

# **A COMPARISON OF APPROACHES TO ESTIMATING TRANSACTION EXPOSURE AND VALUE AT RISK**

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## **ABSTRACT**

This paper measures the transaction exposure of a hypothetical multinational corporation doing business in five different foreign currencies for two recent time periods using the value at risk methodology. While earlier articles by the authors of this paper have assumed the expected percentage change in the exchange rate is zero, this paper employs an adaptive expectations model whereby the MNC expects the exchange rate to change by the same percentage as over the most recent 15-day period. These results are compared to the earlier calculations. This comparison could provide real-world MNCs with critical insight about how to estimate and manage the risks related to their international transactions.

## **INTRODUCTION AND OVERVIEW**

Throughout the 1980s, the growing interdependency of the world's capital and goods markets led businesses to think and act globally. At the same time, increased competition led firms to design production processes that disregarded national boundaries. But these new opportunities to do business across borders and continents created new risks as well as new opportunities.

In the 1990s, the invention and use of complicated derivative securities created another layer of complexity not seen before. Moreover, increased volatility of interest rates and exchange rates resulted in enhanced risk exposure. Some well publicized failures of both financial and nonfinancial corporations resulting from these additional layers of risk heightened awareness that the business environment had, indeed, changed. Business managers, regulators, and even the general public sensed that the risk of insolvency had been underestimated. As a result, there was an effort to better identify and quantify the risk of a catastrophic failure in a worst case scenario.

Ultimately, this new reality led to the development and widespread use of the "value at risk" methodology for assessing risk. Value at risk is a probabilistic approach to measuring downside risk (i.e., the maximum loss) that is likely to occur within a specific time frame at a particular level of confidence. It is a specific number (e.g., a dollar value) that can be readily used to assess a corporation's risk exposure.<sup>1</sup> Both financial and nonfinancial companies can use this methodology. For multinational corporations, the risk of unexpected movements in foreign exchange rates is a key concern. Multinationals can employ the value at risk methodology to assess the transaction exposure associated with net cash flows denominated in one or more foreign currencies.

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<sup>1</sup> As Hull (2009) describes, the usefulness of the value at risk methodology results, in part, from its relative simplicity. Senior managers don't want an arcane statistics lesson. They want to know, very simply, "how bad can things get?" (p. 452)

This research paper measures the “value at risk” (VAR) for a hypothetical multinational corporation transacting business in five specific foreign currencies for two recent time periods. The value at risk for each individual currency (for each time period) are computed and evaluated. While earlier articles about value at risk by the authors of this paper have assumed that the “expected percentage change in the exchange rate” is zero (i.e., the exchange rate is not expected to change over the relevant time period), this paper assumes an adaptive expectations model whereby the MNC expects the exchange rate to change by the same percentage as over most recent 15-day period. In short, this paper estimates value at risk including a forecasted change in the exchange rate. [See Khazeh and Winder (1) and Khazeh and Winder (2)]

The results of the more sophisticated value at risk calculations are then compared to the earlier (and simpler) calculations which implicitly assumed the MNC expected the relevant exchange rates not to change over the designated time period. Comparing these two different approaches to estimating “value at risk” for two different time periods should provide real-world MNCs with critical insight about how to estimate and manage the risks related to their international transactions.

### **TRANSACTION EXPOSURE AND VALUE AT RISK**

Because they conduct business in a variety of currencies, multinational corporations are exposed to exchange rate risk on a continuing basis. One form of exchange rate risk is “transaction exposure” (or transaction risk). This is the risk that the MNC’s cash flows will be affected by exchange rate changes. Both receivables and payables denominated in foreign currencies contribute to this risk.<sup>2</sup>

Optimally, this risk should be viewed on a consolidated basis; that is, across all the firm’s divisions and across all countries. The transaction exposure associated with payables denominated in one particular currency (in any division) will be offset, in whole or in part, by any receivables denominated in that same currency. However, any positive (or negative) net cash flow in a particular currency will subject the MNC to transaction exposure due to potential fluctuations in exchange rates.

In certain circumstances, an MNC may decide not to hedge its transaction exposure. In other circumstances, the MNC may decide to hedge this risk using one or more techniques including a money market hedge, a futures hedge, a forward hedge, a currency option hedge, or some other technique. But in order to make these decisions (i.e., to hedge or not to hedge) in an optimal fashion, the corporation needs an objective assessment of exactly how much risk it faces. One particular approach to assessing risk that has become increasing popular since the middle of the 1990s is an approach described as “value at risk.” While the value at risk approach has wide applicability, it is increasingly used by MNCs to assess transaction exposure. Articles about this approach to measuring risk are now common in the literature.

This “value at risk” technique is a probabilistic approach to measuring downside risk (i.e., the maximum loss) that is likely to occur within a specific time frame at a particular level of confidence. An MNC may utilize this methodology to assess the transaction exposure associated with net cash flows denominated in one (or each) particular currency in which it does business. If the expected percentage change in the exchange rate is zero, the downside risk (maximum loss) is a function of the standard deviation in the percentage changes of the particular exchange rate, the

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<sup>2</sup> Madura (2008) provides an excellent overview of the types of risks that may result from exchange rate fluctuations, including transaction exposure.

(dollar) value of the net cash flow itself, and the desired confidence level. The “value at risk” (the maximum loss) is positively associated with each of these three variables. If the exchange rate is expected to change over the relevant time period (i.e., the “expected percentage change” is not zero), then the estimate for the expected percentage change in the exchange rate also becomes a factor in the value at risk calculation.

In addition, an MNC may utilize this basic approach to assess the riskiness of the net cash flows associated with the “portfolio” of currencies in which it transacts business. This use of the model, which measures the transaction exposure associated with the net cash flows associated with an entire “portfolio” of currencies, is particularly valuable for MNCs that transact business in multiple currencies on a routine basis. Based on standard portfolio theory, the transaction exposure (i.e., the maximum loss) in this latter case is a function of the proportions of the total portfolio in each currency, the standard deviations of the percentage changes in each exchange rate, the correlation coefficients of the percentage changes of the relevant exchange rates, the (dollar) value of the net cash flows, and the desired confidence level. If the expected percentage changes in the relevant exchange rates are not zero, then the estimates for these (nonzero) expected percentage changes also become factors in the value at risk calculations.

Of course, a portfolio of currencies whose values are highly volatile vis-à-vis the dollar (i.e., the standard deviations in percentages changes in the dollar exchange rates are high) will have a high level of transaction risk, *ceteris paribus*. Portfolios of currencies that possess positive and high correlation coefficients will also face more “value at risk,” other things equal. On the other hand, portfolios of currencies that have low (or even negative) correlation coefficients will have less value at risk due to internal (or natural) diversification effects.

Value at risk is sensitive to the “holding period” (i.e., the particular time period being considered). For example, if a particular exchange rate varies more over a month than over a week, or if the anticipated net cash flow denominated in a particular currency is greater for the next month than the next week, then the value at risk (i.e., the maximum loss) will be greater for the next month than the next week, given the same level of confidence. Because MNCs can predict their net cash flows with far more accuracy over relatively shorter periods of time, the value at risk model is most often used for predicting the maximum loss over relatively short periods of time. However, it may be that an MNC would find it useful to predict the value at risk for longer time periods, as well.

## **REVIEW OF THE LITERATURE**

While the expression “value at risk” is widely used, the expression does not refer to one unique methodology (or approach) to quantifying risk. Rather, it refers to a family of related approaches including: 1) the variance-covariance approach (also called the “delta normal “approach” or the “parametric approach”), 2) historical simulation, and 3) the use of Monte-Carlo simulations. Linsmeier and Pearson (2000) provide an excellent overview of the advantages and disadvantages of these three approaches to estimating value at risk.

Al Janabi (2006) provides an excellent primer on the variance-covariance method to measuring value at risk. The article by Glasserman, Heidleberger, and Shahabuddin (2002) discusses the use of Monte Carlo simulations to estimate value at risk. The following articles provide good overviews of VAR methodology or empirical tests of the different approaches: Carrada-Bravo, Hosseini, and Fernandez (2006), Tardivo (2002), Stambach (1996), Hendricks (1996), Angelidis and Degiannakis (2005), Chong (2004) and Gramlich (2002). The article by Kimball (2000)

provides an excellent perspective as to why corporations may, in fact, be prone to miscalculate risk.

As described in the introduction to this paper, increasing globalization, the increased use of derivatives, and a number of blockbuster business failures all contributed to a heightened sensitivity to risk. Platt (2007), for example, provides an excellent discussion of the increased use of value at risk resulting from globalization. Beyond these key environmental changes, the usage of value at risk (VAR) as a management tool increased significantly in the second half of the 1990s as the Securities and Exchange Commission required that publicly held corporations quantify and disclose their market risk associated with volatility in foreign currency exchange rates, interest rates, commodity prices, and additional risk factors using VAR or comparable methods. (See Thiem and Ruiz-Zaiko, 1998) Another factor which promoted the usage of VAR was the Basle II Capital Accord (1997) which required that bank regulators set capital requirements (for individual banks) based on the bank's value at risk. (See Sacks, 1997)

Despite the widespread usage of the value at risk methodology, the potential shortcomings of this approach to measuring downside risk are fairly well known. One of these shortcomings is the possibility that the assumption the variable (or variables) in question is normally distributed is incorrect. Articles that explore the implications of nonnormal distributions, including fat tails and how to employ VAR in these cases (sometimes referred to as "extreme value theory"), include Neftci (2000), Hull and White (1998), Bekiros (2008), Novak, Dalla, and Giraitis (2007), Yamai and Yoshiba (2005), Ferreira (2005), Castellano and Giacometti (2001), Taylor (2000), Mittnik and Paolella (2000), Kaut, Vladimirov, Wallace, and Zenios (2007), and Ghaoui, Oks, and Oustry (2003).

Another potential vulnerability of the VAR approach is that the ability to forecast volatility deteriorates as the time horizon (or "holding period") lengthens. Relevant articles include Christoffersen and Diebold (2000), Fernandez (2005), and Chiu, Lee, and Hung (2005). Jorion (1996) discusses how VAR analyses may be subject to "estimation error" and how VAR forecasts can be improved.

The article by Artzner, Delbaen, Eber and Heath (1999) describes a modification of the basic value at risk methodology referred to as "conditional value at risk" (CVAR) which evaluates the risk the corporation faces given (i.e., assuming) the loss will exceed the VAR. In other words, CVAR attempts to provide information on exactly how big the loss is likely to be, assuming the loss will exceed the VAR at a particular confidence level. Basak and Shapiro (2002) and Alexander and Baptista (2004) pursue the "conditional value at risk" concept.

Despite the potential weaknesses of the VAR approach to measuring risk, a reasonably accurate, albeit imperfect, measure of risk is preferable to ignorance or avoidant behavior. The article by Jorion (2002) presents evidence the "VAR disclosures [by commercial banks] are informative in that they predict the variability of trading revenues."

In the last several years, most textbooks on risk management (or derivatives) have added chapters on value at risk. Excellent examples include Hull (2009) and Chance and Brooks (2007). The international finance text by Madura (2008) includes a good discussion of how value at risk can be employed in the specific context of managing transaction exposure due to fluctuating exchange rates.

## OVERVIEW OF METHODOLOGY

The transaction exposure (transaction risk) of conducting business in a particular foreign currency is a function of the standard deviation in the daily percentage changes of the particular exchange rate and the desired confidence level. More specifically, the risk associated with doing business in “currency Y” is, at the 95-percent confidence level, given by:

$$\text{Maximum one-day loss} = E(e_t) - (1.65 \times \sigma_y) \quad \text{Equation 1}$$

where  $E(e_t)$  = the expected percentage change in the exchange rate

$\sigma_y$  = the standard deviation in the daily percentage change of the exchange rate

Obviously, if the expected percentage change in the exchange rate is zero, the maximum one-day loss at the 95-percent confidence level is simply  $(1.65 \times \sigma_y)$ . Or, in other words, the likelihood of the corporation experiencing a loss greater than  $(1.65 \times \sigma_y)$  is less than 5 percent.

Based on accepted portfolio theory, the standard deviation in the daily percentage changes of a two-currency portfolio can be measured as follows:

$$\sigma_p = \sqrt{W_X^2 \sigma_X^2 + W_Y^2 \sigma_Y^2 + 2W_X W_Y \sigma_X \sigma_Y \text{CORR}_{XY}} \quad \text{Equation 2}$$

where:

$\sigma_p$  = the standard deviation of the two-currency portfolio

$W_X$  = proportion of the total portfolio in currency X

$W_Y$  = proportion of the total portfolio in currency Y

$\sigma_X$  = the standard deviation in the daily percentage changes in currency X

$\sigma_Y$  = the standard deviation in the daily percentage changes in currency Y

$\text{CORR}_{XY}$  = the correlation coefficient of the daily percentage changes between currencies X and Y

The risk associated with carrying net positions in this two-currency portfolio is, at the 95-percent confidence level, given by:

$$\text{Max. one-day loss of the currency portfolio} = E(e_t) - (1.65 \times \sigma_p) \quad \text{Equation 3}$$

where  $E(e_t)$  = the expected percentage change in exchange rate

$\sigma_p$  = the standard deviation in the daily percentage change of the currency portfolio

If the expected percentage change in the exchange rate is zero, the maximum one-day loss at the 95-percent confidence level is simply  $(1.65 \times \sigma_p)$ . Or, in other words, the likelihood of the corporation experiencing a loss greater than  $(1.65 \times \sigma_p)$  on the entire portfolio is less than 5 percent.

This paper measures the “value at risk” (VAR) for a hypothetical multinational corporation transacting business in five specific foreign currencies for two recent time periods using the variance-covariance approach (also called the delta normal approach). The five currencies

evaluated include: the Swiss franc, the British pound, the Euro, the Canadian dollar, and the Japanese yen (i.e., all vis-à-vis the U.S. dollar). The two time periods are i) from February 12, 2007 through March 30, 2007, and ii) from September 3, 2007 through October 12, 2007. Each time period includes thirty consecutive observations on the relevant spot exchange rates.

However, while previous articles about value at risk by the authors of this paper have assumed that the “expected percentage change in the exchange rate” is zero, i.e., the exchange rate is not expected to change over the relevant time period [See Khazeh and Winder (1) and Khazeh and Winder (2)], this paper assumes an adaptive expectations model whereby the MNC expects the exchange rate to change by the same percentage as the average for the most recent 15-day period. In effect, these VAR calculations include a forecasted change in the exchange rate based on the most recent 15-day period. The results of these calculations are then compared to the authors’ earlier results (i.e., which assumed the expected percentage change in the exchange rate is zero).

## EMPIRICAL RESULTS AND DISCUSSION

The results for each of the five individual currencies (i.e., their dollar exchange rates), for each of the two time periods, are shown below in Exhibits 1 through 10. For each Exhibit, the first (top) histogram indicates the value at risk assuming no expected percentage change in the exchange rate (i.e.,  $E(e_t)$  from Equation 1 is assumed to be zero). The second (lower) histogram indicates the value at risk assuming a percentage change in the exchange rate equal to the average percentage change for the prior fifteen trading days (i.e., a fifteen-day moving average). Because these latter VAR calculations include a forecasted exchange rate change equal to the average percentage change over the prior 15-day period, the value at risk is calculated for only the last 15 days of each of the two 30-day periods.

As can be seen in the Exhibits, the VAR calculations which include a forecasted change in the exchange rate based on a 15-day moving average (i.e., the lower histograms) indicate less value at risk for each currency and for each time period.<sup>3</sup> For example, Exhibit 1 (representing the U.S. dollar/British pound exchange rate for the Feb.-March, 2007 time period) shows that assuming no expected change in the exchange rate the VAR for the first day was slightly more than .4 percent (i.e., .4 percent of the MNCs net cash flow denominated in British pounds). By comparison, assuming the U.S. dollar/British pound exchange rate would change by the same percentage as the average for the previous 15 trading days, the VAR was just slightly more than .1 percent. For the fifteenth day, the same comparison was a VAR of slightly more than .6 percent and a VAR of a little more than .3 percent.

The reason why the VAR is reduced when the calculation includes a nonzero expected percentage change in the exchange rate is, of course, that the U.S. dollar depreciated against each of the five foreign currencies during the Feb.-March, 2007 time period. In the context of Equation 1,  $E(e_t)$  was therefore assumed to be a positive number (based on the average percentage change in the dollar/pound exchange rate over the prior 15-day period). Conceptually, if the risk associated

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<sup>3</sup> It should be noted that the comparisons shown in Exhibits 1 through 10 implicitly assume that the MNC has net cash receivables (i.e. inflows) denominated in each of the foreign currencies. While this assumption is plausible (for example, a U.S.-based MNC might sell a product in various foreign markets, thereby resulting in receivables denominated in each respective foreign currency), it is also possible that an MNC could have net cash payables in a particular foreign currency. In this latter case, the value at risk calculations which include a nonzero exchange rate change would be greater than under the zero percentage change assumption during a time when the U.S. dollar is expected to depreciate.

with the dollar/pound exchange rate is .6 percent at a particular confidence level, but the dollar is expected to depreciate by .2 percent (or, alternatively, the value of the foreign currency is expected to rise by .2 percent), the VAR would be reduced to just .4 percent of the net cash flow.

Exhibit 2 indicates a similar phenomenon with respect to the Japanese yen for the Feb./March, 2007 period, except that the VAR is greater due to the greater volatility in the underlying U.S. dollar/Japanese yen exchange rate. Still, because the dollar was generally depreciating vis-à-vis the yen, when a depreciation of the U.S. dollar is built into the calculation, the VAR is reduced. As a specific example, for the first day, the value at risk assuming no change in the exchange rate was approximately 1.4 percent while the value at risk assuming a change in the exchange rate (equal to the average percentage change over the prior fifteen days) was approximately .7 percent of the net cash flow. The results for the additional three currencies (shown in Exhibits 3-5) are consistent with the findings for the British pound and the Japanese yen. In general, including a nonzero change in the exchange rate reduces the VAR by roughly one-half.

Overall, the findings for the Sept.-Oct. 2007 time period are similar (see Exhibits 6-10). While the value at risk is greatest for net cash flows denominated in Japanese yen, the inclusion of a nonzero change in the exchange rates reduces the value at risk by roughly one-half.

## **CONCEPTUAL AND PRACTICAL CONSIDERATIONS FOR THE FUTURE**

These findings raise both conceptual and practical considerations about using the increasingly popular value at risk methodology for assessing transaction exposure. As noted above, the inclusion of a nonzero expected percentage change in the exchange rate in the VAR calculations of transaction exposure will always reduce the value at risk on net receivables (both in percent as well as the actual dollar value) if the U.S. dollar is expected to depreciate vis-à-vis the foreign currency. An appreciation of the U.S. dollar, of course, will have the opposite effect.

Conceptually, the percentage change in the exchange rate,  $E(e_t)$ , is not viewed as probabilistic in the context of the model. Rather, it is assumed to be known with certainty. Nonetheless, how much confidence an MNC can have in such a forecast is unclear. Ultimately, if the MNC chooses to build into the VAR calculation a nonzero percentage change in the exchange rate, the accuracy of the VAR estimate will depend, in part, on the accuracy of the exchange rate forecast. In this event, estimating value at risk is to some extent an exercise in forecasting changes in exchange rates. The adaptive expectations approach utilized in this study may, or may not, be desirable in this regard.

As a practical matter, the best option may be for the MNC to assume that the relevant exchange rate(s) will not change (i.e., assume that  $E(e_t)$  is zero) over the relevant time period. This may be desirable, in particular, for very short holding periods (such as one day) or in cases where the change in the exchange rate is likely to be small in relation to the variability of the exchange rate (i.e.,  $\sigma_y$ ).<sup>4</sup>

As Hull (2009) describes, “It is customary...to assume that the expected change in a market variable over the time period considered is zero. This is not strictly true, but it is a reasonable assumption. The expected change in the price of a market variable over a short time period is

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<sup>4</sup> The standard deviation for a longer holding period of  $N$  days will approximately equal the standard deviation for one day multiplied by the square root of  $N$ . For example, the standard deviation for a holding period of 25 trading days will be approximately five times the standard deviation for a holding period of one day. For more discussion see Hull (2009), p. 456.

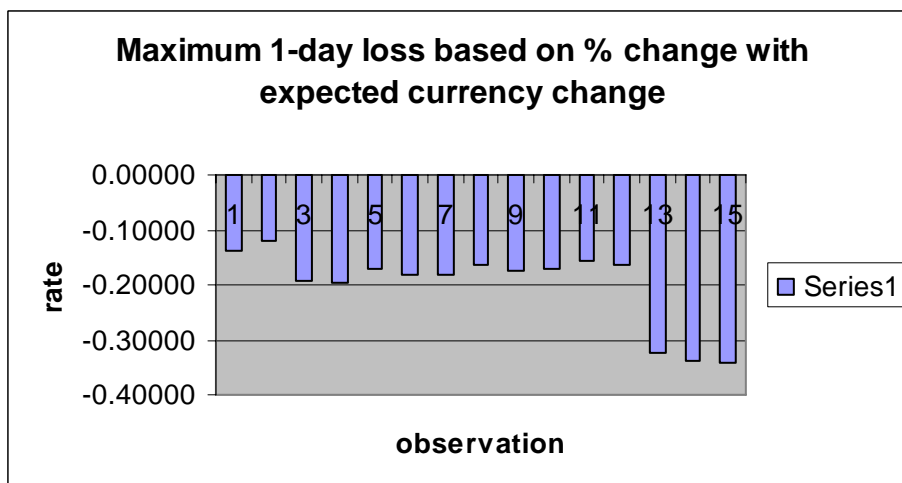
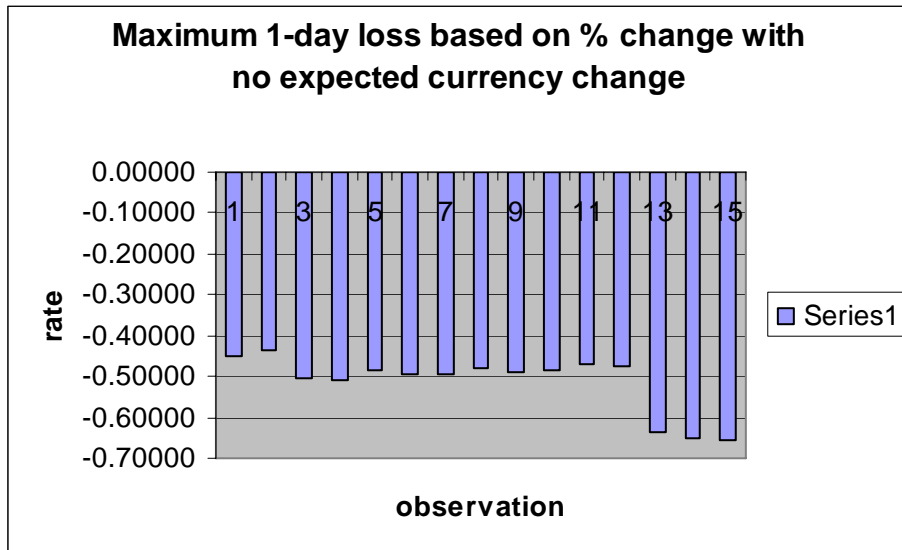
generally small when compared with the standard deviation of the change.” (p. 456) Chance and Brooks (2007) similarly observe “... it is fairly common to assume a zero expected value. This is because one day is a common holding period over which to calculate a VAR and the expected daily return is very small. A typical VAR calculation is much more highly influenced by the volatility than by the expected return.” (p. 531)

Having made this point, it is true, nonetheless, that the inclusion of a nonzero expected change in the exchange rate significantly impacted the values at risk for these particular currencies and for these specific time periods. It should also be noted that the specific examples provided by Hull (2009) and by Chance and Brooks (2007) refer to using value at risk methodology to determine the maximum downside risk associated with equity prices, not foreign currencies. It is unclear whether their views can be generalized to a broader array of financial assets.

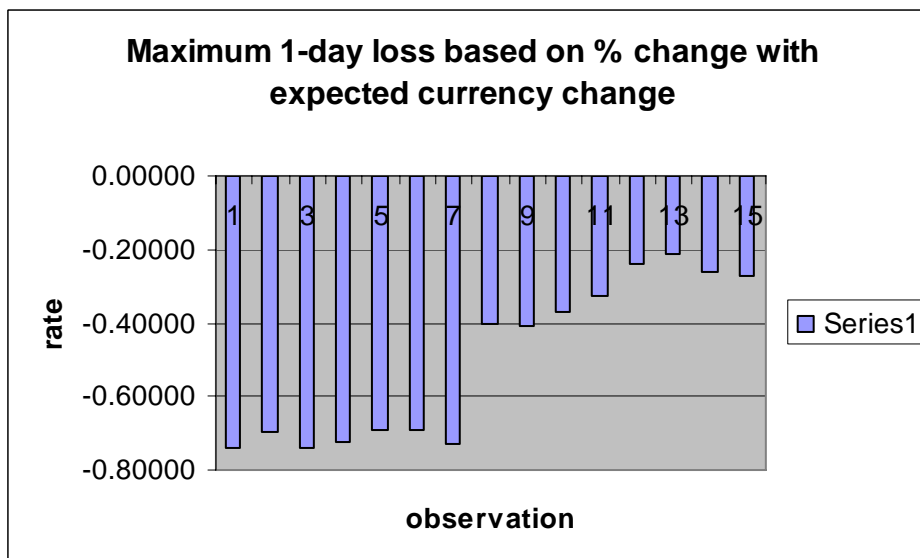
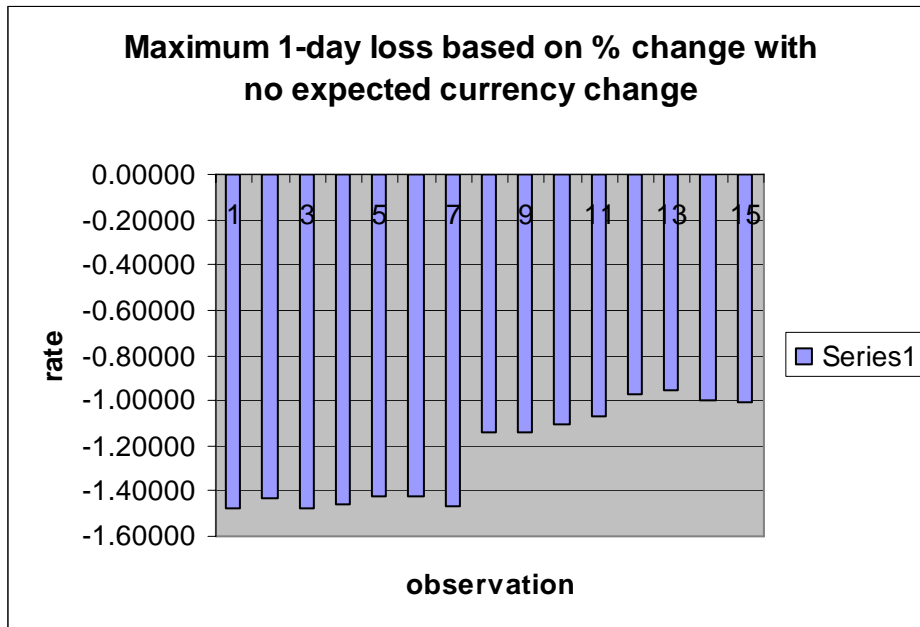
For the future, it may be valuable to examine additional time periods to evaluate the impact of including a nonzero change in the exchange rate. If it can be established that the two time periods evaluated in this paper were atypical, and that for most periods the volatility (i.e., the standard deviation) in the exchange rate does, in fact, dominate the expected change, the assumption of no change in the exchange rate gains credibility. It may also be worthwhile to evaluate longer time periods (e.g., one week or one month) to determine the sensitivity of the results to the length of the holding period.



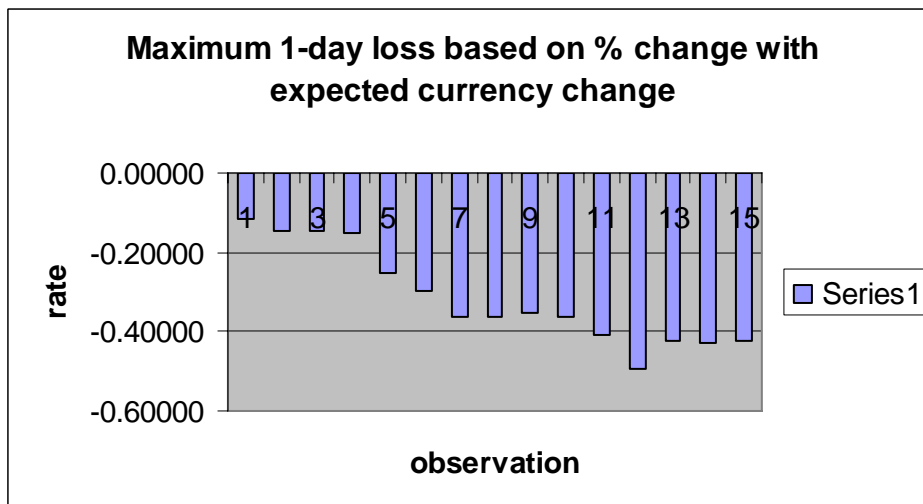
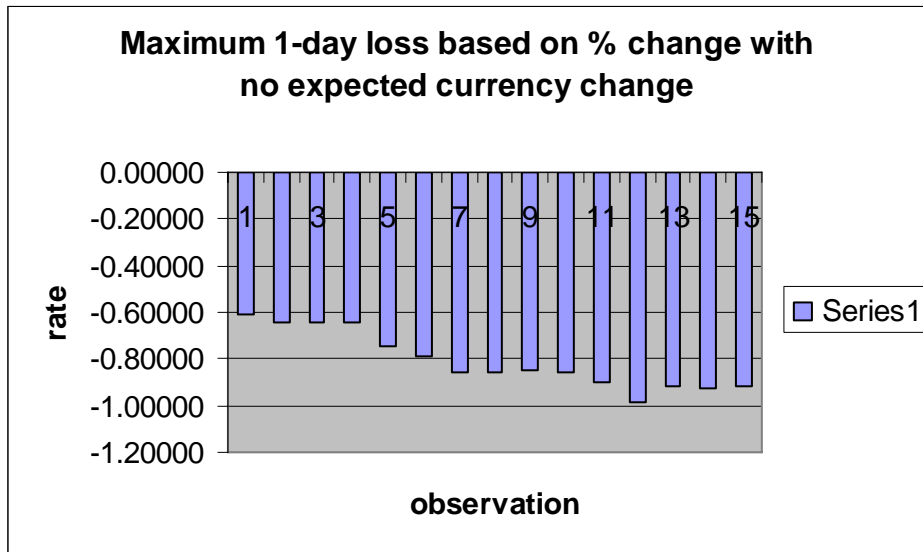
**Exhibit 1--Spring 2007 Comparisons for the British Pound (for Net Receivables)**



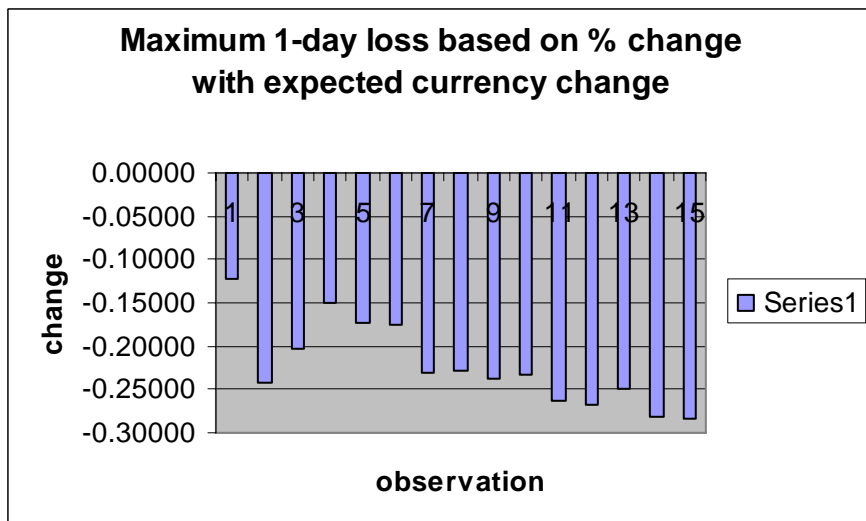
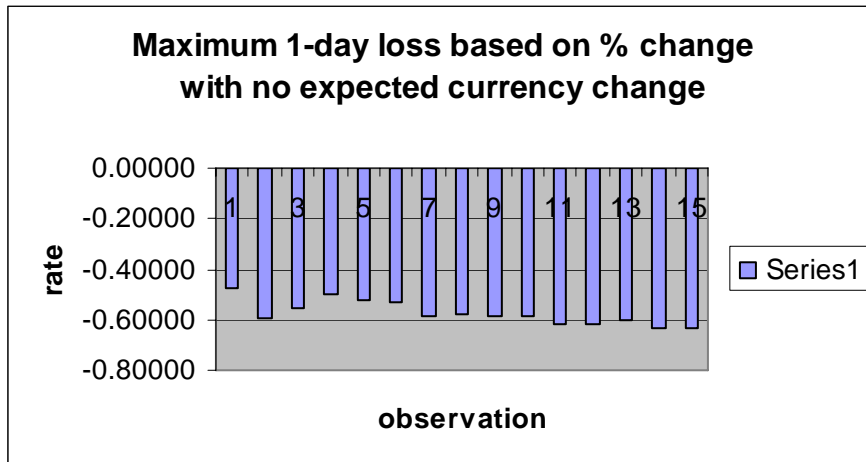
**Exhibit 2--Spring 2007 Comparisons for the Japanese Yen (for Net Receivables)**



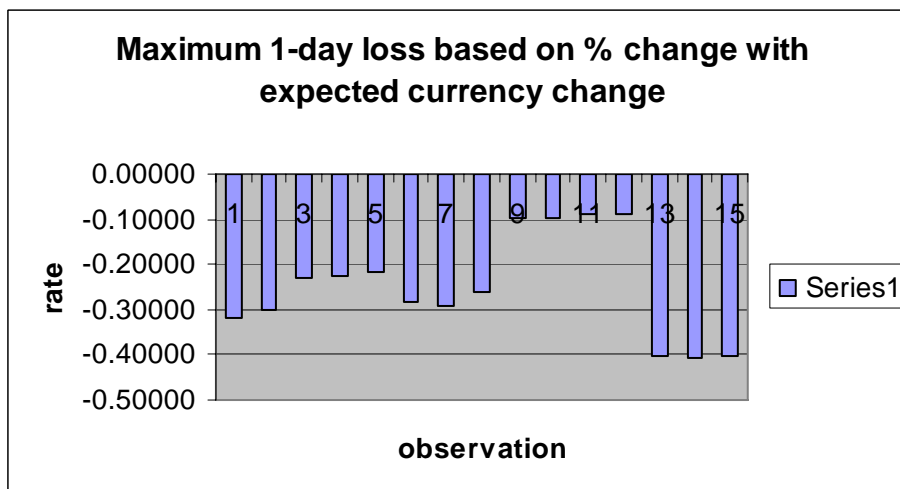
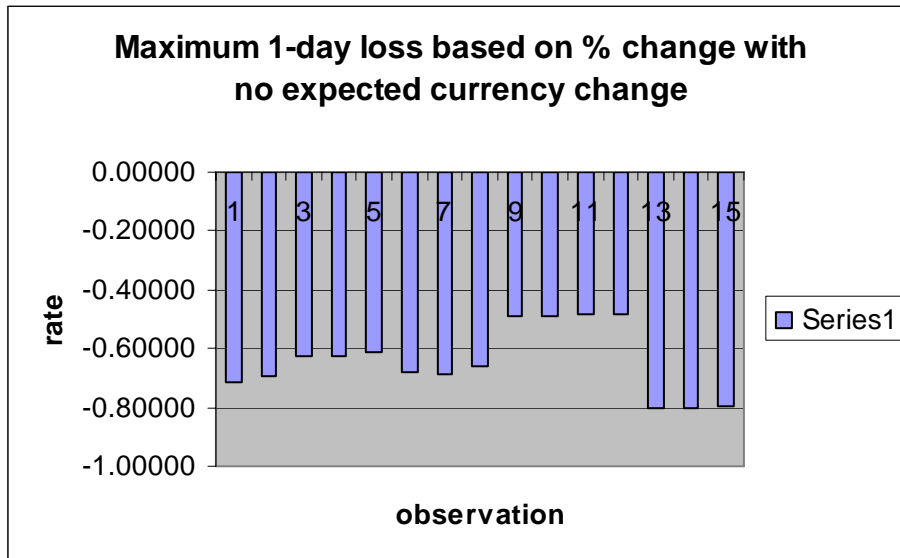
**Exhibit 3--Spring 2007 Comparisons for the Swiss Franc (for Net Receivables)**



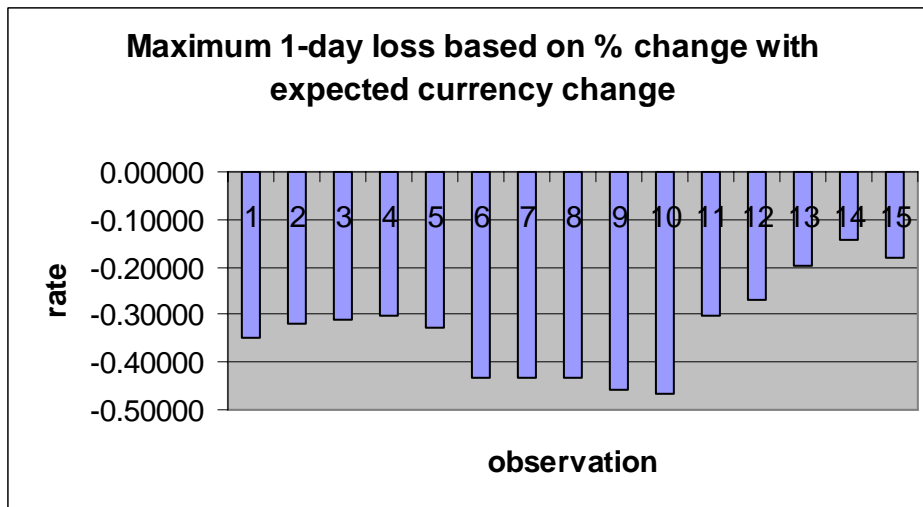
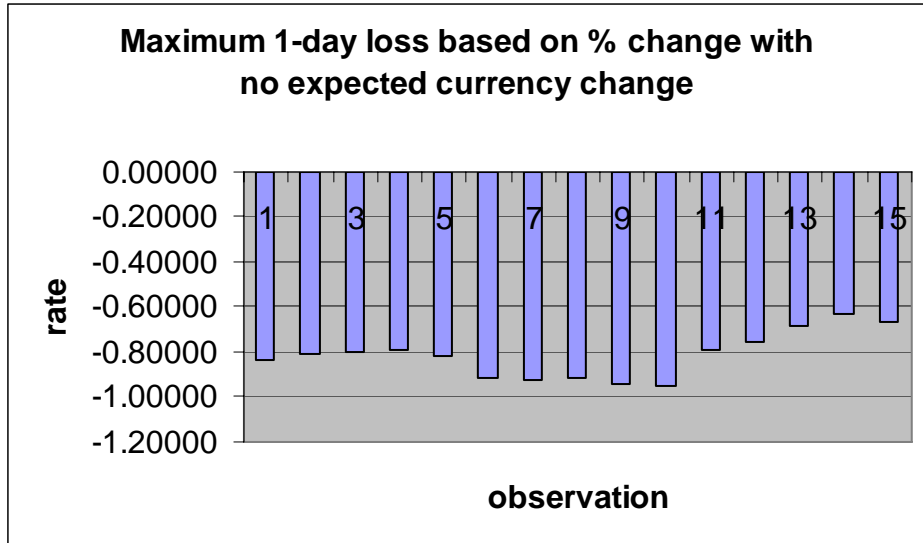
**Exhibit 4--Spring 2007 Comparisons for the Euro (for Net Receivables)**



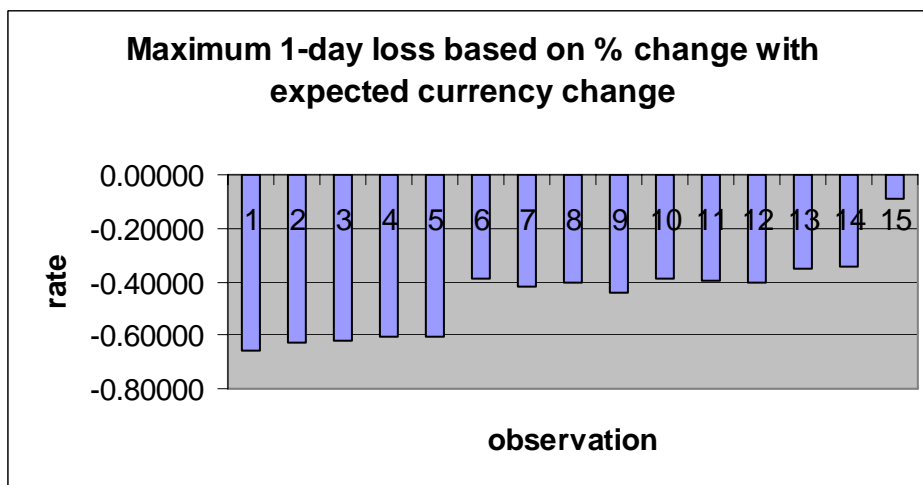
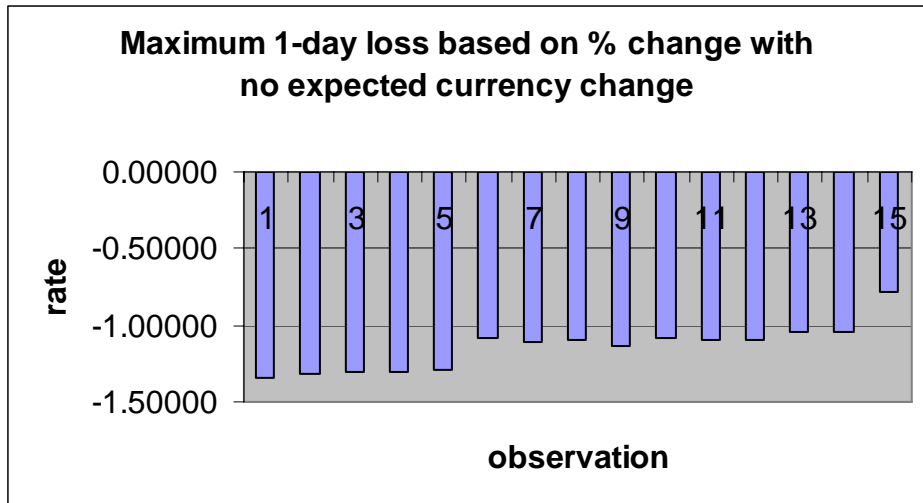
**Exhibit 5--Spring 2007 Comparison for the Canadian Dollar (for Net Receivables)**



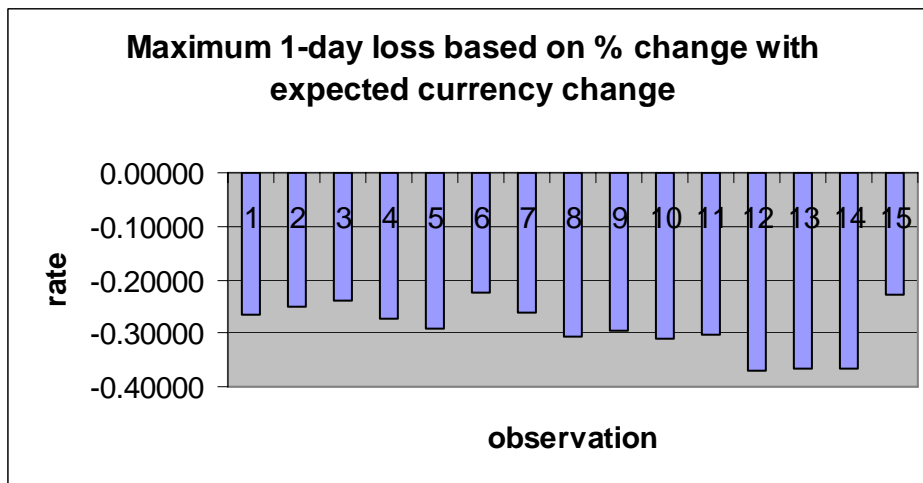
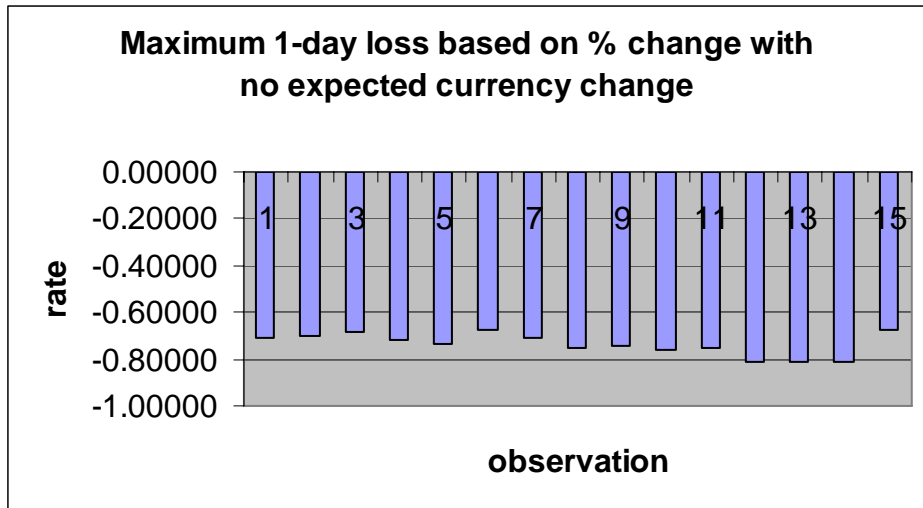
**Exhibit 6--Fall 2007 Comparisons for the British Pound (for Net Receivables)**



**Exhibit 7--Fall 2007 Comparisons for the Japanese Yen (for Net Receivables)**

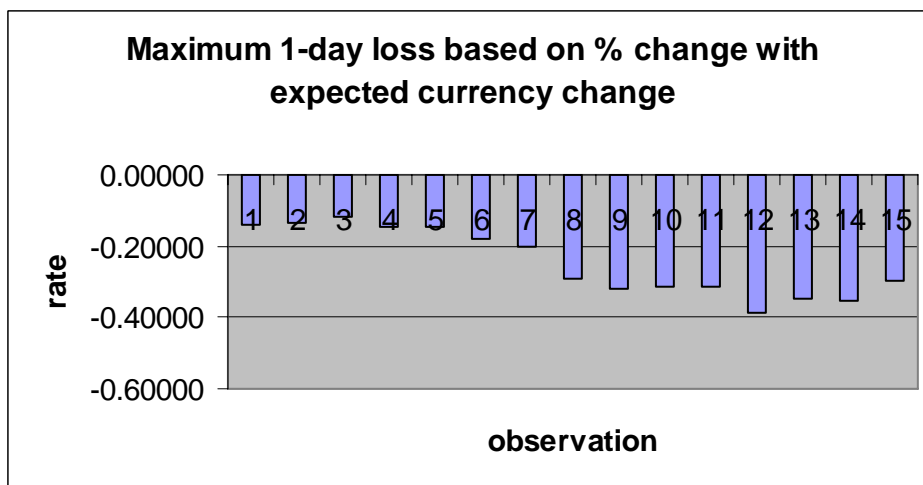
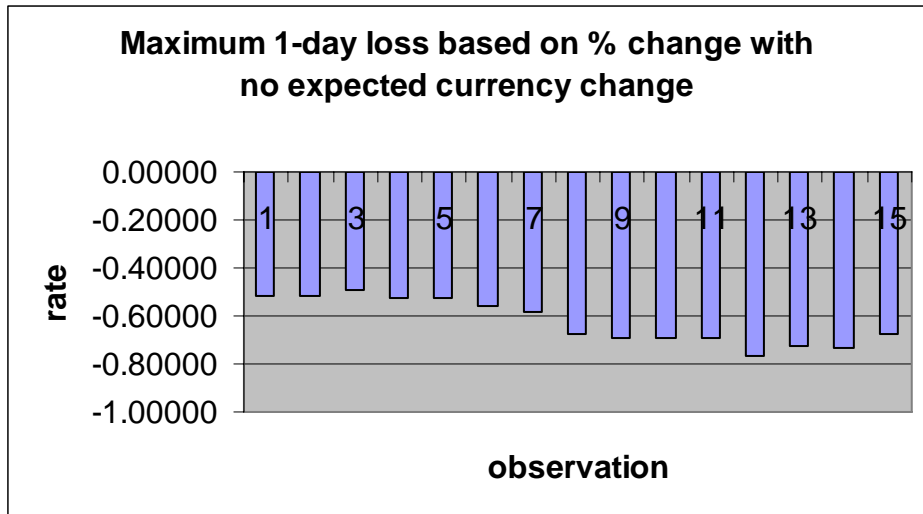


**Exhibit 8--Fall 2007 Comparisons for the Swiss Franc (for Net Receivables)**

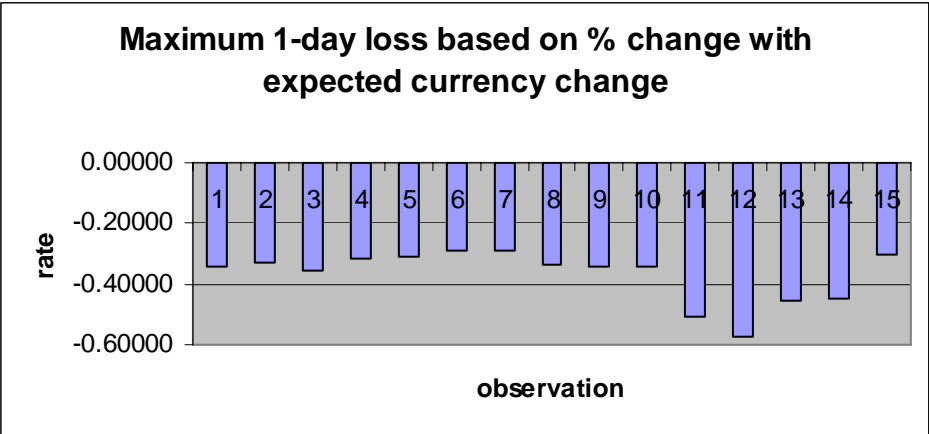
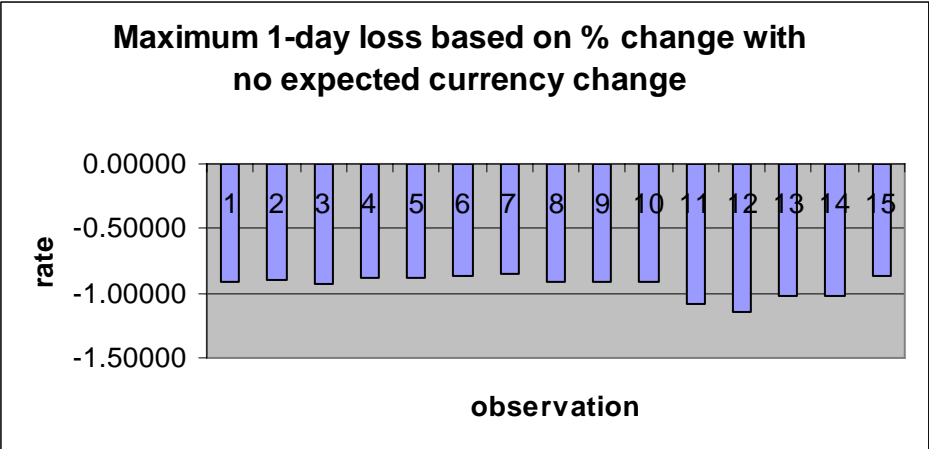




**Exhibit 9--Fall 2007 Comparisons for the Euro (for Net Receivables)**



**Exhibit 10--Fall 2007 Comparisons for the Canadian Dollar (for Net Receivables)**



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