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Exchange Rate Risk in the U.S. Stock Market

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Introduction

In theory, Stulz (1984), Smith and Stulz (1985), and Froot, Sharfstein, and Stein (1993), among others, suggest that exchange rate movements can affect firms' cash flows. In practice, many firms are indeed impacted by exchange rate fluctuations. For instance, Hung (1992) finds that the loss due to exchange rate fluctuations for U.S. manufacturing firms is about $23 billon per year or 10% of gross profits in 1980s; Francis, Hasan, and Hunter (2008) cite a recent Philadelphia Federal Reverse Bank survey which finds that "over 45% of U.S. firms reported that they are affected by currency movements (p. 177); Nucci and Pozzolo (2010) "document a statistically significant effect of exchange rate variations on employment, hours worked and wages in a representative panel of Italian manufacturing firms." (p.121) Therefore, exchange rate risk is widely believed to be relevant to stock returns. Following Adler and Dumas (1983), , researchers typically focus empirically on contemporaneous exchange rate changes, and estimate exchange rate exposure by regressing stock returns on such changes. This approach, in general, finds that exchange rate risk is not priced (e.g. Jorion, 1990, 1991).[1]

A relatively recent study by Kolari, Moorman, and Sorescu (2008) (KMS), however, finds evidence suggesting that exchange rate risk measured by contemporaneous exchange rate changes is priced in the U.S. stock market. Consistent with previous studies (e.g. Jorion, 1990), KMS first estimate the exchange rate sensitivity of each firm by regressing stock returns on contemporaneous exchange rate changes as well as Fama-French-Carhart (1997) four factors in a rolling fashion. Unlike previous studies, KMS further construct an exchange-rate mimicking factor portfolio (along the same line as Fama and French, 1992, 1993), which is a zero investment portfolio that takes long positions in stocks with significant sensitivity (in absolute value) to contemporaneous exchange rate changes and short positions in stocks without significant sensitivity. They find that this exchange rate risk factor can reduce mean pricing errors for the portfolios formed on exchange rate sensitivity and carries a significantly negative (nonlinear) risk premium.

It is important to note that the stocks with significant exchange rate sensitivity in KMS are those of predominantly small firms. For instance, the average size of the stocks in the two KMS extreme portfolios (with significant sensitivity in absolute value) is $116 million, while that of the stocks in other 23 portfolios is $938 million (see Table 1 of KMS, p. 1080). Therefore, by construction, the KMS exchange rate risk factor has a strong correlation with the size factor, and the KMS foreign exchange sensitivity portfolios have a strong factor structure.

Lewellen, Nagel and Shanken (2010) show that any (spurious) factor can seem to be relevant if it is correlated with the size (or value) factor and the testing assets have a strong factor structure. Therefore, an important question to ask is whether the KMS exchange rate risk factor is merely spurious.[2] To provide empirical evidence on this question, we carry out two sets of tests in this paper. The first set is motivated by Lewellen, Nagel and Shanken (2010) who recommend that researchers use industry portfolios that do not have a strong factor structure in empirical tests. We therefore repeat the tests in KMS with the 30 industry portfolios. Our findings suggest that the KMS exchange rate risk factor may be spurious. First, the KMS exchange rate risk factor cannot reduce pricing errors when industry portfolios are used as testing assets. Second, the KMS exchange rate risk factor does not carry a significant risk premium when industry portfolios are used.

The second set of tests is motivated by the voluminous literature which suggests that stock returns are heavy-tailed (e.g. Rachev and Mittnik, 2000). KMS use two-year rolling periods to estimate the exchange rate sensitivity of each firm. Given such a short estimation window, outliers may likely have significant effects leading to spurious correlation. We therefore use alternative methods to obtain more

[1] See also Khoo (1994), Bartov and Bodnar (1994), Allayannis (1997), Chow, Lee and Solt (1997), Vassalou (2000), Bodnar and Wong (2003), Bartram (2004), Bartram and Bodnar (2005), Martin and Mauer (2005), and Bartram (2007).
[2] We discuss the significance of KMS and the implications of our results in more detail in Section 3.3.

robust firm-specific exchange rate sensitivity estimates. First, we still use two-year rolling periods but exclude the returns outside the three standard deviation bands. Second, we use five-year rolling periods instead of two-years as in KMS to mitigate the effects of outliers. Third, we use two-year rolling periods and the least absolute deviations (LAD) regression which is robust to outliers to estimate firm-specific exchange rate sensitivity. In all three cases, we find consistently that the exchange rate risk factor (formed in the KMS fashion) based on more robust firm-specific exchange rate sensitivity estimates is not priced even when the exchange rate sensitivity portfolios are used as the testing assets. Therefore, our evidence suggests that exchange rate risk measured by contemporaneous exchange rate changes is not priced in the U.S. stock market. This suggests that researchers need to take a new perspective on exchange rate risk.

The remainder of the paper is organized as follows: Section 2 discusses the data and the KMS methodology. Section 3 presents the empirical tests with alternative testing assets. Section 4 concludes the paper with a brief summary.

2. Data and KMS methodology

2.1 Data

To construct the exchange rate sensitivity portfolios, we use monthly stock returns data from CRSP (excluding financial firms[3]), the Fama-French factors data from Kenneth French's website[4], and the Federal Reserve's Major Currencies Index (MCI) based on foreign exchange values of the dollar against currencies of major industrial countries from the Federal Reserve Bank in St. Louis. Our sample covers a similar period as KMS, 1973 to 2008.

2.2 KMS methodology

We largely follow KMS to construct the exchange rate sensitivity portfolios. First, starting in 1975, we estimate the exchange rate sensitivity of each firm based on Eq. (1) annually with monthly data and two-year rolling periods.

$$(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}MOM_t + \beta_{i5}E_t + \varepsilon_{it} \qquad (1)$$

where R_{it} is the return on stock *i* in month *t*, E_t is the percentage change in MCI, R_{ft} is the risk-free rate, R_{mt}, SMB_t, HML_t and MOM_t are the returns on the market, the size, the book-to-market and the momentum factors. The β's are the associated factor loadings, and ε_{it} is the disturbance. The estimated coefficient β_{i5} measures the exchange rate sensitivity of the firm. More specifically, we first estimate Eq. (1) for each firm using monthly data from July 1973 to June 1975 to obtain firm-specific β_{i5} estimates for 1975. We then repeat the procedure for the period from July 1974 to June 1976 to obtain firm-specific β_{i5} estimates for 1976, and thereafter continue until 2008.

Then, we rank stocks into 25 portfolios based on their exchange rate sensitivity estimates (β_{i5})[5]. Table 1 shows the summary statistics of these 25 portfolios. Consistent with KMS, we find that firms with high exchange rate sensitivity in absolute value have low average returns (i.e. an inverse U-shaped pattern), and they are much smaller in size. The average annual return of the two extreme portfolios (ranked 1 and 25) is 5.5%, while that of the other 23 portfolios is 11.1%. The average size of the stocks in the two extreme portfolios is \$151 million, compared to \$1,357 million in the other 23 portfolios.

[3] Firms with SIC code between 6000 and 6999.

[4] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

[5] For instance, after we obtain exchange rate sensitivity estimates for the first rolling window between 1973:07 and 1975:06, we form 25 portfolios based on the values of estimates and report the portfolio returns for 1975:07 to 1976:06. Then, we repeat the same procedure for the second rolling window between 1974:07 and 1976:06 and report the portfolio returns for 1976:07 to 1977:06. We continue the procedure until we reach the end of the sample.

Table 1. Summary statistics of the 25 KMS exchange rate sensitivity portfolios: 1975 to 2008

Foreign exchange-sensitivity portfolio	Number of firm months	Sensitivity			Size	Average annual return
		Estimate	Percent positive	Percent significant at 10% level		
1	59877	-6.22	0	54	151,370	5.2
2	61374	-3.43	0	35	334,190	11.5
3	62007	-2.58	0	24	477,570	11.4
4	62478	-2.05	0	16	776,040	9.8
5	62767	-1.66	0	11	1,008,800	10.4
6	62934	-1.35	0	7	1,224,700	11.2
7	63100	-1.10	0	4	1,270,500	11.9
8	63024	-0.88	0	2	1,682,400	10.7
9	63130	-0.69	0	1	1,875,600	13.3
10	63309	-0.51	0	0	1,859,000	11.2
11	63499	-0.34	0	0	2,211,300	10.3
12	63310	-0.18	6	0	1,854,900	11.0
13	63421	-0.02	39	0	1,871,000	9.8
14	63143	0.15	92	0	1,811,300	12.6
15	63475	0.31	100	0	2,038,400	12.5
16	63173	0.48	100	0	2,219,800	12.2
17	62710	0.67	100	0	1,669,600	11.2
18	63200	0.87	100	1	1,635,400	11.3
19	62816	1.10	100	3	1,445,100	12.0
20	62947	1.36	100	6	1,257,300	11.2
21	62755	1.67	100	10	1,057,300	7.3
22	62379	2.05	100	15	806,550	11.9
23	61826	2.58	100	23	509,570	8.5
24	61054	3.39	100	33	304,280	12.6
25	64758	6.06	100	54	150,030	5.7

First, starting in 1975, we estimate the exchange rate sensitivity of each firm based on the following equation annually with monthly data and two-year rolling periods.

$$(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}MOM_t + \beta_{i5}E_t + \varepsilon_{it}$$

where R_{it} is the return on stock *i* in month *t*, E_t is the percentage change in MCI, R_{ft} is the risk-free rate, R_{mt}, SMB_t, HML_t and MOM_t are the returns on the market, the size, the book-to-market and the momentum factors. The β's are the associated factor loadings, and ε_{it} is the disturbance. The estimated coefficient β_5 measures the exchange rate sensitivity of the firm. Then, we rank stocks into 25 portfolios based on their exchange rate sensitivity estimates (β_5). Table 1 shows the summary statistics of these 25 portfolios.

Next, the exchange rate risk factor (XMI) is constructed as a zero investment portfolio that takes long positions in portfolios ranked 1 and 25 and short positions in all other portfolios ranked 2 to 24. KMS argue that if XMI is a relevant factor, it should reduce the mean pricing error of the standard asset pricing models and carries a significant risk premium.

Following KMS, we run time series regressions to compare pricing errors with the 25 exchange rate sensitivity portfolios as the testing assets. Table 2 shows the results based on the standard Fama-French three factor model and a four-factor model that includes XMI. We refer to them as Model 1 and Model 2.

Model 1: $$(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \varepsilon_{it} \quad (2)$$

Model 2: $$(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}XMI_t + \varepsilon_{it} \quad (3)$$

Table 2. KMS exchange rate sensitivity portfolio regressions: 1975 to 2008

	Model 1					Model 2					
Portfolio	α	β_1	β_2	β_3	R^2	α	β_1	β_2	β_3	β_4	R^2
1	-0.71	1.18	0.96	-0.28	0.74	-0.13	1.01	0.25	-0.03	0.90	0.86
	(-3.35)	(21.75)	(9.49)	(-2.79)		(-0.68)	(22.03)	(2.76)	(-0.41)	(10.05)	
2	-0.12	1.09	0.80	-0.22	0.75	0.04	1.04	0.60	-0.15	0.25	0.76
	(-0.50)	(22.40)	(10.67)	(-1.94)		(0.18)	(20.83)	(8.02)	(-1.55)	(3.69)	
3	-0.07	1.15	0.36	-0.17	0.74	0.05	1.11	0.21	-0.12	0.18	0.75
	(-0.30)	(22.77)	(3.41)	(-1.69)		(0.23)	(27.25)	(1.49)	(-1.25)	(2.05)	
4	-0.19	1.10	0.24	-0.08	0.74	-0.13	1.09	0.17	-0.05	0.09	0.74
	(-1.15)	(27.60)	(2.51)	(-0.84)		(-0.75)	(26.98)	(1.74)	(-0.56)	(1.71)	
5	-0.03	1.05	-0.00	-0.15	0.72	-0.01	1.05	-0.03	-0.14	0.03	0.72
	(-0.17)	(30.15)	(-0.02)	(-1.13)		(-0.03)	(28.68)	(-0.33)	(-1.06)	(0.62)	
6	-0.10	1.06	0.07	0.14	0.80	-0.09	1.06	0.06	0.14	0.02	0.80
	(-0.64)	(30.76)	(0.86)	(1.77)		(-0.59)	(32.34)	(0.68)	(1.75)	(0.40)	
7	-0.00	0.98	0.04	0.16	0.75	0.02	0.97	0.01	0.17	0.04	0.75
	(-0.03)	(40.68)	(0.75)	(2.14)		(0.14)	(38.67)	(0.19)	(2.23)	(0.83)	
8	-0.01	1.00	-0.09	-0.01	0.74	-0.01	1.00	-0.09	-0.02	-0.00	0.74
	(-0.09)	(40.79)	(-1.14)	(-0.13)		(-0.11)	(39.54)	(-1.11)	(-0.14)	(-0.09)	
9	0.17	0.95	-0.07	0.10	0.75	0.20	0.94	-0.10	0.11	0.04	0.75
	(1.26)	(24.63)	(-1.22)	(1.75)		(1.37)	(25.45)	(-1.08)	(2.00)	(0.63)	
10	0.03	0.95	-0.06	0.01	0.84	-0.01	0.96	-0.01	-0.01	-0.07	0.85
	(0.44)	(45.19)	(-1.70)	(0.14)		(-0.12)	(40.77)	(-0.20)	(-0.17)	(-2.02)	
11	-0.01	0.89	-0.07	0.02	0.73	0.01	0.89	-0.09	0.03	0.03	0.73
	(-0.13)	(32.71)	(-1.06)	(0.26)		(0.05)	(37.95)	(-1.57)	(0.43)	(0.49)	
12	0.03	0.91	-0.09	0.05	0.81	0.06	0.90	-0.12	0.06	0.04	0.81
	(0.27)	(22.87)	(-2.32)	(1.15)		(0.53)	(27.03)	(-2.23)	(1.34)	(0.83)	
13	-0.07	0.93	-0.17	0.07	0.80	-0.07	0.93	-0.17	0.07	0.00	0.80
	(-0.68)	(30.86)	(-3.68)	(0.90)		(-0.69)	(31.54)	(-3.40)	(0.92)	(0.02)	
14	0.20	0.96	-0.18	-0.03	0.83	0.21	0.96	-0.19	-0.02	0.02	0.83
	(2.17)	(32.29)	(-3.32)	(-0.50)		(2.42)	(35.13)	(-2.56)	(-0.36)	(0.48)	
15	0.12	0.95	-0.15	0.13	0.79	0.08	0.96	-0.10	0.11	-0.06	0.79
	(1.29)	(39.12)	(-2.83)	(1.64)		(0.84)	(39.08)	(-1.62)	(1.46)	(-1.58)	
16	0.17	0.98	-0.14	-0.11	0.83	0.20	0.97	-0.17	-0.10	0.04	0.83
	(1.68)	(30.81)	(-2.25)	(-1.84)		(1.83)	(29.15)	(-2.39)	(-1.82)	(1.10)	
17	0.09	0.92	-0.01	-0.14	0.75	0.09	0.93	-0.00	-0.14	-0.00	0.75
	(0.80)	(21.91)	(-0.10)	(-1.25)		(0.78)	(24.69)	(-0.05)	(-1.26)	(-0.07)	
18	0.03	1.01	-0.10	0.01	0.82	-0.01	1.03	-0.04	-0.01	-0.07	0.83
	(0.31)	(29.06)	(-1.64)	(0.13)		(-0.15)	(32.35)	(-0.56)	(-0.19)	(-1.41)	
19	0.14	1.08	-0.01	-0.25	0.78	0.23	1.05	-0.12	-0.21	0.14	0.78
	(1.30)	(21.72)	(-0.20)	(-2.09)		(1.91)	(22.48)	(-1.44)	(-1.82)	(2.63)	
20	0.05	1.08	-0.01	-0.19	0.79	0.11	1.06	-0.09	-0.16	0.10	0.80
	(0.32)	(20.60)	(-0.11)	(-3.16)		(0.80)	(23.19)	(-1.21)	(-2.68)	(2.29)	
21	-0.38	1.12	0.13	-0.07	0.76	-0.29	1.10	0.02	-0.03	0.14	0.77
	(-2.64)	(23.36)	(1.30)	(-0.62)		(-1.80)	(27.92)	(0.17)	(-0.28)	(1.85)	
22	-0.08	1.14	0.32	-0.00	0.77	0.09	1.08	0.10	0.07	0.27	0.79
	(-0.57)	(17.35)	(3.47)	(-0.05)		(0.56)	(21.97)	(0.91)	(0.95)	(3.63)	
23	-0.39	1.17	0.27	0.06	0.74	-0.26	1.13	0.12	0.11	0.19	0.75
	(-2.23)	(18.65)	(1.76)	(0.46)		(-1.52)	(21.31)	(0.74)	(0.88)	(3.21)	
24	0.02	1.15	0.46	-0.22	0.72	0.26	1.08	0.18	-0.12	0.36	0.75
	(0.12)	(16.73)	(3.44)	(-1.93)		(1.18)	(19.35)	(1.38)	(-1.28)	(4.23)	
25	-0.62	1.26	0.74	-0.36	0.66	0.20	1.01	-0.24	-0.00	1.26	0.89
	(-2.01)	(9.47)	(4.18)	(-2.74)		(1.12)	(18.74)	(-1.67)	(-0.07)	(13.94)	

Model 1: $(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \varepsilon_{it}$

Model 2: $(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}XMI_t + \varepsilon_{it}$

where R_{it} is the return on portfolio *i* in month *t*, R_{ft} is the risk-free rate, XMI_t is the exchange rate risk factor, R_{mt}, SMB_t, and HML_t are the returns on the market, the size, and the book-to-market factors..The numbers in parentheses are the Newey-West HAC t-ratios.

The numbers in parentheses are the Newey-West HAC t-ratios. Consistent with KMS, Model 2 significantly reduce the alphas of the two extreme portfolios from -0.71 (t=-3.35) to -0.13 (t=-0.68) for Portfolio 1 and from -0.62 (t=-2.01) to 0.20 (t=1.12) for Portfolio 25. Overall, the average absolute alpha decreases from 0.15 to 0.11 (Table 2).

Table 3. Risk premium estimates

	1 KMS portfolios	2 Industry Portfolios	3 Sensitivity portfolios excluding extreme returns	4 Sensitivity portfolios with five-year rolling periods	5 Sensitivity portfolios based on LAD
Premium	-0.58	0.02	-0.08	-0.24	-0.10
	(-2.71)	(0.10)	(-0.63)	(-1.34)	(-0.73)

Following KMS, we estimate the risk premium of the exchange rate risk factor with a two-step approach. Specifically, we first estimate the sensitivity coefficients of the portfolios by regressing excess portfolio returns on contemporaneous changes in MCI using three-year rolling periods; then, we regress next year's portfolio returns on the squared sensitivity coefficients using rolling regressions. Table 3 reports the premium estimates with different testing assets.

Following KMS, we estimate the risk premium of the exchange rate risk factor with a two-step approach and the 25 exchange rate sensitivity portfolios as the testing assets.[6] Specifically, we first estimate the sensitivity coefficients of the 25 exchange rate sensitivity portfolios by regressing excess portfolio returns on contemporaneous changes in MCI using three-year rolling periods; then, we regress next year's portfolio returns on the squared sensitivity coefficients using rolling regressions. The estimated risk premium, shown in the first column of Table 3, is -0.58% per month with a Newey-West HAC t-statistic of -2.71. Therefore, we are able to reproduce the main results in KMS with our sample in the sense that the KMS exchange rate risk factor in our sample can also reduce pricing errors and carries a statistically significant risk premium if the KMS exchange rate sensitivity portfolios are used as the testing assets.

3. Empirical tests with alternative testing assets

3.1 Industry portfolios

From Table 1, it is easy to see that, the KMS exchange rate risk factor has a strong correlation with the size factor by construction, and the KMS exchange rate sensitivity portfolios have a strong factor structure. We provide some direct evidence. First, we document the correlations among the factors in Model 2 in Table 4. Not surprisingly, the correlation coefficient between XMI and SMB is 64% in our sample! Then, we depict the factor structure of the 25 KMS exchange rate sensitivity portfolios in a scatter graph, which shows the loadings on SMB of these 25 portfolios based on Model 1. A clear pattern energies: the loading on SMB almost monotonically decreases from the sensitive portfolios to insensitive portfolios (Figure 1).[7]

Table 4. Correlation Matrix of the Relevant Variables

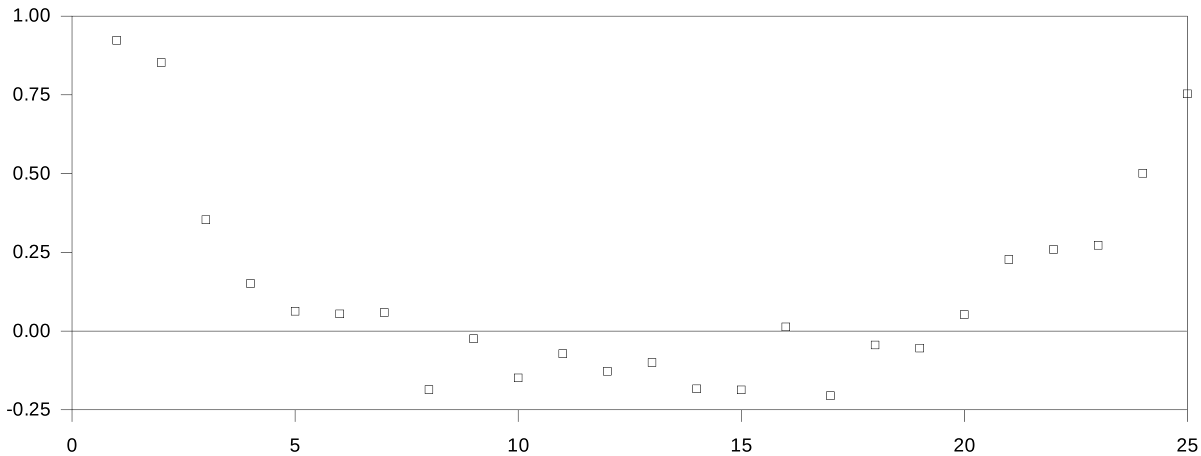
	R_m	SMB	HML	XMI
R_m	1			
SMB	0.24	1		
HML	-0.42	-0.33	1	
XMI	0.39	0.64	-0.44	1

We document the correlations among the relevant factors in Table 4.

[6] Since the relationship between mean returns and foreign exchange sensitivity is nonlinear, we cannot use the standard two-pass regression methodology of Black, Jensen, and Scholes (1972) and Fama and MacBeth (1973).

[7] As a result, now it is easy to understand why the loadings on SMB for two extreme portfolios change dramatically when Model 2 is estimated. As we can see from Table 2, the extreme portfolios 1 and 25 have the highest loadings on the size factor in the three-factor model (Model 1). However, as soon as XMI is added, the loadings on the size factor decrease dramatically: the loading of Portfolio 1 decreases from 0.96 to 0.25, and that of Portfolio 25 decreases from 0.74 to -0.24.

Figure 1. The loadings on SMB of 25 KMS exchange rate sensitivity portfolios: 1975 to 2008



We depict the factor structure of the 25 KMS exchange rate sensitivity portfolios in a scatter graph, which shows the loadings on SMB of these 25 portfolios based on the following model.

$$(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \varepsilon_{it}$$

where R_{it} is the return on portfolio *i* in month *t*, R_{ft} is the risk-free rate, R_{mt}, SMB_t, and HML_t are the returns on the market, the size, and the book-to-market factors.

Lewellen, Nagel and Shanken (2010) show that any (spurious) factor can reduce pricing errors if it is correlated with the size (or value) factor and the testing assets have a strong factor structure. One solution that Lewellen, Nagel and Shanken (2010) suggest is to use the assets such as industry portfolios that do not have a strong factor structure as testing assets. We note that most previous studies focus on industry portfolios (e.g., Jorion, 1990; Francis, Hasan, and Hunter, 2008). We therefore repeat the same exercises in Section 2.2 with the 30 industry portfolios from the Kenneth French's web site.

The time series regressions based on Model 1 and Model 2 are reported in Table 5. When the industry portfolios are used, XMI is not able to reduce pricing errors: the average absolute alpha changes from 0.24 to 0.23 when XMI is added. The risk premium estimate is reported in Column 2 of Table 3, which is equal to 0.02 with a t-statistic of 0.10. Therefore, as soon as we use a set of assets that do not have strong factor structure, the KMS exchange rate risk factor becomes irrelevant in the sense that it cannot reduce pricing errors and does not carry a significant risk premium. This is the central finding of the paper.

Table 5. Industry portfolio regressions: July 1975 to December 2008

Portfolio	Model 1					Model 2					
	α	β_1	β_2	β_3	R^2	α	β_1	β_2	β_3	β_4	R^2
Food	0.32	0.75	-0.24	0.24	0.49	0.16	0.80	-0.04	0.17	-0.25	0.52
	(1.70)	(14.97)	(-3.37)	(2.15)		(0.88)	(17.68)	(-0.54)	(1.69)	(-4.41)	
Beer	0.40	0.82	-0.20	0.19	0.38	0.19	0.88	0.05	0.10	-0.33	0.42
	(1.71)	(9.86)	(-2.14)	(1.58)		(0.87)	(12.09)	(0.52)	(0.96)	(-4.19)	
Smoke	0.58	0.77	-0.23	0.35	0.22	0.43	0.81	-0.05	0.29	-0.22	0.23
	(1.84)	(8.75)	(-1.70)	(2.26)		(1.33)	(10.06)	(-0.34)	(1.87)	(-3.14)	
Games	-0.15	1.23	0.26	0.18	0.69	-0.07	1.21	0.17	0.21	0.12	0.69
	(-0.73)	(17.96)	(1.98)	(1.45)		(-0.36)	(18.68)	(1.17)	(1.63)	(1.55)	
Books	-0.17	1.07	0.08	0.30	0.72	-0.26	1.10	0.20	0.26	-0.15	0.72
	(-0.84)	(19.97)	(1.33)	(3.52)		(-1.39)	(22.26)	(2.31)	(2.72)	(-2.65)	
Hshld	0.11	0.82	-0.20	0.07	0.55	-0.03	0.86	-0.03	0.01	-0.22	0.57
	(0.69)	(12.81)	(-3.28)	(0.76)		(-0.25)	(16.13)	(-0.38)	(0.08)	(-3.35)	
Clths	-0.12	1.15	0.21	0.44	0.59	-0.18	1.17	0.29	0.41	-0.10	0.59
	(-0.56)	(12.87)	(1.02)	(2.18)		(-0.91)	(13.56)	(1.25)	(1.96)	(-1.75)	
Hlth	0.36	0.80	-0.28	-0.21	0.58	0.25	0.84	-0.14	-0.26	-0.18	0.59
	(2.41)	(14.40)	(-4.62)	(-1.81)		(1.68)	(17.37)	(-2.06)	(-2.28)	(-3.71)	
Chems	-0.26	1.13	-0.08	0.40	0.71	-0.32	1.15	0.00	0.37	-0.10	0.71
	(-1.40)	(31.52)	(-1.24)	(3.58)		(-1.74)	(35.10)	(0.03)	(3.41)	(-2.11)	
Txtls	-0.48	1.09	0.53	0.71	0.58	-0.50	1.10	0.55	0.70	-0.03	0.58
	(-1.96)	(16.42)	(3.59)	(4.64)		(-2.03)	(16.91)	(3.00)	(4.44)	(-0.41)	
Cnstr	-0.26	1.23	0.14	0.43	0.77	-0.35	1.26	0.25	0.39	-0.14	0.78
	(-1.66)	(28.03)	(1.49)	(3.72)		(-2.58)	(32.96)	(1.97)	(3.23)	(-2.54)	
Steel	-0.52	1.34	0.44	0.25	0.64	-0.39	1.30	0.29	0.31	0.20	0.65
	(-2.07)	(18.14)	(5.77)	(2.18)		(-1.53)	(21.17)	(2.64)	(2.72)	(2.75)	
FabPr	-0.29	1.21	0.30	0.17	0.76	-0.23	1.19	0.24	0.20	0.08	0.76
	(-1.50)	(26.92)	(3.18)	(1.72)		(-1.21)	(30.58)	(2.23)	(1.88)	(1.74)	
ElcEq	0.26	1.20	-0.12	-0.02	0.73	0.17	1.23	-0.00	-0.06	-0.14	0.73
	(2.02)	(26.26)	(-1.13)	(-0.21)		(1.26)	(28.95)	(-0.03)	(-0.67)	(-2.39)	
Autos	-0.60	1.27	0.06	0.69	0.60	-0.54	1.26	-0.00	0.71	0.08	0.61
	(-2.97)	(19.31)	(0.67)	(5.81)		(-2.73)	(20.05)	(-0.04)	(5.47)	(1.06)	
Carry	0.04	1.19	-0.02	0.42	0.59	-0.01	1.21	0.04	0.39	-0.08	0.59
	(0.23)	(21.69)	(-0.17)	(2.44)		(-0.03)	(23.15)	(0.30)	(2.17)	(-1.12)	
Mines	-0.44	0.98	0.40	0.46	0.30	-0.37	0.96	0.31	0.49	0.11	0.30
	(-1.27)	(10.40)	(2.82)	(3.22)		(-1.05)	(10.24)	(1.87)	(3.60)	(0.79)	
Coal	-0.11	1.18	0.35	0.41	0.25	0.08	1.12	0.12	0.49	0.30	0.26
	(-0.22)	(11.38)	(1.85)	(1.36)		(0.17)	(11.58)	(0.46)	(1.72)	(2.09)	
Oil	0.23	0.87	-0.19	0.31	0.41	0.28	0.86	-0.24	0.33	0.07	0.41
	(1.09)	(13.98)	(-1.80)	(2.26)		(1.22)	(13.72)	(-1.91)	(2.37)	(0.89)	
Util	0.06	0.65	-0.21	0.52	0.46	0.09	0.64	-0.24	0.53	0.05	0.46
	(0.42)	(14.94)	(-2.76)	(5.17)		(0.63)	(14.80)	(-3.33)	(4.87)	(0.91)	
Telcm	0.11	0.84	-0.22	0.01	0.54	0.15	0.82	-0.27	0.03	0.06	0.54
	(0.62)	(13.53)	(-2.76)	(0.11)		(0.77)	(14.80)	(-2.34)	(0.25)	(0.83)	
Servs	0.34	1.16	0.26	-0.53	0.86	0.44	1.13	0.15	-0.49	0.15	0.87
	(2.70)	(28.38)	(2.71)	(-6.08)		(3.41)	(31.54)	(1.26)	(-6.22)	(3.10)	
BusEq	0.10	1.16	0.28	-0.63	0.77	0.28	1.10	0.07	-0.55	0.28	0.78
	(0.51)	(15.26)	(3.73)	(-5.17)		(1.42)	(18.18)	(0.74)	(-4.66)	(3.58)	
Paper	-0.20	1.03	-0.09	0.37	0.67	-0.29	1.06	0.01	0.33	-0.14	0.67
	(-1.43)	(23.00)	(-1.32)	(3.12)		(-2.35)	(25.97)	(0.18)	(2.77)	(-3.07)	
Trans	-0.12	1.07	0.12	0.36	0.65	-0.20	1.09	0.21	0.33	-0.12	0.65
	(-0.74)	(17.18)	(1.04)	(2.59)		(-1.25)	(17.75)	(1.94)	(2.40)	(-2.16)	
Whlsl	-0.11	1.01	0.30	0.22	0.75	-0.18	1.03	0.38	0.19	-0.10	0.75
	(-0.92)	(24.72)	(3.85)	(1.71)		(-1.28)	(28.54)	(3.10)	(1.33)	(-1.15)	
Rtail	0.12	1.01	0.02	0.08	0.63	0.02	1.04	0.14	0.03	-0.16	0.63
	(0.70)	(16.66)	(0.16)	(0.67)		(0.09)	(18.19)	(1.12)	(0.28)	(-3.20)	
Meals	-0.04	1.02	0.10	0.36	0.58	-0.12	1.05	0.20	0.33	-0.13	0.58
	(-0.19)	(17.37)	(0.64)	(2.23)		(-0.62)	(18.06)	(1.15)	(2.00)	(-1.94)	
Fin	-0.11	1.15	-0.14	0.50	0.81	-0.16	1.17	-0.07	0.48	-0.08	0.81
	(-0.85)	(25.78)	(-1.77)	(6.99)		(-1.24)	(26.31)	(-0.83)	(6.28)	(-2.63)	
Other	-0.22	1.03	0.09	0.09	0.67	-0.26	1.04	0.15	0.07	-0.07	0.67
	(-1.18)	(23.43)	(1.23)	(0.65)		(-1.37)	(23.49)	(1.33)	(0.49)	(-1.14)	

Model 1: $(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \varepsilon_{it}$

Model 2: $(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}XMI_t + \varepsilon_{it}$

where R_{it} is the return on portfolio *i* in month *t*, R_{ft} is the risk-free rate, XMI_t is the exchange rate risk factor, R_{mt}, SMB_t, and HML_t are the returns on the market, the size, and the book-to-market factors..The numbers in parentheses are the Newey-West HAC t-ratios.

Table 6. Sensitivity portfolio excluding extreme returns: 1975 to 2008

	Model 1					Model 2					
Portfolio	α	β_1	β_2	β_3	R^2	α	β_1	β_2	β_3	β_4	R^2
1	-0.06	1.18	1.00	-0.44	0.73	0.16	0.99	0.17	-0.13	1.04	0.87
	(-0.20)	(18.99)	(9.21)	(-2.99)		(0.78)	(20.22)	(1.80)	(-1.47)	(11.39)	
2	-0.28	1.11	0.64	-0.23	0.77	-0.25	1.08	0.52	-0.18	0.16	0.78
	(-1.48)	(23.75)	(10.43)	(-3.65)		(-1.29)	(24.51)	(5.88)	(-2.72)	(2.44)	
3	-0.25	1.23	0.27	-0.14	0.73	-0.21	1.19	0.12	-0.08	0.18	0.74
	(-1.22)	(19.38)	(1.91)	(-1.14)		(-0.97)	(19.82)	(0.87)	(-0.77)	(1.83)	
4	0.05	1.03	0.20	-0.19	0.73	0.05	1.03	0.17	-0.18	0.03	0.73
	(0.28)	(27.82)	(2.85)	(-2.13)		(0.32)	(25.42)	(2.60)	(-2.17)	(0.59)	
5	0.07	1.04	-0.03	-0.10	0.71	0.08	1.03	-0.04	-0.10	0.02	0.71
	(0.42)	(29.62)	(-0.35)	(-0.93)		(0.43)	(29.28)	(-0.47)	(-0.91)	(0.32)	
6	-0.12	1.06	0.04	0.21	0.78	-0.12	1.06	0.04	0.22	0.00	0.77
	(-0.83)	(29.82)	(0.45)	(2.39)		(-0.82)	(30.49)	(0.46)	(2.56)	(0.05)	
7	-0.07	1.01	0.00	0.07	0.78	-0.07	1.01	0.00	0.07	-0.00	0.78
	(-0.61)	(38.93)	(0.02)	(0.78)		(-0.60)	(41.71)	(0.01)	(0.82)	(-0.00)	
8	0.12	0.97	-0.08	0.18	0.76	0.10	0.99	-0.00	0.15	-0.09	0.76
	(1.14)	(34.35)	(-1.08)	(2.27)		(0.96)	(36.53)	(-0.06)	(2.18)	(-1.66)	
9	-0.02	0.94	-0.12	-0.02	0.77	-0.01	0.93	-0.16	-0.00	0.06	0.77
	(-0.16)	(29.30)	(-2.42)	(-0.28)		(-0.06)	(31.58)	(-1.97)	(-0.04)	(0.86)	
10	0.12	0.95	-0.08	0.02	0.85	0.11	0.96	-0.04	0.01	-0.04	0.85
	(1.21)	(32.23)	(-1.89)	(0.44)		(1.10)	(33.28)	(-0.90)	(0.17)	(-0.88)	
11	0.00	0.93	-0.01	0.02	0.74	0.02	0.92	-0.07	0.04	0.07	0.74
	(0.01)	(30.36)	(-0.12)	(0.19)		(0.14)	(33.00)	(-0.66)	(0.49)	(0.80)	
12	-0.05	0.94	-0.13	0.01	0.82	-0.03	0.92	-0.20	0.03	0.09	0.82
	(-0.51)	(24.25)	(-3.91)	(0.16)		(-0.35)	(28.83)	(-4.20)	(0.60)	(1.81)	
13	-0.02	0.92	-0.19	0.06	0.78	-0.03	0.92	-0.17	0.05	-0.02	0.78
	(-0.21)	(36.95)	(-3.22)	(0.83)		(-0.24)	(31.23)	(-3.38)	(0.80)	(-0.31)	
14	0.24	0.96	-0.16	0.05	0.81	0.23	0.97	-0.14	0.04	-0.04	0.81
	(2.48)	(35.24)	(-3.46)	(0.60)		(2.40)	(34.12)	(-2.29)	(0.43)	(-0.95)	
15	0.06	0.96	-0.09	0.06	0.82	0.05	0.97	-0.05	0.05	-0.05	0.82
	(0.48)	(43.84)	(-1.84)	(0.95)		(0.40)	(45.97)	(-0.80)	(0.75)	(-1.79)	
16	0.10	0.94	-0.14	-0.02	0.79	0.10	0.94	-0.14	-0.02	0.00	0.79
	(1.18)	(28.77)	(-2.92)	(-0.33)		(1.17)	(28.51)	(-2.53)	(-0.33)	(0.05)	
17	0.07	0.95	-0.04	-0.03	0.77	0.07	0.95	-0.04	-0.03	-0.00	0.77
	(0.63)	(22.81)	(-0.43)	(-0.34)		(0.62)	(25.14)	(-0.34)	(-0.32)	(-0.01)	
18	-0.12	1.01	-0.07	-0.08	0.78	-0.11	1.01	-0.08	-0.08	0.02	0.78
	(-1.02)	(33.42)	(-0.85)	(-0.72)		(-1.00)	(33.41)	(-0.77)	(-0.72)	(0.26)	
19	0.21	1.07	-0.07	-0.11	0.80	0.25	1.04	-0.20	-0.06	0.16	0.81
	(1.68)	(22.74)	(-1.11)	(-1.74)		(2.07)	(25.07)	(-2.49)	(-0.98)	(3.45)	
20	0.09	1.10	0.01	-0.29	0.78	0.12	1.08	-0.09	-0.25	0.13	0.78
	(0.72)	(19.93)	(0.12)	(-2.81)		(1.01)	(22.32)	(-1.22)	(-2.60)	(2.33)	
21	-0.20	1.06	0.13	-0.06	0.75	-0.19	1.05	0.08	-0.04	0.06	0.75
	(-1.43)	(23.57)	(1.77)	(-0.76)		(-1.33)	(26.05)	(0.88)	(-0.52)	(1.06)	
22	-0.35	1.16	0.15	0.00	0.77	-0.31	1.12	-0.02	0.07	0.22	0.79
	(-2.55)	(18.49)	(1.34)	(0.02)		(-2.12)	(22.45)	(-0.19)	(0.90)	(3.76)	
23	-0.24	1.18	0.34	0.04	0.76	-0.20	1.14	0.17	0.11	0.22	0.77
	(-1.38)	(22.40)	(2.74)	(0.40)		(-1.07)	(24.75)	(1.26)	(1.06)	(2.99)	
24	-0.03	1.21	0.54	-0.21	0.76	0.07	1.13	0.18	-0.08	0.46	0.80
	(-0.10)	(20.68)	(5.57)	(-1.90)		(0.35)	(24.86)	(1.54)	(-0.97)	(4.63)	
25	-0.42	1.25	0.69	-0.23	0.69	-0.18	1.05	-0.19	0.11	1.11	0.87
	(-1.52)	(11.31)	(3.98)	(-1.73)		(-0.90)	(18.79)	(-1.93)	(1.09)	(12.59)	

Model 1: $(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \varepsilon_{it}$

Model 2: $(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}XMI_t + \varepsilon_{it}$

where R_{it} is the return on portfolio *i* in month *t*, R_{ft} is the risk-free rate, XMI_t is the exchange rate risk factor, R_{mt}, SMB_t, and HML_t are the returns on the market, the size, and the book-to-market factors..The numbers in parentheses are the Newey-West HAC t-ratios.

3.2 Sensitivity portfolios based on more robust firm-specific sensitivity estimates

There is a voluminous literature which suggests that stock returns are heavy-tailed (e.g. Rachev and Mittnik, 2000). KMS use two-year rolling periods to estimate firm-specific exchange rate sensitivity. Given such a short estimation window, outliers are likely to have significant effects and therefore lead to spurious correlation. We therefore use alternative methods to obtain more robust firm-specific exchange rate sensitivity estimates.

The first method we use is to exclude outliers when we estimate firm-specific exchange rate sensitivity. Specifically, first, we still use two-year rolling periods but exclude the returns outside the three standard deviation bands to estimate firm-specific exchange rate sensitivity. Then, we repeat the procedure in Section 2.2 to form 25 exchange rate sensitivity portfolios. Next, we construct the exchange rate risk factor in the same fashion as in KMS. That is, the exchange rate risk factor is constructed as a zero investment portfolio that takes long positions in portfolios ranked 1 and 25 and short positions in all other portfolios ranked 2 to 24. Finally, we repeat the time-series exposure tests in Table 6 and the risk premium test in Column 3 of Table 3 by using the 25 newly formed exchange rate sensitivity portfolios as our testing assets and the newly constructed exchange rate risk factor as the relevant exchange risk factor. As we can see, as soon as the outliers are excluded, Table 6 shows that the two extreme portfolios do not have significant alphas even when the Fama-French three factor model is used for risk adjustment, and Model 2 with the exchange rate risk factor does not reduce pricing errors (the average absolute alpha changes from 0.13 to 0.12). Table 3 shows that the exchange rate risk factor based on the newly formed sensitivity portfolios does not carry a significant risk premium either. The risk premium is equal to -0.08 with a t-statistic of -0.63.

The second method we use is to employ five-year rolling periods instead of two years as in KMS to mitigate the effects of outliers. That is, we first use five-year rolling periods to estimate firm-specific exchange rate sensitivity. Then, we repeat the same procedure in Section 2.2 to form 25 exchange rate sensitivity portfolios and the exchange rate risk factor. The exposure results are reported in Table 7 and the risk premium is presented in Column 4 of Table 3. Again, as soon as more observations are used to mitigate the effect of outliers, the extreme portfolios do not have significant alphas in the Fama-French three factor model[8]; and the exchange risk factor does not carry a significant risk premium.

The third method we use is to utilize two-year rolling periods combined with the least absolute deviations (LAD) regression which is robust to outliers in the estimation of firm-specific exchange rate sensitivity. That is, we first use two-year rolling periods and LAD to estimate firm-specific exchange rate sensitivity. Then, we repeat the same procedure in Section 2.2 to form 25 exchange rate sensitivity portfolios and the exchange rate risk factor. The exposure results are reported in Table 8 and the risk premium is presented in Column 5 of Table 3. Again, as soon as a more robust estimation method is used, the extreme portfolios do not have significant alphas in the Fama-French three factor model[9]; and the exchange risk factor does not carry a significant risk premium. Therefore, unlike KMS, our findings suggest that exchange rate risk measured by contemporaneous exchange rate changes is still not priced in stock returns.

[8] Overall, the average absolute alpha changes from 0.16 to 0.14 when the exchange rate risk factor is added.

[9] Overall, the average absolute alpha changes from 0.14 to 0.11 when the exchange rate risk factor is added.

Table 7. Sensitivity portfolios with five-year rolling periods: 1978 to 2008

	Model 1					Model 2					
Portfolio	α	β_1	β_2	β_3	R^2	α	β_1	β_2	β_3	β_4	R^2
1	-0.53	1.15	0.84	-0.20	0.58	0.13	0.93	-0.07	0.07	1.24	0.84
	(-1.70)	(12.85)	(6.20)	(-1.20)		(0.77)	(16.95)	(-0.77)	(0.84)	(11.66)	
2	0.02	1.12	0.62	-0.09	0.70	0.22	1.05	0.34	-0.01	0.37	0.74
	(0.07)	(15.98)	(7.72)	(-0.95)		(0.80)	(18.27)	(4.95)	(-0.11)	(5.59)	
3	-0.35	1.02	0.33	-0.26	0.74	-0.27	0.99	0.21	-0.23	0.16	0.75
	(-1.87)	(23.96)	(3.81)	(-2.88)		(-1.50)	(21.88)	(2.05)	(-2.91)	(2.95)	
4	-0.18	1.12	0.10	-0.00	0.69	-0.09	1.10	-0.01	0.03	0.15	0.70
	(-0.97)	(19.73)	(1.00)	(-0.00)		(-0.56)	(20.98)	(-0.07)	(0.30)	(3.12)	
5	0.17	1.03	0.03	-0.09	0.77	0.19	1.02	0.00	-0.08	0.04	0.77
	(1.22)	(29.71)	(0.37)	(-1.05)		(1.28)	(31.04)	(0.05)	(-0.90)	(0.66)	
6	0.07	0.95	0.18	0.22	0.65	0.06	0.96	0.19	0.22	-0.02	0.65
	(0.37)	(21.77)	(2.73)	(2.58)		(0.30)	(22.09)	(3.08)	(2.54)	(-0.36)	
7	0.00	0.96	0.00	0.16	0.69	-0.03	0.97	0.05	0.15	-0.06	0.69
	(0.01)	(23.02)	(0.00)	(1.87)		(-0.25)	(24.93)	(0.88)	(1.80)	(-1.11)	
8	0.02	0.91	0.02	0.06	0.73	0.06	0.89	-0.03	0.07	0.08	0.73
	(0.16)	(18.06)	(0.44)	(0.83)		(0.42)	(17.16)	(-0.67)	(1.13)	(1.22)	
9	0.17	0.90	-0.19	-0.07	0.67	0.16	0.91	-0.18	-0.08	-0.01	0.67
	(1.28)	(24.40)	(-1.91)	(-0.49)		(1.12)	(22.07)	(-1.30)	(-0.57)	(-0.13)	
10	0.04	0.91	-0.07	0.15	0.77	0.02	0.91	-0.05	0.14	-0.03	0.77
	(0.43)	(26.79)	(-1.31)	(2.23)		(0.27)	(28.21)	(-0.99)	(2.20)	(-0.89)	
11	0.01	0.92	-0.12	0.21	0.76	-0.02	0.93	-0.08	0.20	-0.05	0.76
	(0.11)	(29.47)	(-2.40)	(2.93)		(-0.15)	(31.90)	(-1.80)	(2.84)	(-1.68)	
12	-0.02	0.92	-0.24	0.03	0.78	-0.02	0.92	-0.23	0.02	-0.01	0.78
	(-0.16)	(25.57)	(-3.99)	(0.34)		(-0.21)	(24.45)	(-3.15)	(0.32)	(-0.31)	
13	0.24	0.91	-0.17	0.17	0.82	0.22	0.92	-0.14	0.16	-0.05	0.83
	(2.05)	(35.93)	(-4.06)	(2.47)		(1.86)	(38.60)	(-3.38)	(2.44)	(-1.98)	
14	0.30	0.92	-0.13	-0.13	0.72	0.38	0.90	-0.23	-0.10	0.14	0.73
	(2.21)	(24.15)	(-1.46)	(-1.42)		(2.17)	(20.55)	(-2.15)	(-1.35)	(1.29)	
15	-0.08	1.04	-0.14	0.10	0.77	-0.09	1.04	-0.13	0.10	-0.01	0.77
	(-0.63)	(22.93)	(-1.74)	(0.98)		(-0.67)	(25.48)	(-1.46)	(1.00)	(-0.20)	
16	0.10	1.07	-0.18	-0.03	0.83	0.15	1.05	-0.24	-0.01	0.09	0.84
	(0.94)	(23.95)	(-2.60)	(-0.68)		(1.31)	(27.81)	(-3.14)	(-0.22)	(1.64)	
17	0.14	1.00	-0.27	0.07	0.77	0.12	1.00	-0.25	0.07	-0.03	0.77
	(1.29)	(24.96)	(-3.84)	(0.73)		(1.07)	(27.11)	(-4.05)	(0.69)	(-0.47)	
18	0.08	1.00	-0.05	-0.18	0.82	0.13	0.99	-0.12	-0.16	0.09	0.83
	(0.51)	(22.17)	(-0.99)	(-2.71)		(0.83)	(24.26)	(-1.94)	(-2.66)	(2.40)	
19	0.13	1.01	-0.21	-0.10	0.79	0.09	1.02	-0.16	-0.12	-0.08	0.79
	(1.00)	(22.54)	(-3.47)	(-1.32)		(0.67)	(26.05)	(-1.81)	(-1.55)	(-1.12)	
20	0.06	1.02	0.03	0.01	0.79	0.02	1.03	0.09	-0.00	-0.08	0.79
	(0.57)	(25.20)	(0.57)	(0.12)		(0.16)	(25.39)	(1.17)	(-0.06)	(-1.88)	
21	0.26	1.05	0.08	-0.25	0.77	0.37	1.02	-0.06	-0.21	0.19	0.78
	(1.84)	(23.47)	(1.63)	(-2.66)		(2.26)	(26.71)	(-0.75)	(-2.74)	(2.03)	
22	0.07	1.17	0.04	-0.14	0.74	0.14	1.14	-0.06	-0.11	0.13	0.75
	(0.34)	(21.40)	(0.41)	(-1.23)		(0.64)	(23.86)	(-0.58)	(-1.02)	(1.99)	
23	0.21	1.23	0.24	0.06	0.76	0.30	1.20	0.13	0.09	0.16	0.77
	(1.40)	(18.11)	(1.74)	(0.49)		(1.95)	(20.21)	(0.90)	(0.70)	(3.02)	
24	-0.19	1.23	0.60	0.02	0.74	-0.08	1.19	0.44	0.07	0.21	0.75
	(-1.12)	(15.64)	(4.05)	(0.17)		(-0.44)	(17.61)	(2.89)	(0.53)	(2.70)	
25	-0.43	1.23	0.68	-0.24	0.68	0.05	1.08	0.03	-0.05	0.88	0.83
	(-1.88)	(11.74)	(3.75)	(-2.60)		(0.31)	(18.73)	(0.20)	(-0.61)	(8.27)	

Model 1: $(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \varepsilon_{it}$

Model 2: $(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}XMI_t + \varepsilon_{it}$

where R_{it} is the return on portfolio *i* in month *t*, R_{ft} is the risk-free rate, XMI_t is the exchange rate risk factor, R_{mt}, SMB_t, and HML_t are the returns on the market, the size, and the book-to-market factors..The numbers in parentheses are the Newey-West HAC t-ratios.

Table 8. Sensitivity portfolios based on LAD: 1975 to 2008

Portfolio	Model 1					Model 2					
	α	β_1	β_2	β_3	R^2	α	β_1	β_2	β_3	β_4	R^2
1	-0.37	1.25	0.91	-0.19	0.75	-0.05	1.04	0.24	0.07	0.94	0.88
	(-1.75)	(22.31)	(6.54)	(-1.30)		(-0.26)	(21.04)	(2.62)	(0.81)	(8.92)	
2	-0.21	1.15	0.52	-0.26	0.78	-0.14	1.11	0.37	-0.20	0.21	0.79
	(-1.15)	(19.03)	(6.52)	(-2.96)		(-0.78)	(19.65)	(4.83)	(-2.34)	(3.29)	
3	0.01	1.20	0.25	-0.19	0.74	0.11	1.14	0.05	-0.11	0.29	0.76
	(0.07)	(21.52)	(1.94)	(-1.19)		(0.67)	(23.67)	(0.31)	(-0.74)	(3.64)	
4	-0.07	1.14	0.07	-0.10	0.77	0.02	1.09	-0.11	-0.03	0.25	0.78
	(-0.40)	(26.01)	(0.80)	(-1.39)		(0.12)	(25.48)	(-1.30)	(-0.48)	(3.19)	
5	0.15	1.01	0.15	0.02	0.75	0.17	1.00	0.10	0.04	0.07	0.75
	(0.83)	(19.57)	(1.70)	(0.19)		(0.96)	(19.42)	(1.11)	(0.41)	(1.25)	
6	-0.20	1.05	-0.06	0.11	0.77	-0.17	1.03	-0.11	0.13	0.07	0.77
	(-1.29)	(35.87)	(-0.86)	(1.20)		(-1.11)	(33.81)	(-1.25)	(1.42)	(1.18)	
7	-0.11	0.97	-0.11	0.13	0.74	-0.10	0.97	-0.12	0.14	0.02	0.74
	(-0.87)	(27.82)	(-2.05)	(1.34)		(-0.81)	(30.32)	(-2.26)	(1.35)	(0.43)	
8	-0.16	0.99	-0.07	-0.01	0.80	-0.18	1.00	-0.03	-0.02	-0.06	0.80
	(-1.31)	(44.12)	(-1.18)	(-0.06)		(-1.49)	(39.67)	(-0.40)	(-0.27)	(-1.27)	
9	0.10	0.98	-0.10	0.15	0.81	0.11	0.97	-0.13	0.16	0.05	0.81
	(0.79)	(33.13)	(-1.83)	(2.61)		(0.97)	(35.70)	(-1.78)	(2.66)	(1.02)	
10	-0.05	0.91	-0.06	-0.09	0.81	-0.02	0.89	-0.11	-0.06	0.08	0.81
	(-0.54)	(19.51)	(-1.52)	(-1.75)		(-0.25)	(20.87)	(-1.89)	(-1.46)	(1.48)	
11	-0.11	0.97	-0.14	0.07	0.75	-0.12	0.98	-0.12	0.06	-0.03	0.75
	(-0.75)	(24.88)	(-2.99)	(0.95)		(-0.78)	(22.95)	(-2.29)	(0.91)	(-0.56)	
12	-0.09	0.96	-0.04	0.25	0.78	-0.08	0.95	-0.06	0.26	0.02	0.78
	(-1.03)	(36.57)	(-0.74)	(3.30)		(-0.99)	(37.15)	(-0.79)	(3.11)	(0.49)	
13	0.20	0.93	-0.10	-0.06	0.80	0.20	0.93	-0.09	-0.06	-0.01	0.80
	(2.35)	(32.81)	(-1.43)	(-1.06)		(2.22)	(32.28)	(-1.14)	(-1.00)	(-0.23)	
14	0.13	0.90	-0.13	0.08	0.79	0.13	0.91	-0.13	0.08	-0.01	0.79
	(1.25)	(32.64)	(-2.40)	(1.36)		(1.19)	(34.03)	(-2.04)	(1.23)	(-0.21)	
15	0.11	0.93	-0.12	-0.08	0.82	0.09	0.94	-0.09	-0.10	-0.05	0.82
	(1.12)	(31.68)	(-2.85)	(-1.19)		(0.91)	(30.49)	(-1.87)	(-1.29)	(-1.18)	
16	0.09	0.93	-0.13	-0.13	0.78	0.10	0.93	-0.15	-0.13	0.03	0.78
	(0.81)	(33.59)	(-2.24)	(-1.47)		(0.94)	(38.93)	(-1.77)	(-1.57)	(0.37)	
17	0.14	0.98	-0.08	-0.08	0.79	0.17	0.97	-0.12	-0.06	0.07	0.79
	(1.41)	(27.72)	(-1.10)	(-1.06)		(1.58)	(25.96)	(-1.33)	(-0.88)	(1.04)	
18	0.10	0.99	-0.10	-0.12	0.74	0.13	0.97	-0.15	-0.10	0.07	0.74
	(0.75)	(20.03)	(-1.16)	(-0.80)		(0.93)	(19.91)	(-1.32)	(-0.71)	(0.99)	
19	-0.01	0.96	-0.11	-0.08	0.78	0.05	0.93	-0.23	-0.03	0.17	0.79
	(-0.12)	(22.23)	(-1.44)	(-1.22)		(0.42)	(23.95)	(-2.40)	(-0.51)	(2.43)	
20	-0.11	1.12	0.06	0.13	0.77	-0.08	1.10	0.00	0.16	0.08	0.77
	(-0.85)	(24.97)	(0.57)	(1.30)		(-0.61)	(32.63)	(0.03)	(1.46)	(1.07)	
21	0.14	1.04	0.17	0.01	0.76	0.17	1.02	0.11	0.03	0.08	0.76
	(0.90)	(21.65)	(3.15)	(0.13)		(1.04)	(23.86)	(1.29)	(0.50)	(1.18)	
22	-0.15	1.21	0.12	0.14	0.81	-0.10	1.17	0.02	0.18	0.15	0.81
	(-1.07)	(19.72)	(1.36)	(1.59)		(-0.75)	(22.44)	(0.17)	(2.00)	(2.83)	
23	-0.21	1.22	0.18	-0.17	0.79	-0.09	1.14	-0.08	-0.07	0.37	0.82
	(-1.61)	(20.40)	(1.40)	(-1.48)		(-0.72)	(24.49)	(-0.60)	(-0.66)	(5.18)	
24	-0.16	1.17	0.42	-0.23	0.74	-0.03	1.08	0.15	-0.12	0.38	0.77
	(-0.80)	(17.62)	(2.41)	(-1.68)		(-0.16)	(16.64)	(0.76)	(-1.10)	(3.25)	
25	-0.36	1.25	0.57	-0.42	0.69	0.07	0.98	-0.33	-0.06	1.27	0.90
	(-1.26)	(10.60)	(2.82)	(-2.47)		(0.46)	(20.77)	(-3.06)	(-0.75)	(14.33)	

Model 1: $(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \varepsilon_{it}$

Model 2: $(R_{it} - R_{ft}) = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{i3}HML_t + \beta_{i4}XMI_t + \varepsilon_{it}$

where R_{it} is the return on portfolio *i* in month *t*, R_{ft} is the risk-free rate, XMI_t is the exchange rate risk factor, R_{mt}, SMB_t, and HML_t are the returns on the market, the size, and the book-to-market factors..The numbers in parentheses are the Newey-West HAC t-ratios.

3.3 Discussion

Why is KMS significant and warrants a re-examination?

The significance of KMS to the literature is that their methodology overcomes some major methodological weaknesses in previous studies, and therefore in principle should be more powerful. First, previous studies typically use raw exchange rate changes, which, as macroeconomic variables (not returns), contain information that is irrelevant to asset pricing (and may also have measurement errors). In contrast, KMS use a mimicking factor portfolio, which in principle captures only the information in contemporaneous exchange rate changes that is pertinent to stock returns, and therefore should reduce the noise in estimations. See Chan, Karceski and Lakonishok (1998 and 1999) for more discussion and applications of the mimicking portfolio approach. Second, previous studies usually do not allow for time variation in exchange rate exposure, which as Francis, Hasan, and Hunter (2008), among others, point out is a major methodological weakness. In contrast, KMS estimate firms' exchange rate sensitivities in a rolling regression fashion and construct the exchange rate risk factor based on such time-varying sensitivities. Their approach thus takes into account time variation in exposure in a non-structural framework. See Doidge, Griffin, and Williamson (2006) for more discussion.

Unlike most previous studies, KMS find that contemporaneous exchange rate changes are priced in the U.S. market by using this more powerful approach. Whether or not their findings are robust has critically important implications. As we have discussed in the introduction, exchange rate movements affect firms' cash flows both in theory and in practice. However, most empirical studies fail to show that exchange rate risk is priced. Therefore, if the KMS findings are robust, the status quo is changed and the anomaly is solved; on the other hand, if their findings are spurious, researchers may have to explore alternative perspectives because contemporaneous exchange rate changes are still not priced even if a more powerful approach is utilized. This observation motivates us to re-examine KMS.

How can this paper advance the field?

The evidence in Sections 3.1 and 3.2 shows that the KMS results are not robust if we use alternative testing assets, which suggests that researchers should explore alternative perspectives. Previous studies essentially test a joint hypothesis: exchange rate movements matter for stock returns and relevant movements are contemporaneous movements. Therefore, a rejection of this joint hypothesis does not necessarily mean that exchange rate movements are irrelevant for asset pricing. Rather, the rejection may be due to the possibility that relevant movements are not contemporaneous movements. In theory and in practice, exchange rate movements affect firms' cash flows (as we have emphasized in the introduction). However, intuitively, it is future not current cash flows that matter for stock returns. Therefore, an alternative perspective researchers could explore is to focus on future not contemporaneous exchange rate changes.

One major difficulty of this new perspective is to model news or changing expectations about future exchange rate changes. Given the voluminous literature suggesting that exchange rates follow random walks, time-series approaches may not be promising. We suggest researchers consider alternative approaches. One such approach is the tracking portfolio approach of Breeden, Gibbons, and Litzenberger (1989) and Lamont (2001). An excellent application of this approach is Vassalou (2003). Although GDP is known to follow a random walk (i.e. Murray and Nelson, 2002), Vassalou (2003) is able to use the tracking portfolio approach to construct a mimicking portfolio that tracks news about future GDP growth.

Our new perspective may also have important implications to practitioners. If stock returns reflect expectations about future exchange rate changes, practitioners may be able to use stock market information to forecast future exchange rate changes. One prominent example of using financial market information in forecasting is Roll (1984).

If it is future exchange rate changes that matter, contemporaneous exchange rate movements used in previous studies will be a poor proxy of exchange rate risk, because evidence (e.g. Meese and Rogoff, 1988) suggests that exchange rates follow random walks (implying contemporaneous changes in exchange rates have little correlation with future exchange rate movements). The exchange rate anomaly might be in part due to this poor proxy used in previous studies.

In brief, this paper makes an important contribution to the literature. We find that exchange rate risk based on contemporaneous exchange rate changes is still not priced even if we address the methodological weaknesses in previous studies. Our finding suggests that researchers take a new perspective on exchange rate risk, which may also benefit practitioners.

4. Conclusion

In a recent paper, KMS document evidence supporting the notion that exchange rate risk measured by contemporaneous exchange rate changes is priced in the U.S. stock market. However, by construction, the KMS exchange rate risk factor has a strong correlation with the size factor, and the KMS exchange rate sensitivity portfolios have a strong factor structure. To test whether the KMS results are spurious, we carry out two sets of tests. The first set is motivated by Lewellen, Nagel and Shanken (2010), while the second set is motivated by the voluminous literature which suggests that stock returns are heavy-tailed (e.g. Rachev and Mittnik, 2000). Unlike KMS, we find that exchange rate risk measured by contemporaneous exchange rate changes is still not priced if we use industry portfolios which do not have a strong factor structure as the testing assets or if we use more robust methods to estimate firm-specific exchange rate sensitivity. Bartram (2008) and Bartram, Brown, and Minton (2010) argue that firms use hedges to greatly reduce currency exposures. However, their arguments do not seem to be consistent with the firm-level evidence in Hung (1992), Francis, Hasan, and Hunter (2008) and Nucci and Pozzolo (2010). Therefore, we suggest that researchers take a new perspective on exchange rate risk by focusing on future exchange rate changes. This perspective may not only benefit academics but also practitioners.

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