Time-varying exchange rate exposure and exchange rate risk pricing in the Canadian Equity Market

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Time-Varying Exchange Rate Exposure and Exchange Rate Risk Pricing in the Canadian Equity Market

Mohammad Al-Shboul
Department of Accounting, Banking and Financial Sciences
College of Business Administration and Economics
Al-Hussein Bin Talal University, PO Box (20) Ma'an, Ma'an, Jordan, 71111
Tel: 962-3-217-9000 Ext 8343

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Sajid Anwar
School of Business, University of the Sunshine Coast
Maroochydore DC, QLD 4558
Australia
Email: SAnwar@usc.edu.au
Tel: 61-7-5430-1222

Abstract

This paper aims to extend the existing literature on foreign exchange rate risk pricing. Unlike the existing studies on Canada, we use six alternative bilateral and one multilateral exchange rate proxies. Furthermore, using both a two-factor and a three-factor capital asset pricing model (CAPM), we test for the presence of a long-run relationship among exchange rate risk pricing, herding behavior, term structure and the interest rate. The estimated results based on both the ordinary least squares (OLS) and generalized least squares (GLS) estimation techniques confirm that exchange rate risk in the Canadian equity market is priced and that the pricing of this risk is time-varying. This result holds for all seven exchange rate proxies. Our empirical analysis also suggests the presence of a long-run relationship among exchange rate risk pricing, herding behavior, term structure and the interest rate. This relationship is found to be insensitive to variations in the world market return.

Keywords: Foreign exchange risk; time-varying risk; exchange rate risk pricing; Canadian equity market; rolling window regression; asset pricing; herding behavior; cointegration

JEL classification: F31; G15; G10; C50; G12; G02; G01; E43
1. Introduction

Irrespective of whether or not a firm is involved in international business, foreign exchange rate fluctuations can affect its value. Investors who are not compensated for exchange rate risk expect a higher return and hedging becomes highly desirable. Since the work of Jorion (1991), a number of studies have attempted to test for the presence of exchange rate risk pricing in stock markets around the globe. However, the evidence provided by the exiting literature is mixed. This has led to substantial research in this area.

Using an international version of the Capital Asset Pricing Model (CAPM), Jorion (1991) found that there was a link between the value of the US dollar and stock returns but exchange rate risk was not priced in the US stock market. Using a two factor asset pricing model, Loudon (1993a) reached the same conclusion for Australia where equity market returns were sensitive to exchange rate movements but exchange rate risk was not priced. Doukas et al. (1999) considered the case of Japan and concluded that exchange rate risk was priced in the Japanese equity market. The distinguishing feature of this study is time varying nature of the exchange rate risk premium. Using a conditional version of International CAPM (ICAPM) involving time varying risk, De Santis and Gérard (1998) found that foreign exchange rate risk was not priced in the US equity market. Dumas and Solnik (1995) conducted a multi-country study where both the conditional and unconditional versions of asset pricing models were considered and risk premiums were allowed to fluctuate over time. They found some evidence in support of exchange rate risk pricing. Dumas and Solnik concluded that ICAPM out performs the national version. Recent studies such as Saleem and Vaihekoski (2008) consider the case of Russia whereas Kodongo and Ojah (2011) consider the case of some African countries.

The empirical studies in the area of exchange rate risk pricing can be divided into two groups. Group 1 includes studies that use unconditional multi-factor pricing models (e.g., Chen et al., 1986; Jorion, 1991; Loudon, 1993b; Choi et al., 1998; Di Iorio and Faff, 2002; Carrieri and Majerbi, 2006; and Apergis et al., 2011). These studies assume that exchange rate risk premium is constant over time. Even within this group, the empirical evidence is mixed. The second group includes studies that use conditional multi-factor asset pricing models. These studies assume that exchange rate risk premium varies over time. Generally speaking, studies in this group report evidence in favor of exchange rate risk pricing in some Asia-Pacific equity markets, such as Japan, Taiwan, and Australia (e.g., Chiang, 1991; Brown and Otsuki, 1993; Dumas and Solnik, 1995; Tai, 2003). In addition, empirical studies that consider the European equity markets found that exchange rate risk was priced in Finland, France, Eurozone and in Russia (e.g., Korajczyk and Viallet, 1992; Antell and Vaihekoski, 2007, 2012; Saleem and Vaihekoski, 2008; Apergis et al., 2011). Some multi-country studies (such as Groen and Balakrishnan, 2006; Guo et al., 2008; Bae et al., 2008) found evidence in favour of exchange rate risk pricing. However, generally speaking, the evidence provided by the existing studies is mixed and hence the literature in this area is continuously growing.

While the issue of exchange rate risk pricing has been examined in the context of a number of countries, few studies have considered the case of the Canadian equity market. Recent studies on Canada include the work of Samson (2013) and Al-Shboul and Anwar (2014). This paper aims to extend the existing literature in a number of ways. First, we utilize both multilateral and bilateral exchange rate factors. Specifically we use the Canadian exchange rate
trade-weighted index (TWI) and the value of Canadian dollar against several foreign currencies – the US dollar (USD), Euro (EUR), Japanese Yen (JPY), British Pound (GBP), Chinese Yuan (CNY) and Mexican Peso (MXN) are used as proxies for exchange rates. Second, we examine the pricing of exchange rate risk phenomenon by means of a two-factor as well as a three-factor capital asset pricing model, which is an improvement over the existing Canadian studies. Third, we explore the issue of exchange rate risk pricing and the possibility of time-varying risk pricing by means of the Generalized Least Squares (GLS). Fourth, we conduct a full sample cointegration analysis to test for the presence of a stochastic trend among exchange rate risk pricing, herding behavior, term structure and the interest rate.

The need for testing for the presence of a long-run relationship also arises from the fact that recent studies, such as Pastor and Stambaugh (2012), argue that stock investors may encounter more volatile stock prices over long horizons compared to short horizons. This follows from the fact that, in real life, values of population parameters are unknown and the estimated parameters can lead to imperfectly predictions of the conditional expected returns. This imperfect prediction of expected returns may be attributed to the fact that stock returns generally tend to exhibit mean reverting behavior in the long-run. In addition, as a result of the persistence in the expected returns, the variances of stock returns in long-run may surpass short-horizon variances (Berentsen et al., 2009). Finally, uncertainty in current returns resulting from the use of predicted parameters can contribute to an increase in variances over longer horizons.

The choice of herding behavior, terms structure and the interest rate allows a wider analysis of the effects of both equity market (herding) and debt market instruments (interest rate and terms structure) on exchange rate risk pricing. While these three variables may be viewed as important determinants of the exchange rate risk pricing, focusing only on these variables is a limitation of our work. In real life a number of fundamental factors also affect the price of exchange rate risk. Bailliu and King (2005, P. 8) suggest that macroeconomics factors can be unsuccessful in explaining the exchange rate risk exposure. The paucity of studies investigating the relationship between herd behavior of stock investors and exchange rate risk is one of the main motivations for our investigation of this issue. Recent studies, such as Russell (2012), suggest that the relationship between herding and exchange rate risk pricing has not been extensively examined in the existing literature. Kurz and Motoleso (2001) argue that equity investors believe that the herd behavior would influence the price of currency risk. They further argue that as investors are different in their levels of herding, they may also price exchange rate risk differently (Kurz and Motoleso, 2001). Changes in interest rates and their term structure not only affect investor behavior but also the Canadian economy and hence it is useful to focus on the impact of these variables on exchange rate risk pricing. Changes in the dollar values are often driven by non-fundamental or speculative factors. Monetary policy, by neutralizing the impact of these factors, can be used to stabilize the economy. Finally, because of the unavailability of data and to limit the length of our study, we focus on only three variables.

Based on weekly data on the largest 58 Canadian listed firms over the period 2003-2010, our empirical analysis indicates the presence of a time varying exchange rate risk exposure. In addition, we find evidence of exchange rate risk pricing in the Canadian equity market in terms

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1 The US, the UK, Euro zone, Mexico, China, and Japan are Canada’s major trading partners.
of all foreign exchange rate proxies. This suggests that equity returns in Canada include a premium for fluctuations in exchange rates. Using all exchange rate proxies, we found exchange rate risk pricing in the Canadian equity market to be time-varying. Furthermore, using Johansen’s approach to cointegration, we found that a long-run relationship exists among exchange rate risk pricing, herding behavior, term structure and the interest rate. This result holds when the exchange rate risk pricing is measured using both a two-factor and a three-factor capital asset pricing model. It can therefore be argued that the long-run relationship among exchange rate risk pricing, herding behavior, term structure and the interest rate in Canada is insensitive to the inclusion of a proxy for the world market return in the model.

The rest of this paper is structured as follows. Section 2 contains a brief review of the related literature. Methodology is presented in section 3. The empirical results are presented and discussed in Section 4. Section 5 concludes the paper.

2. Review of the Related Literature

The issue of exchange rate risk pricing arises from the fact that the assumption of purchasing power parity (PPP) does not always hold in real life and hence equity investors from different countries are exposed to greater uncertainty. This situation arises due to the uncertainty associated with future exchange rate changes that can affect the expected returns on stocks. Exchange rate changes are yet another source of systematic risk that cannot be diversified away (see Nance et al., 1993; Bodnar et al., 1995 & 1996). As a result, capital market investors require additional return in the form of a risk premium. An exchange rate risk premium term is included in empirical models containing the return on an asset with an exchange rate risk factor. The inclusion of an exchange rate risk factor to the classical CAPM model allows one to investigate the issue of exchange rate risk pricing.2

The general issue of exchange rate risk pricing has been the subject of a large number of empirical studies. Most of these studies examine the issue of exchange rate risk pricing in developed countries. Early studies used the unconditional asset pricing model and the issue of time varying risk pricing was not investigated. For instance, using a multi-factor model, Chen et al. (1986) found that exchange rate risk was not priced in the U.S. stock market. Using both a two-factor and a multi-factor model, Jorion (1991) failed to find evidence of statistically significant exchange risk pricing in the U.S. stock market. Using data over the period of January 1975 to December 1984, Hamao (1988) found no evidence of exchange rate risk pricing in the Japanese equity market. In addition, after taking into account several Japanese macroeconomic factors, Hamao found that there was no difference in the overall performance of CAPM and Arbitrage Pricing Theory (APT) based empirical models of exchange rate exposure. Using an unconditional APT based empirical model, Brown and Otsuki (1993) found that exchange rate risk was not priced in the Japanese equity market.

Loudon (1993b) found that exchange rate risk was not priced in the Australian equity market. This study is based on data from 1980 to 1991. Di Iorio and Faff (2002), using three

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2 While this paper focuses on the issue of exchange rate risk pricing, a good analysis of pricing in other contexts can be found in Jindra and Walkling (2004), Eberhart (2005), Bartram (2007), Heng and Chan (2008), Daniels, Ejara, and Vijayakumar (2009), Colla, Ippolito, and Wagner (2012), Lel (2012), and Zhang (2012).
versions of CAPM (a two-factor version, a zero-beta version and an orthogonalized version), reported that exchange rate risk was not priced in the Australian equity market during the full sample period of 1988-1998. However, some evidence of exchange rate risk pricing was found in periods of economic declines and during a secularly weak Australian dollar regime (i.e., during the sub-periods of 1990-1993 and 1997-1998).

However, more recent studies are based on conditional asset pricing models where the exchange rate risk premium is allowed to vary over time. These studies have shown that exchange rate risk is priced at the aggregate stock market level in most developed countries. The seminal work of Dumas and Solnik (1995) is based on a conditional model involving covariance of assets with exchange rates as well as the traditional premium based on the covariance of the market portfolio. Such an approach allows for time-variation in risk premium associated with the exchange rate exposure. Based on the framework of Dumas and Solnik (1995), De Santis and Gérard (1998) developed a conditional model that can be used to examine the issue of exchange rate risk pricing. Their model is based on a modified version of the multivariate GARCH-in-Mean specification. De Santis and Gérard found that (i) exchange rate risk was priced in the equity markets of Germany, Japan, the U.K., and the U.S. and (ii) the risk premium was time-varying. They argued that unconditional models were unable to detect highly time-varying exchange rate risk.

A large number of empirical studies have utilized De Santis and Gérard’s framework. For example, in the case of Japan, Choi et al. (1998) found that exchange rate risk was priced in the Japanese stock market. In fact, Choi et al. reached the same conclusion using both a conditional and an unconditional model involving (i) the Yen/US dollar exchange rate and (ii) a trade-weighted exchange rate. In addition, they argued that the price of exchange rate risk is time-varying. Using data over the period of 1975-1995 and by making use of both unconditional and conditional multifactor asset pricing testing procedures, Doukas et al. (1999) found that exchange rate risk was priced in the case of multinationals and high-export Japanese firms and the price of exchange rate risk was time-varying.

Using data from the European markets over the period of 1970 to 2004, Antell and Vaihekoski (2007) examined whether exchange rate risk is priced in the Finnish stock market. This study is based on an international conditional CAPM. They found that exchange rate risk was priced in the Finnish market but it was not time-varying. Antell and Vaihekoski (2012) used the same conditional ICAPM that was used in their 2007 study to investigate whether exchange rate risk is priced in the Finnish and Swedish stock markets. They concluded that exchange rate risk was not only priced in both stock markets but it was also time-varying. This study is based on data collected from 1970 to 2009.

Saleem and Vaihekoski (2010) considered the pricing of exchange rate risk in the Russian stock market over the period from 1999 to 2009. They found that exchange rate risk was priced in the Russian stock market. The price of exchange rate risk was also found to be time-varying. Apergis et al. (2011) found that foreign exchange risk was priced in a cross section of the German stock returns over the period from 2000 to 2008. Furthermore, the exchange rate risk pricing was time-varying.
The issue of exchange rate risk pricing has also been recently examined within the context of a number of multi-country studies. However, these studies are based on unconditional models where risk pricing is assumed to be constant over time. As far the studies on developed countries are concerned, using data over the period of 1999 to 2001, Bae et al. (2008) examined how economic and translation exposure components of the exchange rate risk are priced across four European and Asian economies (i.e., Australia, France, Japan, and the U.K). They found the exchange rate risk to be not only priced but also time-varying. While extending the work of Vassalou (2000), Kolari, Moorman, and Sorescu (2008) found that exchange rate risk was priced and time-variant in the US equity markets.

Within the context of emerging and developing economies, Carrieri and Majerbi (2006) used different specifications of unconditional model and assumed that exchange rate risk premium was constant over time for Argentina Brazil, Chile, Mexico, Greece, India, Korea, Thailand, and Zimbabwe. They found some evidence in favour of exchange rate risk pricing. This evidence contradicts the findings of early studies that used the same methodology and data from developed countries. Kodongo and Ojah (2011), using a multifactor unconditional asset pricing model, reported that foreign exchange risk was not priced in Africa’s stock markets (Botswana, Egypt, Ghana, Kenya, Morocco, Nigeria and South Africa). Kodongo and Ojah assumed that exchange rate risk premium was constant over time.

Within the context of Pacific-Basin stock markets, a number of studies allowed the exchange rate risk premium to be time-varying. For example, Tai (2003) examined time-varying exchange rate risk pricing in Asia-Pacific forward exchange markets (i.e., Japan, Hong Kong, Singapore and Malaysia). Using monthly data from January 1986 to July 1998, Tai found the exchange rate risk pricing to be time-varying.3

While the existing literature has considered the issue of exchange rate risk pricing in a number of developed and developing countries, only a few studies have considered the case of Canada. Recent studies that have focused on Canada include Al-Shboul and Anwar (2014a & 2014b) and Samson (2013). Using industry level data, Al-Shboul and Anwar (2014a) examined the issue of linear and non-linear exchange rate risk exposure in Canada. Using the Generalized Method of Moments (GMM) and GARCH-in-mean estimation techniques, Al-Shboul and Anwar (2014b) examined the possibility of time-varying exchange rate risk pricing and market segmentation in Canada’s equity market. However, our earlier work is based on a three-factor conditional CAPM, where only two foreign exchange rate proxies are used. On the other hand, the present study makes use of GLS to estimate a two-factor as well as three-factor unconditional CAPM, where seven exchange rate proxies are used. In addition, using Johansen’s cointegration methodology, this paper also investigates the presence of a long-run relationship among exchange rate risk pricing, herding behavior, term structure and the interest rate. Using monthly data over the period of January 1970 to December 2004, Samson (2013) investigated the impact of exchange rate and inflation risk on the value of Canadian firms. Samson concluded that exchange rate risk is consistently priced in the Canadian market since Canada adapted the flexible exchange rate system. Samson found the price of exchange rate risk in Canada to be stable.

The issue of exchange rate risk in Canada has also been investigated by a few multi-countries studies. For example, Vassalou (2000) found that exchange risk and foreign inflation risk are priced in the 10 developed countries (Australia, Canada, France, Italy, Switzerland, the Netherlands, Japan, Germany, the UK, and the US). However, Vassalou did not focus on the time-varying nature of exchange rate risk pricing. Using data from January 1973 to December 2006, Moore and Wang (2013) found evidence of exchange rate risk pricing in some developed (the US, Australia, Canada, Japan and the UK) and emerging Asian markets (Indonesia, Malaysia, South Korea, the Philippines, Singapore, and Thailand). By making use of 33 industry portfolios from each of the G-7 stock markets, Roache and Merritt (2006) found evidence of exchange rate risk pricing in all countries. These multi-countries studies have not investigated the issue of time-varying exchange rate risk pricing. In this paper, using the unconditional model we investigate the possibility of time-varying exchange rate risk pricing in the Canadian equity market.

3. Methodology and Data

In stage 1, we use a two-factor asset pricing model to examine whether the exchange rate risk is priced in the Canadian equity market. Specifically, the sensitivity of the firm rate of return to changes in an exchange rate factor is examined. As a starting point, we follow the traditional approach (see Jorion, 1991) as follows:

\[ R_{it} = \alpha_0 + \alpha_1 R_{Lm} + \alpha_3 R_{FX} + \xi_{it} \]  

(1)

where \( R_{it} \) is the stock return of firm \( i \); \( R_{Lm} \) is the return on the local market portfolio; \( R_{FX} \) is the return on an exchange rate (i.e., the traded weighted index or one of the six individual hard currencies); and \( \xi_{it} \) is the error term.

The estimated value of the coefficient \( \alpha_{Lm} \) measures the exposure of firm \( i \) to changes in the value of the Canadian dollar. If the exchange rate is measured in the units of the Canadian currency per unit of a foreign currency or an index of foreign currencies, a positive value of the estimated \( \alpha_{Lm} \) suggests that depreciation of Canadian dollar increases the value of the firm. However, if the estimated coefficient is negative then appreciation of Canadian dollar increases the value of the firm.

In stage 2, a three-factor asset pricing model is used to examine whether exchange rate risk is priced in the Canadian equity market. This model is an extension of equation (1), where the world stock market return has been taken into account.

\[ R_{it} = \alpha_0 + \alpha_1 R_{Lm} + \alpha_2 R_{WM} + \alpha_3 R_{FX} + \epsilon_{it} \]  

(2)

where \( R_{WM} \) is the return on the world market portfolio and \( \epsilon_{it} \) is the error term.

Following Rosenberg (1973) and Cooley and Prescott (1976), we apply a time-varying test of exchange rate risk exposure. This involves estimation of equations (1) and (2) for each firm using a 50 rolling window regression, which allows us to obtain the best estimates of the
As the cross-sectional exposure parameter $\alpha_{3i}$ in both equations (1) and (2) has a time index, the cross-sectional average of the exposure coefficients for each exchange rate risk proxy is plotted against time to show the time-varying results. The time-varying parameters follow a random walk without drift (Pierdzioch and Kizys, 2011). The random walk provides a simple empirical model of the dynamic behavior of the regression coefficients and contains constant coefficients as a special case (Garbade, 1977; Engle and Watson, 1987). Recent studies such as (Kim et al., 2001; Kizys and Pierdzioch, 2007 and Pierdzioch and Kizys, 2011) have used the random walk model to analyze the implications of time-varying parameters. The estimated standard errors are corrected for autocorrelation and heteroskedasticity using Newey-West procedure.

Based on equations (1) and (2), we also tested the hypothesis that exchange rate risk is priced in the Canadian equity market. In the case of a two factor model, the pricing of exchange rate risk is examined by estimating equation (3) as follows:

$$\alpha_{0i} = \delta_0 + \delta_1 \alpha_{ui} + \delta_2 \alpha_{3i} + \eta_i$$

where $\alpha_{3i}$ is the cross-sectional average of the exposure coefficients of a specific exchange rate; $\alpha_{ui}$ is the cross-sectional average of the local market risk exposure coefficients and $\eta_i$ is the usual error term. These cross-sectional averages in equation (3) are based on the results of rolling window estimates obtained from equation (1). Equation (3) is estimated using both OLS and GLS.

Using the estimated parameters of the three-factor model, i.e., equation (2), the issue of exchange rate risk pricing can be examined by means of equation (4) as follows:

$$\alpha_{0i} = \delta_0 + \delta_1 \alpha_{ui} + \delta_2 \alpha_{2i} + \delta_3 \alpha_{3i} + \zeta_i$$

where $\alpha_{3i}$ is the cross-sectional average of the world market risk exposure coefficients and $\zeta_i$, is the error term. All variables in equation (4) are the cross-sectional averages of the parameters obtained from rolling window estimation of equation (2). Equation (4) is estimated using both OLS and GLS.

### 3.1 Data

The data was sourced from the Canadian stock exchange database, which includes the largest 58 listed firms. Weekly data starting from the beginning of 2003 to the end of December 2010 is used in this study. The results of the Augmented Dickey–Fuller (ADF) test are shown in

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4 Other studies that have used rolling regression to estimate the change in Okun’s coefficient over time include Moosa (1997), Perman and Tavera (2005), Knotek (2007) and Pierdzioch and Kizys (2011).
Table 1. The results of unit root testing suggest that the data series are stationary. In addition, the data series are also tested for autocorrelation. The hypothesis that no serial correlation exists cannot be rejected at lags 1, 5, 10 and 20. The estimated coefficients of the autoregressive lags continue to decline as the number of lags increases.

The return on share prices of the firms included in our sample, the return on the Toronto stock market index (S&P/TSX-Composite index) and the return on the world stock market index (S&P 500) were obtained from the Datastream International. Other relevant data such as the returns on trade-weighted exchange-rate index (TWI) (the Canadian-dollar effective Return Index - CERI), the bilateral foreign exchange rate of the Canadian dollar with respect to six individual hard currencies (USD, AUD, JPY, EUR, CNY, MXN), and risk free rate of interest (13-week Treasury Notes) were obtained from the Bank of Canada database.

4. Empirical Results

A summary of the descriptive statistics of the variables used (the average of stock returns of all firms, stock market index return and the return on the foreign exchange rate proxies) in this paper is reported in Table 1.

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<th>Table 1 : Descriptive Statistics</th>
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This Table shows the summary of the descriptive statistics, the estimated autocorrelation coefficients and the results of stationarity testing for all variables using ADF and KPSS tests. The maximum lag length of 17 for KPSS test was chosen based on the Schwert criterion. The critical values of KPSS test are as follows: 10%: 0.119; 5%: 0.146; 2.5%: 0.176; 1%: 0.216. The null hypothesis (i.e., $H_0$) is that the variable is trend stationary. Ave is the average return on stocks; $R_{LMt}$ and $R_{WMt}$, respectively, are local and world stock market returns; $R_{CNYt}$, $R_{EURt}$, $R_{GBPt}$, $R_{JPYt}$, $R_{USDt}$, $R_{MXNt}$ and $R_{TWIt}$ and the bilateral and trade weighted foreign exchange rate proxies; ***, **, and * respectively refer to significance at the 1%, 5% and 10% level.

4.1 Exchange rate risk exposure

The exchange rate risk exposure using the two-factor and the three-factor models is estimated using OLS rolling window regression technique. The rolling window regression technique involving 50 observations (step size = 1) is used. Once the exposure coefficients are estimated, the cross-sectional exposure coefficients are calculated by taking the cross-sectional average of the coefficients of each firm for each foreign exchange rate proxy. The cross-sectional average of the exposure, for each foreign exchange rate, is plotted against time to see if these coefficients vary over time. Figure (1) suggests that the cross-sectional exposure coefficients vary across time. This implies that variations in exchange rates affect the firm values and these effects vary across time.
The results of the cross-sectional average of the rolling window exposures of the three-factor model are shown in Figure 2. The estimated coefficients, plotted against time, exhibit variation over time, which suggests the presence of a time-varying exposure with respect to each
foreign exchange rate. Generally speaking, the inclusion of the world market index in the original two-factor model has not affected the results of the time-varying test and the presence of exchange rate exposure. This suggests that Canadian firms are affected by changes in exchange rates differently over time.

Figure 2: Time-varying cross-sectional average of exchange rate exposures - the three-factor model

| Cross-sectional average of exchange rate exposure using TWI |
| Cross-sectional average of exchange rate exposure using USD |
| Cross-sectional average of exchange rate exposure using EUR |
| Cross-sectional average of exchange rate exposure using JPY |
| Cross-sectional average of exchange rate exposure using GBP |
| Cross-sectional average of exchange rate exposure using CNY |
| Cross-sectional average of exchange rate exposure using MXN |
4.2 Pricing of the exchange rate risk

Using OLS, both the two and three-factor exchange rate risk pricing models (i.e., equations (3) and (4)) are estimated. The rolling window regression technique of 50 observations (step size = 1) is implemented, where the number of rolling windows for the full sample period is 321. The estimated pricing coefficients (i.e., $\delta_3$), in equation (3), for each individual exchange rate proxy are plotted against time in Figure 3. A visual examination of the estimated coefficients of exchange rate risk pricing suggests time-varying risk pricing in Figure 3.

\[
R_{it} = \alpha_0 + \alpha_1 R_{LWt} + \alpha_3 R_{FXt} + \varepsilon_{it} \\
\alpha_0 = \delta_0 + \delta_1 \alpha_1 + \delta_3 \alpha_3 + \eta_i
\]

$\delta_0$ is the cross-sectional average of the rolling window regression of intercept coefficients estimated using Eq. (3). $\delta_1$ is the cross-sectional average of the rolling window regression of the local market risk pricing coefficients estimated using Eq. (3). $\delta_3$ is the cross-sectional average of the rolling regression exchange rate risk pricing coefficients estimated using Eq. (3).

Figure 3: Time-varying foreign exchange rate pricing - the two-factor model

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<tr>
<th>Currency risk pricing using TWI</th>
<th>Currency risk pricing using USD</th>
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The results using a three-factor model are shown in Figure 4. Just like Figure 3, we report time-varying evidence of the pricing of exchange rate risk using all foreign exchange rate proxies. The rolling window regression technique was used to estimate the pricing coefficients $\delta_3$ for each individual exchange rate proxy. Figure 4 suggests that the coefficients of exchange rate risk pricing vary over time. In other words, there is clear evidence of time-varying risk pricing.
In this section, we report the results of GLS estimation. The GLS technique has higher power as compared to the traditional OLS approach. In addition, GLS allows one to test the cross-sectional restrictions imposed by the model through a likelihood ratio test. This latter test can be used to find out whether the multi-factor model provides a reasonable fit for the data. The estimated results are shown in Table 2. The estimated coefficient of $\delta_3$ is statistically significant in the case of all exchange rate proxies. Table 2 shows that exchange rate risk is priced in the Canadian equity market and it is negative. All estimated values of the Chi-square test statistic reported in Table 2 are highly significant suggesting that the model is adequately specified and fits the data well.

Table 2: GLS estimation of the two-factor model

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<th></th>
<th>$\delta_0$</th>
<th>$\delta_1$</th>
<th>$\delta_3$</th>
<th>$\chi^2(2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWI</td>
<td>0.004***</td>
<td>-0.001***</td>
<td>-0.005***</td>
<td>383.286***</td>
</tr>
<tr>
<td></td>
<td>(12.765)</td>
<td>(-2.800)</td>
<td>(-15.648)</td>
<td></td>
</tr>
</tbody>
</table>
Table 3 contains the results of the exchange rate pricing tests for the three-factor model. The estimated asymptotic $t$-values are reported underneath the corresponding estimated parameter values. These results indicate that, in terms of all currencies, foreign exchange rate risk is priced in the Canadian equity market. These results are similar to those presented in Table 2. Generally speaking, these results are consistent with Carriero and Majerbi (2006) who reported evidence of significant exchange rate risk pricing. However, our results contradict the findings of Chen et al. (1986), Jorion (1991) and Kodongo and Ojah (2011).

We also tested the hypothesis that all pricing coefficients are jointly equal to zero but this hypothesis was strongly rejected. This suggests that adding a proxy for the world market risk does not affect our original results reported in Table 2. However, the estimated values of the Chi-square test statistic reported in Table 3 are highly significant, which suggests that the three-factor model is a useful tool for the analysis of the exchange rate risk pricing phenomenon.
estimated parameters of the three-factor model of Eq. (2). ***, **, and * respectively represent significance at the 1%, 5%, and 10% level.

The results presented in Table 3 are not very different from those presented in Table 2. Most estimated exchange rate risk pricing coefficients are significant and negative in the case of all exchange rate proxies. The negative sign suggests that Canadian firms earn higher return as they are exposed to negative exchange rate risk. In summary, the results presented in this section suggest that Canadian investors do price the foreign exchange rate risk.

4.3 Cointegration test

In this section we first show the relationship between the exchange rate risk pricing and each of the three variables of interest (i.e., herding behavior, term structure and the interest rate) by graphical means. This is followed by testing for cointegration among all four variables using Johansen’s methodology. However, before reporting our empirical results, we first report diagnostic testing results in Table 4. All variables appear to exhibit high variability, which reflects time-varying nature of the exchange rate risk pricing in terms of all exchange rate proxies. The results of J-B (Jarque-Bera) test suggest that the distribution of all variables is non-normal. We also tested for stationarity by using the augmented Dickey-Fuller (ADF) unit root test (Dickey and Fuller, 1981) and the KPSS unit root test (Kwiatkowski et al., 1992). In the case of the ADF unit root test, based on Akaike information criterion (AIC), the optimal lag length of \( p = 2 \) was selected. The results of ADF presented in Table 4 suggest the presence of non-stationarity. However, the first differences were found to be stationary.

The relationship between the estimated exchange rate risk pricing coefficients and each of the three variables (i.e., herding behavior, term structure and interest rate) is shown in different panels of Figures 5 and 6. Herding behavior of stock investors is considered one of the variables affecting exchange rate risk pricing. Herding means that investors blindly follow the actions of each other in buying and selling stocks. The reasons for herding include the fact that investors tend to protect their portfolios from changes in stock prices, downside risk and exchange rate risk in particular (Russell, 2012). Based on Chang et al. (2000), we measure herding by the absolute deviation of stock return from the stock market return. Herding is detected when the absolute deviation increases at a decreasing rate. The reason for using this variable is the existence of heterogeneity of beliefs in financial markets. The existing literature in this area suggests that dispersion of such beliefs arises due to information asymmetry (Frankel and Rose, 1995; Jongen et al., 2008). All market participants do not hold identical information. Generally speaking, different market participants hold different information but part of the information is common among all market participants. In other words, part of the information held is public, whereas the rest is private. Kurz and Motolesce (2001) argue that structure of market expectations can give rise to differences in information and its interpretation. Because stock market investors are different in their levels of herding, they may price exchange rate risk differently.

In Figure 5, we report a scatter plot of the GLS estimation based exchange rate risk pricing coefficients (for each of the seven exchange rate proxies) based on a two-factor model. The regression line shown in the scatter plot captures the correlation between exchange rate risk pricing and herding for all exchange rate proxies (see panel (a) of Figure 5). This correlation presents a stochastic trend. A similar stochastic trend is observed in the case of the three-factor model as shown in panel (a) of Figure 6. Because the exchange rate risk exposure follows a
random walk, it is possible for the results of the unit root tests to show a stochastic trend. As the exposure might have a stochastic trend, the pricing of the exchange rate risk may also have a similar trend. In addition, if there is a substantial increase in international trade, the results of the unit root test would also exhibit a stochastic trend. Stock investors herd for protection from changes in stock prices. Due to the presence of the exchange rate risk, investors require additional return, which increases stock trading and the end result is a stochastic trend.

We also plot the relationship between the exchange rate risk pricing coefficients for all currencies and the term structure of interest rate. It is well-known that an increase in interest rate differential leads to appreciation of the domestic currency, which results in an increase in the cost of borrowing which promotes economic growth. Increase in the rate of economic growth contributes to increase in international trade and therefore an increase in exposure to exchange rate risk. The increase in exchange rate risk encourages stock investors to price this risk. Schmukler and Serven (2002) have shown that interest rate differentials vary substantially over time. Since changes in the interest rate differentials may cause changes in exchange rate risk exposure, one can also expect changes in the pricing of exchange rate risk. In panel (b) of Figures 5 and 6, the relationship between the term structure and pricing shows a stochastic trend and exchange rate risk pricing is negatively associated with the term structure. The relationship between exchange rate risk pricing and the interest rate is also plotted in panel (c) of Figures 5 and 6. In general, interest rate and pricing coefficients are negatively related and their relationship exhibits a stochastic trend.
Figure 5: The relationship between exchange rate risk pricing and herding, term structure and interest rate using the two-factor model.

Panel a: Exchange rate risk pricing coefficients (vertical axis) and herding (horizontal axis)

Panel b: Exchange rate risk pricing coefficients and term structure.
Panel c: Exchange rate risk pricing coefficients and interest rate

Pricing coefficients of GBP and term structure

Pricing coefficients of JPY and term structure

Pricing coefficients of TWI and term structure

Pricing coefficients of CNY and Interest rate

Pricing coefficients of USD and Interest rate

Pricing coefficients of MXN and Interest rate

Pricing coefficients of EUR and Interest rate

Pricing coefficients of GBP and Interest rate

Pricing coefficients of JPY and Interest rate

Pricing coefficients of TWI and Interest rate
Figure (6): The relationship between exchange rate pricing and herding, term structure and interest rate using the three-factor model.

Panel a: Exchange rate risk pricing coefficients (vertical axis) and herding (horizontal axis)

Panel b: Exchange rate risk pricing coefficients and term structure
Panel c: Exchange rate risk pricing coefficients and Interest rate
In order to check for robustness of the observed stochastic trend, we tested for the presence of a long run relationship among all four variables (i.e., the rolling window estimates of the exchange rate risk pricing coefficients, herding behavior, terms structure and the interest rate). The results of the ADF test reported in Table 4 suggest that almost all variables are non-stationary in levels and therefore it makes sense to test for the presence of a cointegrating relationship. The test statistic used is the Johansen’s (1988) trace test of cointegration for the joint null hypothesis that there is no long-run relationship (non-cointegration) among all the four variables.
Table 4: Diagnostic testing of the pricing coefficients, herding, term structure and interest rate

<table>
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<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std.</th>
<th>Min</th>
<th>Max</th>
<th>J-B $\chi^2$(2)</th>
<th>AR(1)</th>
<th>AR(5)</th>
<th>AR(20)</th>
<th>AR(40)</th>
<th>ADF</th>
<th>ADF 1st diff</th>
<th>ADF 2nd diff</th>
<th>KPSS 1st diff</th>
<th>KPSS 2nd diff</th>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>0.004</td>
<td>-0.016</td>
<td>0.008</td>
<td>35.75***</td>
<td>0.983***</td>
<td>0.841***</td>
<td>0.094***</td>
<td>-0.482***</td>
<td>-1.535</td>
<td>-12.54***</td>
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<td>0.005</td>
<td>-0.017</td>
<td>0.009</td>
<td>9.964***</td>
<td>0.988***</td>
<td>0.847***</td>
<td>-0.018***</td>
<td>-0.321***</td>
<td>-0.920</td>
<td>-7.92***</td>
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<tr>
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<td>319</td>
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<td>0.007</td>
<td>-0.024</td>
<td>0.023</td>
<td>41.67***</td>
<td>0.961***</td>
<td>0.755***</td>
<td>0.208***</td>
<td>-0.106***</td>
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<td>0.041</td>
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<td></td>
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<tr>
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<td>0.005</td>
<td>-0.011</td>
<td>0.011</td>
<td>13.48***</td>
<td>0.978***</td>
<td>0.769***</td>
<td>0.074***</td>
<td>0.125***</td>
<td>-1.617</td>
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<td>0.005</td>
<td>-0.015</td>
<td>0.010</td>
<td>16.97***</td>
<td>0.974***</td>
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<td>0.212***</td>
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<td>0.021</td>
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<td>0.991***</td>
<td>0.894***</td>
<td>0.465***</td>
<td>0.169***</td>
<td>-1.387</td>
<td>-8.55***</td>
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<tr>
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<td>319</td>
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<td>0.004</td>
<td>-0.017</td>
<td>0.007</td>
<td>21.13***</td>
<td>0.983***</td>
<td>0.828***</td>
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<td>-0.547***</td>
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<td>-11.39***</td>
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<td>Panel (b): Exchange rate risk pricing coefficient series from the three-factor model</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>TWI</td>
<td>319</td>
<td>-0.005</td>
<td>0.004</td>
<td>-0.018</td>
<td>0.006</td>
<td>74.01***</td>
<td>0.976***</td>
<td>0.779***</td>
<td>0.071***</td>
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<td>-1.958</td>
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<tr>
<td>USD</td>
<td>319</td>
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<td>0.004</td>
<td>-0.018</td>
<td>0.010</td>
<td>12.16***</td>
<td>0.982***</td>
<td>0.807***</td>
<td>-0.056***</td>
<td>-0.251***</td>
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<td>0.030</td>
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<tr>
<td>JPY</td>
<td>319</td>
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<td>0.007</td>
<td>-0.024</td>
<td>0.018</td>
<td>57.39***</td>
<td>0.967***</td>
<td>0.793***</td>
<td>0.229***</td>
<td>-0.215***</td>
<td>-2.339</td>
<td>-14.85***</td>
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<td>319</td>
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<td>-0.011</td>
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<td>12.46***</td>
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<td>0.736***</td>
<td>0.087***</td>
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<td>GBP</td>
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<td>0.004</td>
<td>-0.016</td>
<td>0.007</td>
<td>10.64***</td>
<td>0.959***</td>
<td>0.749***</td>
<td>0.403***</td>
<td>0.118***</td>
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<td>-13.93***</td>
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<td>MXN</td>
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<td>0.002</td>
<td>0.007</td>
<td>-0.007</td>
<td>0.022</td>
<td>56.24***</td>
<td>0.991***</td>
<td>0.909***</td>
<td>0.487***</td>
<td>0.115***</td>
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<td>-12.14***</td>
<td>0.053</td>
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<tr>
<td>CNY</td>
<td>319</td>
<td>-0.005</td>
<td>0.004</td>
<td>-0.019</td>
<td>0.007</td>
<td>56.40***</td>
<td>0.979***</td>
<td>0.796***</td>
<td>0.055***</td>
<td>-0.475***</td>
<td>-1.713</td>
<td>-11.97***</td>
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<td>Panel (c): determinants of risk pricing</td>
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<td></td>
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<td></td>
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<tr>
<td>Herding</td>
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<td>0.000</td>
<td>0.005</td>
<td>-0.024</td>
<td>0.025</td>
<td>301.3***</td>
<td>-0.169***</td>
<td>0.094**</td>
<td>-0.013***</td>
<td>0.027***</td>
<td>-21.09***</td>
<td>-11.73***</td>
<td>0.063</td>
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<tr>
<td>Term structure</td>
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<td>0.002</td>
<td>0.163</td>
<td>-1.566</td>
<td>1.261</td>
<td>109.8***</td>
<td>-0.120**</td>
<td>-0.017**</td>
<td>-0.073***</td>
<td>0.067***</td>
<td>-20.05***</td>
<td>-12.16***</td>
<td>0.092</td>
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<tr>
<td>Interest rate</td>
<td>319</td>
<td>-0.002</td>
<td>0.041</td>
<td>-0.177</td>
<td>0.152</td>
<td>96.77***</td>
<td>-0.097**</td>
<td>0.006**</td>
<td>0.072***</td>
<td>0.003***</td>
<td>-19.59***</td>
<td>-13.16***</td>
<td>0.073</td>
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</table>

This Table shows the summary of the descriptive statistics and diagnostic testing results for the risk pricing coefficients for all currencies for both models as well as herding, term structure and interest rate. We test for autocorrelation of the order AR(1) to AR(40). The normality test is performed by using Jarque-Bera (J-B) test where $H_0$: normality. The stationarity is tested by means of the ADF and KPSS tests. Based on the Schwert criteria a maximum lag length of 16 for KPSS test was selected. The critical values of KPSS test are as follows: 10%: 0.119; 5%: 0.146; 2.5%: 0.176; 1%: 0.216. The null hypothesis tested is that $H_0$: the variable is trend stationary. The results of ADF test for unit root are interpolated by MacKinnon et al. (1999) approximate technique. The critical values of ADF are -3.455:1%; -2.877:5%; -2.570:10%. The number of observations is 319. **, *, and * respectively refer to significance at the 1%, 5% and 10% level.
In Table 5, the results of the cointegration test are reported.\(^5\) We used a likelihood ratio test to select the optimal lags for each of the estimated series of pricing coefficients. Based on the 5% level of significance, a maximum of four lags was allowed. In addition, we considered the case of a linear trend. The results of Johansen’s trace test suggest that the four variables are cointegrated. In other words, there is a long-run relationship among these variables and hence there is evidence of a common stochastic trend among all the four variables. Table 5 shows that this result holds in the case of all exchange rate proxies.

For robustness, the long run relationship was also tested using Autoregressive Distributed Lags (ARDL) bounds testing procedure developed by Pesaran et al. (2001). The results were qualitatively similar to those found from Johansen’s test. The ARDL bounds testing results are available from authors upon request.

<table>
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<th>Hypothesized No. of CE(s)</th>
<th>TWI</th>
<th>USD</th>
<th>JPY</th>
<th>EUR</th>
<th>GBP</th>
<th>MXN</th>
<th>CNY</th>
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<td>TWI</td>
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</tr>
<tr>
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<td></td>
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<tr>
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<td>122.820</td>
<td>29.798</td>
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<td>0.173</td>
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<td>29.798</td>
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<td>0.159</td>
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<td>0.0037</td>
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<td>8.501</td>
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\(^5\) For robustness, the long run relationship was also tested using Autoregressive Distributed Lags (ARDL) bounds testing procedure developed by Pesaran et al. (2001). The results were qualitatively similar to those found from Johansen’s test. The ARDL bounds testing results are available from authors upon request.
The Table presents the results of Johansen cointegration test through Eigenvalue and Trace test for the null hypothesis that there is no long run relationship between the four variables: the exchange rate risk pricing series, herding, interest rate, and term structure. The unrestricted cointegration rank test (Trace) is used. The maximum lags interval used (in first differences): 1 to 4
* denotes rejection of the null hypothesis at the 0.05 level.

Furthermore, Table 5 also shows that when the world market return proxy is taken into account (i.e., when the three-factor model is used), the results are similar to those reported for the two-factor model. It can therefore be argued that the long-run relationship among exchange rate risk pricing, herding behavior, term structure and the interest rate is insensitive to fluctuations in the world market return.

5. Conclusion

Using a two-factor (and also a three-factor) unconditional capital asset pricing model, this paper examines whether (i) the exchange rate risk is priced in the Canadian equity market, (ii) the pricing of exchange rate risk varies over time, and (iii) there is a long-run relationship among exchange rate risk pricing, herding behavior, term structure and the interest rate. Unlike the existing studies, we use six alternative bilateral exchange rates (the Chinese Yuan, Euro, the UK pound, Japanese Yen, Mexican Peso and the US dollar) and one multilateral (trade weighted index) exchange rate proxies. The sample consists of monthly data on 58 largest Canadian firms over the period 2003 to 2010. The foreign exchange risk exposure is estimated using rolling window regression on both the two and three-factor models. The three factor model is found to be more reliable.

Empirical investigation based on ordinary least squares and generalized least squares technique reveals that foreign exchange rate risk is priced in the Canadian equity market. This conclusion holds in the case of all seven exchange rate exchange rate proxies. The estimated pricing coefficients are negative and significant indicating that Canadian firms achieve lower returns when exchange rate exposure increases. By making use of Johansen’s cointegration approach, we also tested for the presence of a long-run relationship among exchange rate risk pricing, herding behavior, term structure and the interest rate. Using all seven exchange rate proxies, we found that within the context of both the two-factor and the three-factor models, a cointegrating relationship exists among all variables. This suggests that the presence of a long-run relationship among exchange rate pricing, herding behavior, terms structure and the interest rate is insensitive to fluctuations in the world market return.

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References


