

Analysis of Foreign Currency Transaction Exposure Using Simulations

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The paper uses bootstrapping simulations for an analysis of foreign currency transaction risk faced by multinational corporations. The method avoids the model and “parameter estimation” risks. This work illustrates that if risk exposure is short-term, as transaction exposure, bootstrapping simulations work reasonably well. The mean absolute errors of the average daily forecasts of net income for two firms with international sales were 1.27% and 1.91%. The study demonstrates that bootstrapping simulations can be applied for forecasting exchange rates in the short-run, what can be useful for evaluating sensitivity to exchange rate movements, assessing international portfolio returns, and making hedging decisions.

INTRODUCTION

The paper shows how to use bootstrapping simulations for an analysis of foreign exchange transaction risk faced by multinational corporations. Foreign currency exposure is divided into three types: transaction exposure, economic exposure, and translation exposure (Bekaert and Hordick, 2012; Eun and Resnick, 2015; Eiteman et al., 2013; Shapiro, 2014). Economic exposure refers to sensitivity of company's market value to exchange rate changes, while translation exposure implies sensitivity of consolidated financial statements to exchange rate movements¹. This study focuses on transaction risk, which arises when companies enter into contracts with obligations expressed in fixed foreign currency amounts². The home currency value of these obligations changes with the exchange rates fluctuations, creating uncertainty about the values on the settlement date. In order to estimate possible gains or losses or to evaluate a likelihood of a certain range of cash flows, multinational companies obtain forecasts of future exchange rates or develop in-house models. Majority of the exchange rate forecasting approaches can be divided into three groups: efficient market method, fundamental method, and technical method. The efficient market method is based on the random walk assumption, which says that, on the average, tomorrow's exchange rate is the same as today's exchange rate. The efficient market hypothesis followers forecast future spot exchange rate based on the current spot exchange rate or the current forward rate. The fundamental method suggests that the exchange rate depends on a set of exogenous economic variables. An example of the fundamental method is the monetary approach. It assumes that the exchange rate depends on the money supply, velocity of money, and national output. The exchange rate forecasting under the fundamental approach involves designing a model, estimating parameters of the model – fitting the model to historical data, forecasting exogenous economic variables, plugging the forecasts of the independent variables into the model, and deriving the exchange rate estimate. The fundamental method has drawbacks. The chosen model can be inaccurate. The parameters of the model might change over time. Even if the model is correct, forecasts of explanatory variables might be tainted. Studies show that the fundamental models do not outperform the random walk model. Although, in the long-run, economic

fundamentals are important determinants of foreign exchange rates. The technical approach suggests that historical trends continue into the future. It examines historical data on the foreign exchange rates, identifies patterns, and extrapolates them into the future to forecast future exchange rates. As for the fundamentals methods, existing studies do not find evidences that the technical analysis methods outperform the random walk model. This work projects exchange rates using the bootstrapping simulations method, which is close to the technical methods. It also assumes that the history repeats in the future and projects changes in the exchange rates by “bootstrapping” from historical observations.

Commonly, multinational corporations use the sensitivity and scenario analyses to assess foreign exchange exposure. In the sensitivity analysis, an output (for transaction exposure, it could be Profit After Tax in home currency units) is evaluated for a few values of one input (the exchange rate). The sensitivity is estimated as a ratio of changes in the output to changes in the input. The scenario analysis calculates the output values for several scenarios, with different combinations of inputs’ values. However, the sensitivity and scenario analyses have drawbacks: choices of input variables and scenarios are arbitrary, need to derive estimates of the scenarios probabilities, and it is difficult to succinctly interpret multiple scenarios results (Brealey at al., 2011; Khindanova, 2013; Spinney and Watkins, 1996). This study uses another methodology for evaluating foreign currency exposure – a simulation analysis, which can take into account multiple sources of uncertainty (for example: exposure to several exchange rates) and their interrelationship. There are two groups of simulations approaches: Monte Carlo and historical. A Monte Carlo simulations approach describes uncertainty of inputs with probability distributions, estimates distributions parameters, repeats generation of random values from the inputs distributions and calculates the output, what allows users to generate a probability distribution for the output (Khindanova, 2013; Khindanova and Rachev, 2000; Spinney and Watkins, 1996). The historical simulations method does not impose the distribution assumptions. It avoids model risk and “parameter estimation” risk³. The historical simulations forecast inputs by drawing from past observations and estimate the output. A common critique of the historical simulations methodology is that it produces inaccurate estimates in distributions tails (Boudoukh at al., 1998; Danielsson and de Vries, 1997), what might be important for modeling foreign exchange rates characterized by fat tails. The paper employs a bootstrapping modification of historical simulations. It repetitively draws from a set of inputs’ historical observations, plugs the drawn values into the output model, and derives multiple values of the output to form its probability distribution (Boudoukh at al., 1998; Khindanova and Rachev, 2000).

Examples of simulations in foreign currency studies can be found in Charemza, 1996; Corona and Ecça, 2008. Charemza (1996) analyzed the crash of the Polish exchange market in 1989. The author simulated the unobservable component of the bubble process. The results indicate the speculative bubble burst. Corona and Ecça (2008) simulated interactions between two stock markets in two different countries, linked by a foreign exchange market. There are several illustrations of foreign exchange rate simulations in financial modeling books. Benninga (2008) employs Excel’s VBA⁴ to do bootstrapping simulations of the Ruble/US dollar exchange rate, a Russian interest rate, and an index price. The simulated data are used to derive a distribution of the portfolio return and to estimate the 1% Value-at-Risk (VaR) for the portfolio. Winston (2008a) applies Excel and @Risk, an Excel add-in, to simulate exchange rates and value a foreign currency swap. He generates future interest rates in two countries and forecasts the exchange rates using the interest rate parity, the simulated interest rates, and the current spot exchange rate. Then he simulates a swap and derives a value of the swap. Winston (2008b) considers a US multinational company with three receivables in francs, pounds, and yen. He illustrates how to minimize the variability of six-month profit in dollars, subject to the condition that the average profit will be at least \$4.8 million. Winston employs the bootstrapping technique to simulate 1000 scenarios for three exchange rates using @Risk. Then, he determines the number of put options on each currency to achieve the needed risk profile.

This study implements the bootstrapping simulations in the EViews environment. The EViews is an econometrics software. It is not commonly used in finance, but is widely applied for building macroeconomic models. Comparing to Excel and @Risk, the EViews package is more flexible for incorporating macroeconomic and firm-level sources of risk into financial models.

This work is one of the first papers to apply the bootstrapping simulations for evaluating foreign currency transactions exposure of a multinational company. The paper considers a hypothetical U.S.-based firm with sales in the U.S., the Eurozone, Canada, Japan, Mexico, Malaysia, and South Africa. The revenues in local currencies terms are constant, but the dollar values of sales fluctuate with exchange rates movements. Bekaert and Hodrick (2012) suggest that monthly percentage changes of major currencies can be described by normal distributions, while currencies of many emerging economies have non-normal distributions, characterized by heavy tails, higher peaks, and skewness. These findings imply that historical simulations might underestimate probabilities of extreme events for currencies from emerging markets. To investigate whether origins of currencies affect the simulations results, the paper simulates separate sales and net incomes in dollar terms for two groups of countries/regions: (i) representing major currencies (the Eurozone, Canada, and Japan) and (ii) emerging economies (Mexico, Malaysia, and South Africa). The U.S. sales are included in both cases. The projected local sales values and numbers for other income statement variables are based on the Diva Shoes case application in Eun and Resnick, 2012. The follow-up paper will build the EViews macroeconomic models to forecast sales abroad and integrate those models with the dollar net income simulations, following Cuddington and Khindanova, 2011 and 2012. The simulations for the company involve repetitive (5,000 times) forecasting of foreign exchange rates in six months by bootstrapping from the exchange rates daily returns over the past six months, calculating the U.S. dollar values of sales under projected exchange rates, and estimating net income in dollar terms. Thus, the simulations generate 5,000 possible values of the 6-month net income, what allows to form a distribution for the net income. The derived distributions for two cases of sales (in developed and emerging countries) facilitate a much deeper risk assessment comparing to a single point estimate of the net income or a collection of scenario results. The paper estimates different risk measures (standard deviation, skewness and behavior in the distribution tails) and probabilities of certain ranges of the net income and extreme events.

In order to assess the forecast performance of the bootstrapping simulations technique, the paper carries out rolling simulations of exchange rates over the one-month out-of-sample forecast period (22 trading days), calculates corresponding net incomes, and compares them to the net incomes values under the actual exchange rates. The mean absolute error (MEA) of the average daily forecasts for net income from sales in the U.S., Canada, the Eurozone, and Japan is only 1.27%. A similar simulation of sales in U.S., Mexico, Malaysia, and South Africa produces MEA of 1.91%.

This work illustrates that if risk exposure is short-term, as transaction exposure, and the focus is not on the extreme quantiles, bootstrapping simulations work reasonably well. They can be applied for forecasting exchange rates in the short-run, what can be useful for evaluating sensitivity to exchange rate movements and making hedging decisions.

The next section presents a deterministic model of the income statement. The third section explains the bootstrapping simulations of exchange rates and the net income. The fourth section describes the historical exchange rate series. Then the paper examines generated distributions for the net income and discusses the forecast performance of the simulations. The sixth section summarizes findings and outlines directions for future research.

DETERMINISTIC MODEL OF INCOME STATEMENT

The paper considers a hypothetical U.S.-based firm with shoes sales in the Eurozone, Canada, Japan, Mexico, Malaysia, and South Africa. Suppose the current time is March 31, 2014. The company has shoes orders for the next six months from domestic and foreign markets. However, fluctuating exchange rates create uncertainty about the dollar values of the total sales and the net income by September 30, 2014 (over the 6-month period). The company is facing increasing exposure to foreign currency risk, but it does not actively manage the risk. As the first step of changing risk management policies, the company would like to assess the transaction exposure risk. What is the expected net income level in dollar terms? How volatile are the net income projections? What is the likelihood of reaching the target level of the net income?

The assessment begins with outlining a deterministic model of the income statement. Table 1 shows the historical and projected sales (shoe orders), adapted from the Diva Shoes minicase in Eun and Resnick, 2012. The paper examines separate sales and net incomes in dollar terms for two groups of countries/regions: (i) representing major currencies (the Eurozone, Canada, and Japan) and (ii) emerging economies (Mexico, Malaysia, and South Africa). The U.S. sales are included in both cases. Notice that total sales in dollar terms in Table 1 are the same for both groups (\$81,252,942). The local currencies values of orders in Table 1 show that sales in the US and Canada will decline, grow slightly in the Eurozone, and increase substantially in Japan.

**TABLE 1
HISTORICAL AND PROJECTED SALES**

Case	3.31.14				9.30.14
	Markets	Sales in local currencies units, 10.01.13-3.31.14	Exchange rate	Sales in the U.S. dollar terms	Orders in local currencies units, 4.01.14-9.30.14
1	US	USD15,000,000		15,000,000	USD7,500,000
	Canada	CAD29,984,442	CAD/USD 1.1207	26,755,101	CAD29,234,831
	Eurozone	EUR11,697,690	USD/EUR 1.2628	14,771,843	EUR11,873,156
	Japan	YEN2,711,452,893	YEN/USD 109.6600	24,725,998	YEN3,253,743,472
	Total sales, \$			81,252,942	
2	US	USD15,000,000		15,000,000	USD7,500,000
	Mexico	MXN322,822,624	MXN/USD 13.0560	24,725,998	MXN387,387,149
	Malaysia	MYR87,301,896	MYR/USD 3.2630	26,755,101	MYR85,119,348
	South Africa	ZAR155,510,580	ZAR/USD 10.5275	14,771,843	ZAR157,843,239
	Total sales, \$			81,252,942	

The paper assumes that the dollar expenses are the same for both cases. Since the dollar sales and expenses are equal, the two cases have identical income statements, given in Table 2.

**TABLE 2
CONSOLIDATED INCOME STATEMENT, IN USD**

	March 31, 2014
Sales	81,252,942
Costs of goods sold	44,674,127
Gross profit	36,578,815
SG&A expenses	20,288,250
Operating profit	16,290,565
Interest expense	4,000,000
Pretax income	12,290,565
Income taxes (40%)	4,916,226
Net Income	7,374,339

*Adapted from Exhibit 8.17 in Eun and Resnick, 2012.

A deterministic model of the income statement supposes that the interest payments are constant (\$4,000,000); the ratios of expenses with respect to sales are constant too: (Cost of goods sold)/Sales = \$44,674,127 / \$81,252,942 = 0.55, (SG&A expenses)/Sales = \$20,288,250 / \$81,252,942 = 0.25; the tax rate stays at 40%. The model equations:

$$Total\ Sales_{\$,t} = Sales_{US,t} + Sales_{Eurozone,t} \cdot S(USD/EUR)_t + Sales_{Canada,t}/S(CAD/USD)_t + Sales_{Japan,t}/S(YEN/USD)_t \quad (1)$$

$$Cost\ of\ Goods\ Sold_{\$,t} = Total\ Sales_{\$,t} \cdot 0.55 \quad (2)$$

$$Gross\ profit_{\$,t} = Total\ Sales_{\$,t} - Cost\ of\ Goods\ Sold_{\$,t} \quad (3)$$

$$SG\&A\ expenses_{\$,t} = Total\ Sales_{\$,t} \cdot 0.25 \quad (4)$$

$$Operating\ profit_{\$,t} = Gross\ profit_{\$,t} - SG\&A\ expenses_{\$,t} \quad (5)$$

$$Interest\ expense_{\$,t} = 4,000,000 \quad (6)$$

$$Pretax\ income_{\$,t} = Operating\ profit_{\$,t} - Interest\ expense_{\$,t} \quad (7)$$

$$Taxes_{\$,t} = Pretax\ income_{\$,t} \cdot 0.40 \quad (8)$$

$$Net\ income_{\$,t} = Pretax\ income_{\$,t} - Taxes_{\$,t}, \quad (9)$$

where t denotes the current time - March 31, 2014; $S(USD/EUR)_t$, $S(CAD/USD)_t$, and $S(YEN/USD)_t$ are current spot exchange rates; USD stands for US dollar, EUR – Euro, CAD – Canadian dollar, YEN – Japanese yen. For Case 2, the model equations do not change, except for equation (1):

$$Total\ Sales_{\$,t} = Sales_{US,t} + Sales_{Mexico,t}/S(MXN/USD)_t + Sales_{Malaysia,t}/S(MYR/USD)_t + Sales_{South\ Africa,t}/S(ZAR/USD)_t, \quad (10)$$

where $S(MXN/USD)_t$, $S(MYR/USD)_t$, and $S(ZAR/USD)_t$ are the current spot exchange rates; MXN denotes the Mexican peso, MYR – Malaysian ringgit, ZAR – South African rand.

BOOTSTRAPPING SIMULATIONS OF EXCHANGE RATES AND NET INCOME

A stochastic version of the income statement for the September 30, 2014 forecasts is based on the deterministic model (1) - (10). It assumes that model inputs (exchange rates) are random, replaces the current spot exchange rates in equations (1) and (10) by simulated forecasts, and considers orders' values from Table 1:

$$Total\ Sales_{\$,T,k} = Sales_{US,T} + Sales_{Eurozone,T} \cdot \hat{S}(USD/EUR)_{T,k} + Sales_{Canada,T}/\hat{S}(CAD/USD)_{T,k} + Sales_{Japan,T}/\hat{S}(YEN/USD)_{T,k} \quad (11)$$

$$Cost\ of\ Goods\ Sold_{\$,T,k} = Total\ Sales_{\$,T,k} \cdot 0.55 \quad (12)$$

$$Gross\ profit_{\$,T,k} = Total\ Sales_{\$,T,k} - Cost\ of\ Goods\ Sold_{\$,T,k} \quad (13)$$

$$SG\&A\ expenses_{\$,T,k} = Total\ Sales_{\$,T,k} \cdot 0.25 \quad (14)$$

$$\text{Operating profit}_{\$,T,k} = \text{Gross profit}_{\$,T,k} - \text{SG\&A expenses}_{\$,T,k} \quad (15)$$

$$\text{Interest expense}_{\$,T,k} = 4,000,000 \quad (16)$$

$$\text{Pretax income}_{\$,T,k} = \text{Operating profit}_{\$,T,k} - \text{Interest expense}_{\$,T,k} \quad (17)$$

$$\text{Taxes}_{\$,T,k} = \text{Pretax income}_{\$,T,k} \cdot 0.40 \quad (18)$$

$$\text{Net income}_{\$,T,k} = \text{Pretax income}_{\$,T,k} - \text{Taxes}_{\$,T,k}, \quad (19)$$

where T denotes the forecast time – September 30, 2014; k is the simulation number, $k = 1, \dots, 5000$; $Sales_{US,T}$, $Sales_{Eurozone,T}$, $Sales_{Canada,T}$, and $Sales_{Japan,T}$ are orders from markets for the 6-month period, ending at time T - September 30, 2014; $\hat{S}(USD/EUR)_{T,k}$, $\hat{S}(CAD/USD)_{T,k}$, and $\hat{S}(YEN/USD)_{T,k}$ are the exchange rates forecasts for time T derived during the k -th simulation. For Case 2, the total sales equation (10) becomes:

$$\begin{aligned} \text{Total Sales}_{\$,T,k} = & Sales_{US,T} + Sales_{Mexico,T}/\hat{S}(MXN/USD)_{T,k} \\ & + Sales_{Malaysia,T}/\hat{S}(MYR/USD)_{T,k} + Sales_{South Africa,T}/\hat{S}(ZAR/USD)_{T,k}, \end{aligned} \quad (20)$$

where $Sales_{Mexico,T}$, $Sales_{Malaysia,T}$, and $Sales_{South Africa,T}$ are orders from markets for April-September, 2014; $\hat{S}(MXN/USD)_{T,k}$, $\hat{S}(MYR/USD)_{T,k}$, and $\hat{S}(ZAR/USD)_{T,k}$ are the exchange rates forecasts for time T derived during the k -th simulation.

The exchange rates forecasts are generated by bootstrapping from the exchange rates daily percentage changes (returns) over the past six months, from September 24, 2013 to March 31, 2014. The length of the observation period is equal to 128 trading days, the number of trading days between the current time t (March 31, 2014) and the forecast day T (September 30, 2014). At each simulation k , the EViews resamples the original set of historical returns of exchange rates and calculates the forecast using the following formula:

$$\hat{S}(i/j)_{T,k} = S(i/j)_t \prod_{d=t+1}^T (1 + r'_d), \quad (21)$$

where i and j are currencies, T is the forecast time (September 30, 2014); k is the simulation number, $k = 1, \dots, 5000$; $\hat{S}(i/j)_{T,k}$ is a forecast of the exchange rate between currencies i and j for time T derived during the k -th simulation; d is a day index, $d = t+1, \dots, T$; r'_d is a resampled exchange rate return for day d .

Bootstrapping simulations steps for Case 1:

1. Resample sets of returns over past six months (128 trading days) for each exchange rate: CAD/USD, USD/EUR, and YEN/USD
2. Forecast exchange rates for day T (September 30, 2014) following formula (21):

$$\hat{S}(CAD/USD)_{T,k} = S(CAD/USD)_t \prod_{d=t+1}^T (1 + r'_{CAD/USD,d}) \quad (22)$$

$$\hat{S}(USD/EUR)_{T,k} = S(USD/EUR)_t \prod_{d=t+1}^T (1 + r'_{USD/EUR,d}) \quad (23)$$

$$\hat{S}(YEN/USD)_{T,k} = S(YEN/USD)_t \prod_{d=t+1}^T (1 + r'_{YEN/USD,d}) \quad (24)$$

3. Plug the forecasts of exchange rates (22)-(24) into equation (11) to calculate total sales in dollar terms
4. Recalculate expenses, profits, taxes using equations (12)-(18)
5. Estimate the net income in dollars following equation (19)
6. Repeat 5,000 times the simulations steps 1-5.

Thus, the simulations generate 5,000 possible values of the 6-month net income, what allows to form its distribution. For Case 2, the simulations steps are similar. The next section examines historical exchange rate series used for drawing future returns in step 1 of the simulations. After that part, the paper analyzes the generated distributions for the net income and assesses the associated risks.

FOREIGN EXCHANGE RATE SERIES

As it was explained in the previous section, the exchange rates forecasts are generated by drawing from the past exchange rates daily returns. This section describes historical level and return series of the six involved exchange rates. The exchange rate were downloaded from the Federal Reserve Economic Data (FRED) database (Federal Reserve Bank of St. Louis, 2015). The observation period covers seven months, from September 24, 2013 to April 30, 2014. The past six months data are used for forecasting an exchange rate on the forecast date out in six months. One extra month is added for rolling simulations to assess the forecast performance of the bootstrapping technique. Figure 1 depicts the nominal levels of the exchange rates over time, Figure 2 shows the daily returns of the exchange rates, while Figure 3 plots the returns histograms.

Figure 1 shows trends in the exchange rate movements over the 9.24.2013-4.30.2014 period. The Canadian dollar has been depreciating against the US dollar through January 2014, then CAD started to slightly appreciate, with ups and downs. The CAD depreciation against USD implies that the Canadian sales in the USD terms will decline, what should be a concern for the US-based company. The USD/EUR exchange rate was volatile. The Japanese yen was depreciating against dollar through December 2013, lowering the dollar value of Japanese sales. Yen seems to stabilize in February – April 2014. The Mexican peso was strengthening against dollar from February to mid-April 2014. If MXN continues to appreciate against USD, the dollar proceeds from the Mexican sales will be stronger. The Malaysian ringgit and the South African rand were also appreciating against the dollar from mid-January to April 2014, increasing dollar values of sales in Malaysia and South Africa.

FIGURE 1
NOMINAL LEVELS OF THE EXCHANGE RATES, 9.24.2013-4.30.2014

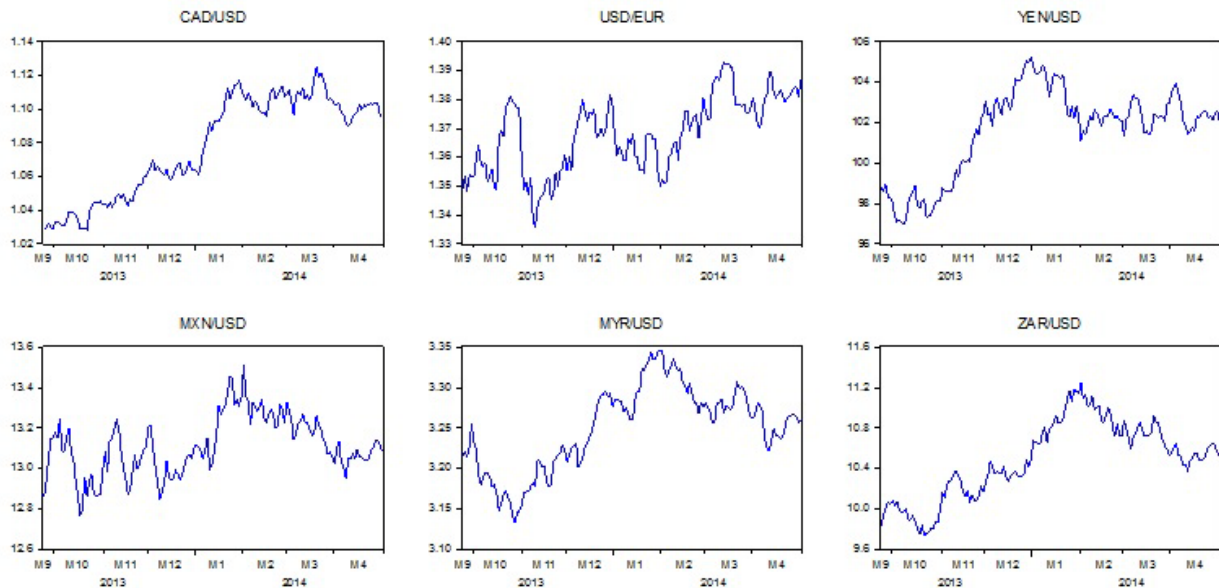
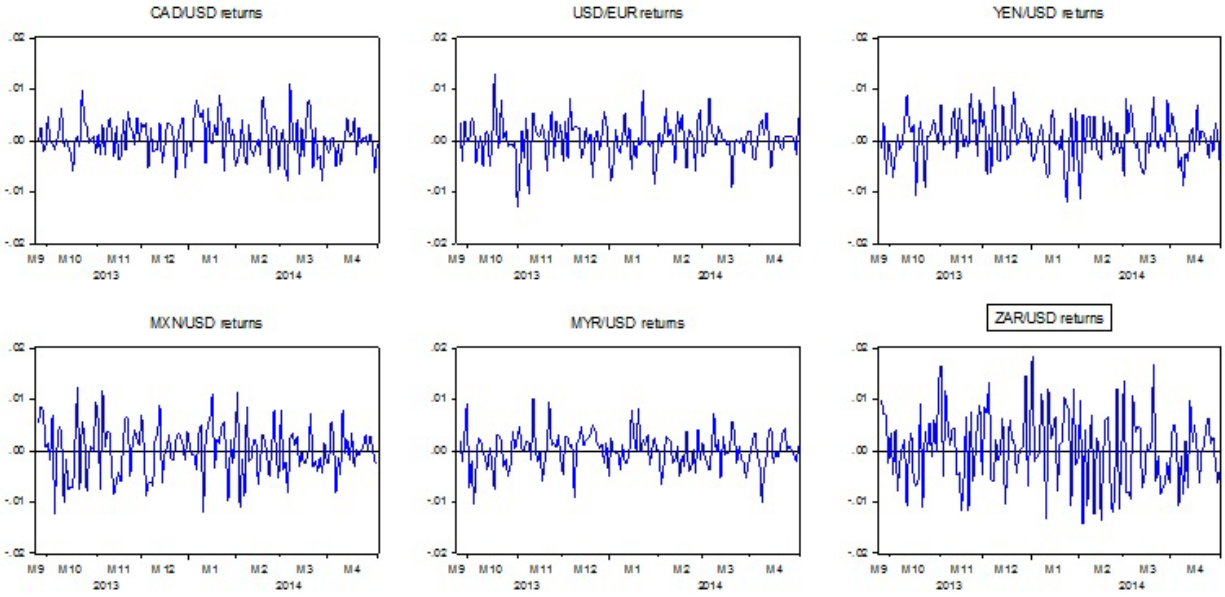


FIGURE 2
EXCHANGE RATES DAILY RETURNS, 9.25.2013-4.30.2014



Returns series in Figure 2 appear to be stationary, they fluctuate around the zero line. The South African rand fluctuates the most. Its histogram in Figure 3 confirms the higher volatility of ZAR. It has a wider range of daily returns. The histograms in Figure 3 indicate that the returns distributions over the observation period are overall symmetric. Red lines in Figure 3 depict density functions of the normal distributions with the same means and standard deviations as the return series. It appears that distributions of the considered exchange returns are close to the normal distributions. The statistics of the returns series in Table 3 help check normality of the empirical distributions.

FIGURE 3
EXCHANGE RATES DAILY RETURNS HISTOGRAMS, 9.25.2013-4.30.2014

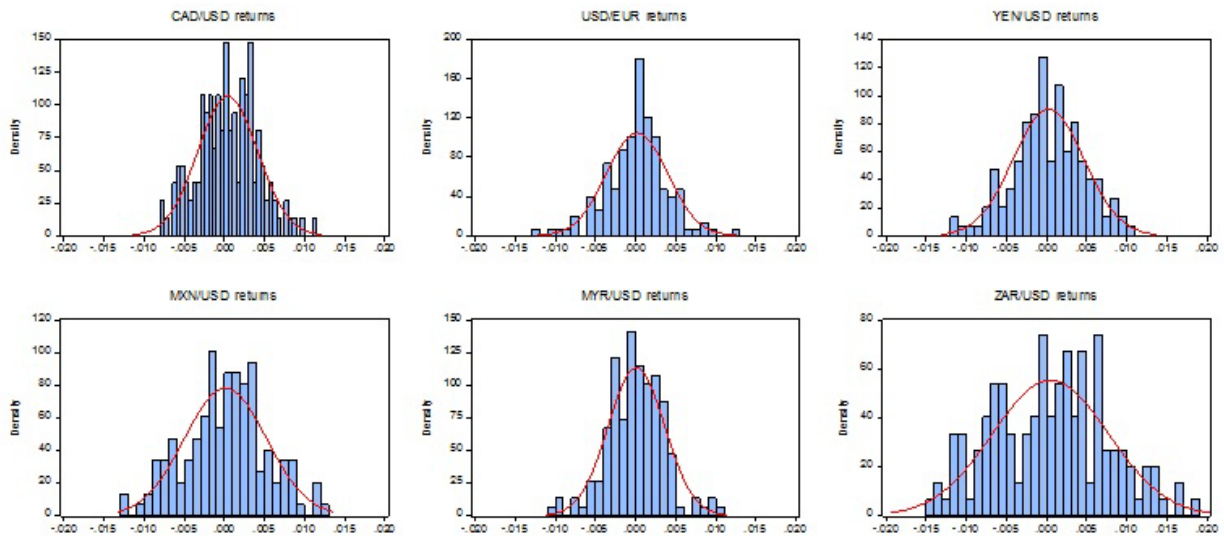


TABLE 3
STATISTICS OF EXCHANGE RATES DAILY RETURNS, 9.25.2013-4.30.2014

Statistics	CAD/USD	USD/EUR	YEN/USD	MXN/USD	MYR/USD	ZAR/USD
Mean	0.0004	0.0002	0.0002	0.0001	0.0001	0.0005
Median	0.0002	0.0004	0.0000	0.0006	0.0002	0.0008
Maximum	0.0112	0.0129	0.0104	0.0123	0.0102	0.0186
Minimum	-0.0078	-0.0129	-0.0120	-0.0122	-0.0102	-0.0143
Std. Dev.	0.0037	0.0038	0.0044	0.0051	0.0035	0.0072
Skewness	0.1236	-0.2295	-0.1751	-0.0682	-0.0676	0.0824
Kurtosis	2.8740	4.3758	2.9687	2.7898	3.8873	2.4484
Jarque-Bera	0.4779	13.0587	0.7676	0.3897	5.0018	2.0579
Probability	0.7874	0.0015	0.6813	0.8230	0.0820	0.3574
Observations	149	149	149	149	149	149

The mean returns in Table 3 are close to zero percent for all six exchange rates. The South African rand and the Mexican peso exhibit highest standard deviations (0.72% and 0.51%, respectively), indicating that these two currencies are more volatile than the others. The skewness parameters of all six exchange rates are close to zero, suggesting that their distributions are approximately symmetric. The kurtosis of the CAD/USD, YEN/USD, and MXN/USD exchange rates is close to three, implying that their distributions are peaked similarly to the normal distribution. The kurtosis of the ZAR/USD exchange rate is slightly smaller than three, indicating its distribution is somewhat flatter than the normal distribution. The kurtosis of the USD/EUR and MYR/USD exchange rates exceeds three, suggesting their distributions have higher peaks and fatter tails than the normal distribution. The Jarque-Bera is used to test if the series is normally distributed. The probabilities below the Jarque-Bera statistics lead us to reject the normality hypothesis for the USD/EUR exchange rate at the 1% significance level and for the MYR/USD exchange rate - at the 10% significance level. We cannot reject the hypothesis of normal distribution for the CAD/USD, YEN/USD, MXN/USD, and ZAR/USD exchanges rates. The forecasts of these four exchange rates could be simulated by drawing from the normal distributions.

SIMULATIONS RESULTS

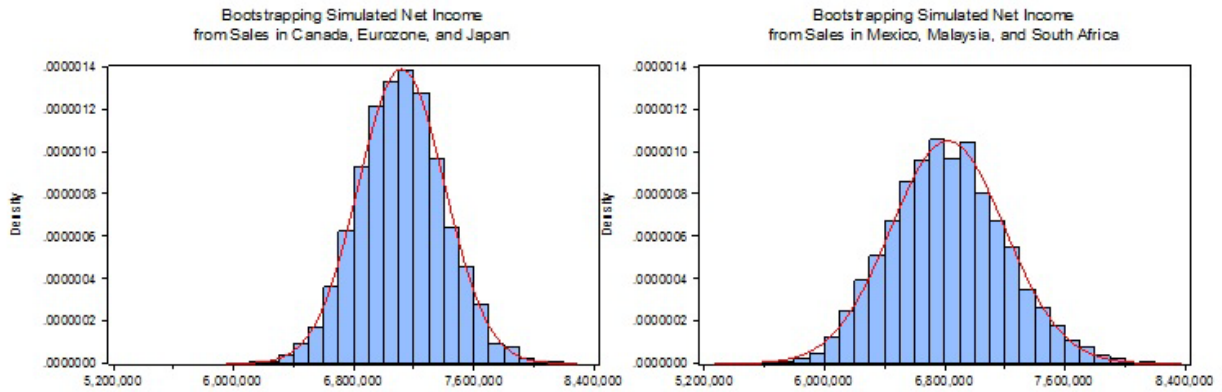
Using the exchange rates daily return series over the 9.25.2013-3.31.14 period and following the bootstrapping simulations steps described in the third section, the paper simulates 5,000 combinations of forecasts for the CAD/USD, USD/EUR, and YEN/USD exchange rates on September 30, 2014 and generates 5,000 possible values of the net income over the next six months, ending on September 30, 2014. Similarly, the paper simulates 5,000 scenarios of forecasts for the MXN/USD, MYR/USD, and ZAR/USD exchange rates on September 30, 2014 and calculates the corresponding net income values. The generated net incomes statistics are provided in Table 4 and the distributions are illustrated in Figure 4.

TABLE 4
STATISTICS FOR SIMULATED NET INCOMES OVER THE 6-MONTH PERIOD
ENDING ON SEPTEMBER 30, 2014

Statistics	Net Income, Case 1	Net Income, Case 2
Mean	\$7,118,812	\$6,821,697
Median	\$7,116,697	\$6,810,444
Maximum	\$8,185,536	\$8,240,865
Minimum	\$6,113,216	\$5,542,842
Std. Dev.	\$287,329	\$380,193
Skewness	0.0958	0.1820
Kurtosis	3.0972	2.9421
Jarque-Bera	9.6299	28.3013
Probability	0.0081	0.0000
Observations	5,000	5,000

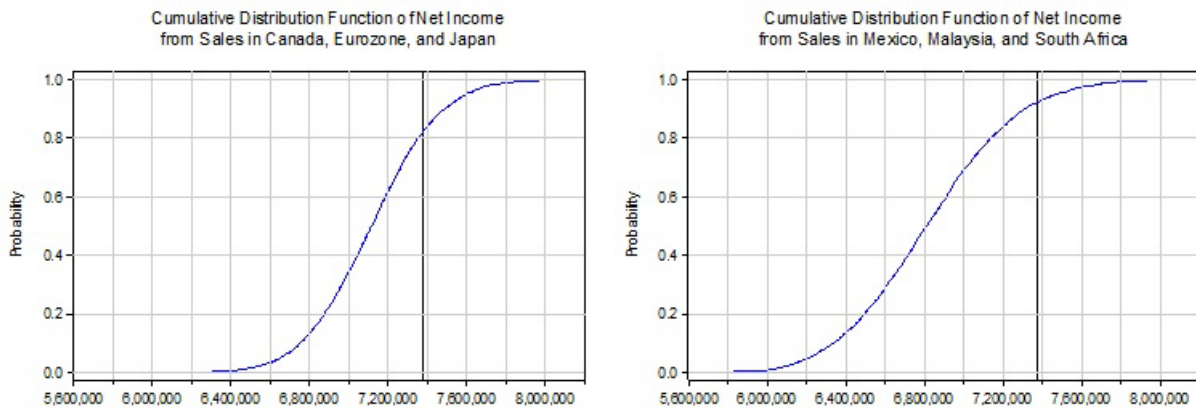
The net income in dollar terms is \$7,374,339 on March 31, 2014 (the current time) in both cases, see Table 2. The projected mean net incomes in Table 4 are lower than the current net income: $Mean\ Net\ Income_{Case\ 1} = \$7,118,812 < \$7,374,339$ and $Mean\ Net\ Income_{Case\ 2} = \$6,821,697 < \$7,374,339$. The simulations predict that, on the average, the dollar values of the net income from sales in both groups of markets will decline. The net income forecasts in Case 1 fluctuate in narrower range, from \$6,113,216 to \$8,185,536; the Case 2 net income forecasts change in the [\$5,542,842; \$8,240,865] range. The wider range of Case 2 indicates that the revenues in dollar terms from sales in Mexico, Malaysia, and South Africa will fluctuate more. The standard deviation is higher for Case 2, indicating that the dollar proceeds from sales in Mexico, Malaysia, and South Africa will be more volatile, what can be explained by higher volatility of the MXN/USD and ZAR/USD exchange rates. The skewness parameters do not differ much from zero, suggesting that the net income distributions are close to being symmetric. The kurtosis statistics are close to three, the kurtosis value of the normal distribution. The Case 1 kurtosis is 3.0972, slightly above three, suggesting that a distribution of the net income from sales in Canada, the Eurozone, and Japan is more peaked than the normal distribution, and might have heavier tails than the normal distribution. The heavier tails imply that the probabilities of extreme events are higher than for the normal distribution. The Case 2 kurtosis is 2.9421, slightly smaller than three, indicating that a distribution of the net income from sales in Mexico, Malaysia, and South Africa is flat comparing to the normal distribution, and might have thinner tails than the normal distribution.

FIGURE 4
SIMULATED NET INCOMES DISTRIBUTIONS



Red lines in Figure 4 are density functions of the normal distributions with the same means and standard deviations as the derived net incomes sets. Although the normal density functions seem to trace the histograms well, the Jarque-Bera statistics in Table 4 reject the hypotheses that net incomes in two cases follow the normal distribution. The simulated distributions of net incomes enable estimation of probabilities that net incomes will be within certain ranges. For example, there is 90% chance net income in case 1 will be lower than \$7,488,370. In case 2, there is 90% likelihood that net income will be below \$7,311,196. A complete picture of probabilities can be obtained from the cumulative distribution functions, shown in Figure 5.

FIGURE 5
CUMULATIVE DISTRIBUTION FUNCTIONS OF SIMULATED NET INCOMES



The vertical lines in Figure 5 mark the current net income value of \$7,374,339. The lines show that the probability of having the case 1 net income below the current net income level is about 80%, while for case 2 that probability is close to 90%.

In order to assess the forecast performance of the bootstrapping simulations technique, the paper calculates the mean absolute error (MEA) of the average daily forecasts for net income using rolling simulations for 22 forecast trading days (one month). The simulations begin at the current date of March 31, 2014, the forecast day of September 30, 2014, and the observation period covering September 24,

2013-March 31, 2014. The simulations are executed as described in the third section, generating a distribution of the net income, and a mean net income value. In the second set of simulations, the forecast date shifts to the next day – October 1, 2014; observation period moves forward by one day, now covering September 25, 2013 – April 1, 2014; the simulations are done using the moved observation period, and the mean net income is calculated. The process is repeated by rolling the forecast date and the observation period by one trading day 20 more times, generating mean net income values over 22 forecast days. They are compared to net incomes values with actual exchange rates on the forecast days to derive the mean absolute errors (MAE):

$$MAE = \frac{\sum_{f=1}^{22} |(\widehat{NI}_f - NI_f) / NI_f|}{22},$$

where NI_f is the net income with actual exchange rates on the forecast day f ; \widehat{NI}_f is the average simulated net income for the forecast day f . The MAE of the average daily forecasts for net income from sales in the U.S., Canada, the Eurozone, and Japan is only 1.27%. A similar simulation of sales in U.S., Mexico, Malaysia, and South Africa produces MAE of 1.91%.

CONCLUSIONS

The study demonstrates that the bootstrapping simulations are a valuable tool for conducting a detailed risk analysis of foreign currency transaction exposure. Relatively to a single point estimate of the net income or a collection of scenario results, the simulated distributions of net incomes forecasts enable visualization and quantification of the transaction risk. It becomes possible to estimate different risk measures: standard deviation, skewness, kurtosis, and probabilities of specific ranges of the net income.

The paper shows that bootstrapping simulations can be applied for forecasting exchange rates in the short-run, what can be useful for evaluating sensitivity to exchange rate movements, assessing international portfolio returns, and making hedging decisions.

In a follow-up paper, I will integrate sales forecasting and exchange rates simulations to assess foreign currency transaction risk.

ENDNOTES

1. Economic exposure studies were conducted by Bartram, 2004; Bodnar et al., 2002; Cho and Song, 2011; Choi and Denzau, 2007; Dominguez and Tesar, 2006; Chue and Cook, 2008; Decke, 2005; Doidge et al., 2006; Faff and Marshall, 2005; Frazer and Pantzalis, 2004; He and Ng, 1998; Jorion, 1990; Muller and Vershoor, 2006a and 2006b; Nguen and Faff, 2003; and Pritamani et al., 2004. It is not an exhaustive list of the economic exposure papers.
2. Receivables and payables are examples of contracts with fixed contractual obligations.
3. Sometimes, the historical simulations method is called a nonparametric method.
4. Visual Basic for Applications (VBA) is a programming language incorporated into Microsoft applications.

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