-815, doi: 10.1016/j.jempfin.2008.02.003.

Stoopen, M. (2015), *Global Industry Sensitivity to Country Risk*, Master Thesis Finance, Tilburg School of Economics and Management.

Trejo-Pech, C.O., Samaniego-Alcántar, A. and Treviño, E. (2012), "Modelo Fama and French: resultados empíricos", *Fronteras en Economía y Finanzas*, Vol. 1, pp. 261-272, available at: http://hdl.handle.net/11117/1733.

Treviño, M.D. (2011), "Time varying arbitrage pricing factors in the Mexican Stock Market", *SSRN Electronic Journal*. doi: 10.2139/ssrn.1929141.

Valencia-Herrera, H. (2015), "Decomposition of the stocks returns in the sustainable index of the Mexican stock exchange", *Revista Mexicana de Economía y Finanzas*, Vol. 10 No. 1, pp. 87-100.

Velarde, J. (2004), "The Mexican stock market: multi-factor pricing model", Unpublished manuscript, available at: http://acacia.org.mx/busqueda/pdf/370_the_mexican.pdf.

Zhang, Q., Hopkins, P., Satchell, S. and Schwob, R. (2009), "The link between macroeconomic factors and style returns", *Journal of Asset Management*, Vol. 10, pp. 338-355, doi: 10.1057/jam.2009.32.

Corresponding author
Eduardo Saucedo can be contacted at: eduardo.saucedo@tec.mx