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Foreign Exchange Risk Control in the Context of Supply Chain Management*

Koo-Woong Park**

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Abstract

Purpose – Foreign exchange risk control is in an important component in the international supply chain management. This study shows the importance of the reference period in forecasting future exchange rates with a specific illustration of KIKO currency option contracts, and suggests feasible preventive measures.

Research design, data, and methodology – Using monthly Won-Dollar exchange rate data for January 1995~July 2007, I evaluate the statistical characteristics of the exchange rate for two sub-periods; 1) a shorter period after the East Asian financial crisis and 2) a longer period including the financial crisis. The key instrument of analysis is the basic normal distribution theory.

Results – The difference in the reference period could lead to an unexpected development in contract implementation and a consequent financial loss. We may avoid foreign exchange loss by using derivatives such as forwards or currency options.

Conclusions – We should consider not only level values but also the volatilities of financial variables in making a binding financial contract. Appropriate measures may differ depending on the specific supply chain pattern. We may extend the study with surveys on actual risk measures.

Keywords: Supply Chain, KIKO, Volatility, Foreign Exchange Risk, Forward/Options.

JEL Classifications: F31, F36, G13.

1. Introduction

Following the Nixon doctrine of ending the gold exchange standard in 1971, fixed exchange rate system under Bretton Woods regime effectively broke down and turned into flexible exchange rate system. Beginning with the United Kingdom in 1972, major countries including France, Belgium, Italy, and the US transformed into floating exchange rate regime and the fixed exchange rate regime became completely dissolved by 1974(Kim & Rhee, 2013). Most advanced countries adopted floating exchange rate system and many developing countries including Korea adopted managed floating system. Consequently, exchange rate volatilities of individual currencies have become much greater. In case of Korea, most foreign currency transactions have been accommodating to exports and imports of goods and services until early 1990s. However, from mid 1990s on, autonomous transactions of foreign exchange by private financial institutions and corporations have grown rapidly following the liberalization of foreign exchange trade by the government. Number of large corporations of Korea accumulated excessive foreign currency borrowings in the course of international expansion of their businesses through the 1990s. East Asian financial crisis broke out in 1997 and those indebted corporations suffered great difficulty in paying back the foreign loan and could not get rollover from the international creditors. From 2003 on Korean Won exchange rate became lower and stable and large US dollar forward sell has become very popular following the rapidly growing exports by the Korean ship builders from around 2007. Hundreds of small & medium sized Korean firms engaged in international trade along with dozens of large corporations entered into the so-called KIKO (Knock-In Knock-Out) foreign exchange hedging contract around 2007 arguably to avoid foreign exchange risk. Demand for the KIKO contract has grown enormously since and the contract amount by 519 companies has become 10.1 billion US dollars by June 2008 (Lee & Kim, 2009). This figure amounts to 35.2% of the export value of 28.7 billion dollars by those firms in the previous year. Meanwhile, 71 companies made a binding KIKO contract of 4 billion dollars, which amounted to 166% on average of the export value of 2.4 billion dollars (Lee & Kim, 2009). Faced with unexpected 2008 global economic crisis kindled by the bank-

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** "I declare that this paper is a modified and updated version of my previous paper presented at 2013 National Conference of International Trade Researchers in Inje, Gangwon-Do on 16th August 2013 hosted by Korea Trade Research Association, faithfully reflecting the comments by two discussants and anonymous referees."Corresponding Author & First Author, Division of International Trade, Incheon National University, Korea. Tel: +82-32-835-8546.
E-mail: kwpark@inu.ac.kr.

ruptcy of Lehmann Brothers, Korean Won exchange rate against the US dollar soared surpassing 1,460 Won/dollar in March 2009 and these firms suffered enormous amounts of foreign exchange loss. They (mostly small & medium sized firms) had to sell double amounts of dollars contracted in the KIKO agreement to the counterpart banks at contracted par value much lower than the then current exchange rates. Total accumulated loss related to the KIKO contracts during January ~ December 2008 amounted to 3.26 trillion Won although this figure mainly indicates accounting loss and not exactly the outflow of cash from the firms (Lee & Kim, 2009).

Korea has traditionally pursued export-oriented growth strategy and her trade dependency is prominently high recording almost 90% of GDP on average in the past 10 years (Bank of Korea, Economic Statistics System, http://ecos.bok.or.kr/). The ratio was 68% in 2003 and has been continually rising to 110% in 2012. International market participation is certain to continue to grow for the small & medium sized Korean firms and the ensuing foreign exchange risk will always matter. Even those companies that are not directly involved in international trade are potentially susceptible to foreign exchange risk via the competition with foreign goods or the fluctuations of prices of imported raw materials and intermediate parts. Lacking specialized experts and experience, small & medium sized firms cannot afford hardly any proper foreign exchange management. This paper first analyzes the basic structure of the KIKO contract and identifies the implied foreign exchange risk. Secondly, I suggest number of precautionary measures in order to reduce the foreign exchange risk and to minimize related financial loss especially for the small & medium sized Korean firms.

This paper is comprised of as follows. Section 2 reviews current literature on the subject. Section 3 analyzes the base structure and implied foreign exchange risk in the KIKO contract. Section 4explains possible measures to avoid the exchange risk and Section 5 concludes with a summary.

2. Literature Review

Gehrmann, Scharrer and Wetter(1978) analyze the measures against foreign exchange risk of the 686 export/import German firms in 1972 and 1976 under floating exchange rate system. Among the exporters,87% settled the payments in Deutsche Mark (D-Mark) and 4.6% in the US dollar. This trend was stronger in the small sized firms. This outcome was partly due to the preference of the German exporters and partly due to the strong competitive position of the German firms induced by their technological advantage. For importers D-Mark transaction share was 43% and second highest share was 31.4% by the US dollar in 1976. Among 545 exporters using external techniques of exchange risk control, only 17% covered 100% of exchange risk 47% partially and 24% never took any measure. Forward was adopted by 262 (82%) out of 321 trading companies which transacted in foreign currency. Meanwhile 102 (32%) firms used discounting, forfeiting, and exchange rate risk insurance. Adler and Dumas (1984) define the exposure to currency risk as being the estimated coefficient in the linear regression of domestic currency value at maturity of foreign currency denominated assets on the exchange rate. Adler & Dumas (1984) also show that forward contract could completely eliminate the risk due to exchange rate fluctuations but not the risk of the future changes of the foreign currency denominated prices e.g. of stocks. Bodnar and Gentry (1993) study the effect of the industry characteristics on the relation between the changes in exchange rates and industry values in Canada, Japan, and the US. Bodnar and Gentry (1993) proposed three routes for the exchange rate changes to affect corporate profitability: First, changes in relative competitiveness of exporters/importers against foreign firms, second, changes in production cost for importers of raw material or parts in the international market, and third, changes in the values of foreign currency denominated assets. Bodnar and Gentry (1993) listed export/import share in total revenue of the industry, supply market structure of raw material, and foreign direct investment of the industry as major factors affecting the relation between industry profitability and domestic currency value.

Dornbusch (1974) argues that the appreciation of domestic currency causes production factors other than physical capital to move from traded goods industry to non-traded goods industry and consequently the market value of capital in the latter industry becomes higher in the short run. This implies a positive correlation between domestic currency appreciation and the value of non-traded goods industry. Dominguez and Tesar (2001a) analyzed the relation between exchange rate changes and firm level value and trading volume, and found a counter-intuitive outcome in that firms with higher ratio of foreign trade face smaller size of foreign exchange exposure. Dominguez and Tesar (2001a) assert that this may be due to the better recognition of the exchange risk by the firms with large volume of foreign trade and resulting counter measures against potential risks. Dominguez and Tesar (2001b) show a significant correlation between changes in exchange rates and profitability at industry and firm levels using data for 1980~1999 for 8 countries; Chile, France, Germany, Italy, Japan, Netherlands, Thailand, and the United Kingdom. Dominguez and Tesar (2006) show that exchange exposure is related to the firm size, multinational corporation status, foreign sales, foreign assets, competitiveness and trade, in an analysis of the relation between exchange rate movements and corporate value.

Naylor, Marshall and Greenwood (2007) study how the relation between the executive board and finance department influences the foreign exchange risk management pattern using corporate data for a small open economy of New Zealand. The bigger the size of the finance department is, and the larger the exchange exposure is, the more likely the company is to hold treasury policy. Among the firms with hedging practices, 93% used forwards, 38% OTC (over the counter) options, and 31% swaps. Entorf, Moebert and Sonderhof (2011) find in an empirical study of 27 countries that the size of exchange exposure is closely linked to the sizes of current account and financial account. Analyzing monthly data for January 1991 ~ July 2004,

Entorf et al. (2011) show that exchange exposure of a country is positively affected by its exports and negatively by imports. Consequently, the size of the current account has a positive effect on the exchange exposure. In contrast, depreciation of domestic currency has a negative impact on capital exports and thus the size of financial account has a negative effect on the exchange exposure.

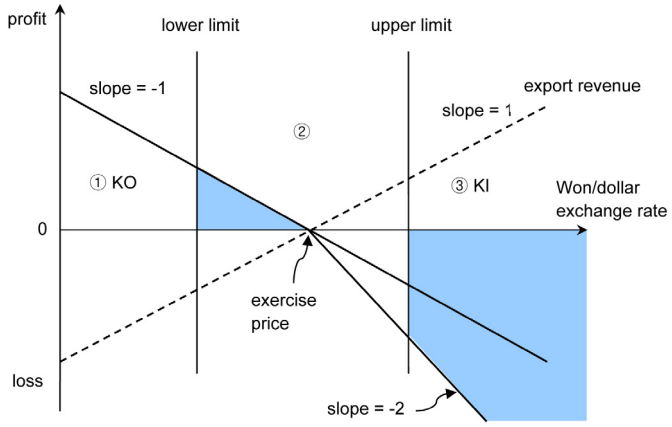
Kim and Sung (2005) examined the factors that induce firms to carry out foreign exchange risk control for 223 non-financial Korean companies. According to the study (Kim & Sung, 2005), firm size as a proxy for hedging cost or economies of scale was the most important element to stimulate a measure for exchange risk prevention. Export revenue was more important than foreign currency denominated debt, especially for public firms (= registered firms). As for the measures of exchange risk control, forwards accounted for 26%, leading & lagging for 23%, matching for 19%, money market utilization for 18%, and pricing policy for 13%. Meanwhile, currency options for 3%, currency swaps for 5%, netting for 5%, and currency futures for 6% were rarely used. Large corporations were more frequently adopting exchange risk control than small & medium sized firms. Lee and Kim (2009) explain the structure and characteristics of KIKO related financial derivatives. Lee and Kim (2009) also carried out comprehensive analysis of legal issues and policy implications with regard to KIKO contracts. Ko and Moon (2012) study the rapid expansion of KIKO contracts during 2006~2007 especially among small & medium sized Korean firms, rapid depreciation of Korean Won following 2008 global economic crisis, and the substantial foreign exchange loss of the firms involved in behavioral law and economics perspective.

Lee and Zhao (2014) conducted rigorous empirical tests on the causal relation between exchange rates and stock prices for China using data for 2002~2012. Carrying out unit root tests, cointegration tests and applying error correction models (ECMs), Lee andZhao (2014) find three key results. First, there is a long-run causation from exchange rates to stock prices. Second, changes in the nominal exchange rates of Chinese yuan against Japanese yen and Korean won strongly lead stock price dynamics in the short-run especially for Shanghai Stock Exchange market. Third, global financial crisis of 2007~2009 did not cause structural break in the Chinese stock market. These results indicate another avenue of research of exchange rate dynamics. Go & Lau (2014) examine the dynamic relations between price changes and trading volume of Kuala Lumpur Options and Financial Futures Exchange (KLOFFE) futures market for 2000~2008. Go & Lau (2014) identify the asymmetric effect in the information arrival of futures return and trading volume under bull and bear markets and attribute this outcome to noise-trading behavior. Go and Lau (2014) also show that past trading volume is positively correlated with subsequent volatility of returns. Ishaq, Hussain, Khaliq and Waqas (2012) review the triple-A of supply chain management – Agility, Adaptability and Alignment. Especially, alignment with supply chain partners and in sharing risks associated with supply chain may have implications for our study.

3. Base Structure and Summary Statistics

3.1. KIKO Structure

A typical KIKO (Knock-In Knock-Out) contract is an asymmetric composite option with a long position of one unit of a put option and a short position of two units of a call option with the same exercise prices. In addition, KIKO has a lower limit below which put option becomes nullified (knock-out) and an upper limit above which call option becomes operative (knock-in). Consequently, if the exchange rate at the maturity date exceeds the exercise price by a large margin the KIKO contract buyer (usually, companies) incurs great amount of financial loss. <Figure 1> shows the basic structure of KIKO contract and the corresponding profit/loss of KIKO buyer as a function of exchange rate at maturity date.



Source: Kim (2009, Figure 10)

<Figure 1> Profit/loss structure of a typical KIKO contract at maturity

In <Figure 1>, the region '① KO' to the left of the lower limit is the knock-out range where the right of the KIKO contract buyer to exercise the put option becomes nullified and the region '③ KI' to the right of the upper limit is the knock-in range where the obligation of the KIKO buyer to service the call option (i.e. must accept the exercise by the counterparty, usually banks) becomes operative. The highlighted parts indicate prospective loss (pentagon below the zero horizontal line) or profit (triangle above the zero horizontal line) of a KIKO contract buyer compared to the pre-contract situation. For example, let us assume that the exercise price is 1,100Won/$, lower limit is 850Won/$, and upper limit is 1,350Won/$. If the exchange rate at maturity happens to be between 850Won/$and 1,100Won/$, then the KIKO buyer company can make a profit as highlighted (the vertical height). However, if the exchange rate turns out to be higher than 1,350Won/$, then the KIKO buyer firm faces proportionately higher amount of financial loss. We should note the strictly limited profit opportunity but the possibility of an un-

limited loss for the KIKO contract buyer. In ranges below 850Won/$ or between 1,100Won/$ and 1,350Won/$, KIKO buyer firm's profit/loss show no difference before and after the contract except any transaction fees.

3.2. Exchange Rates Volatility and Their Prediction

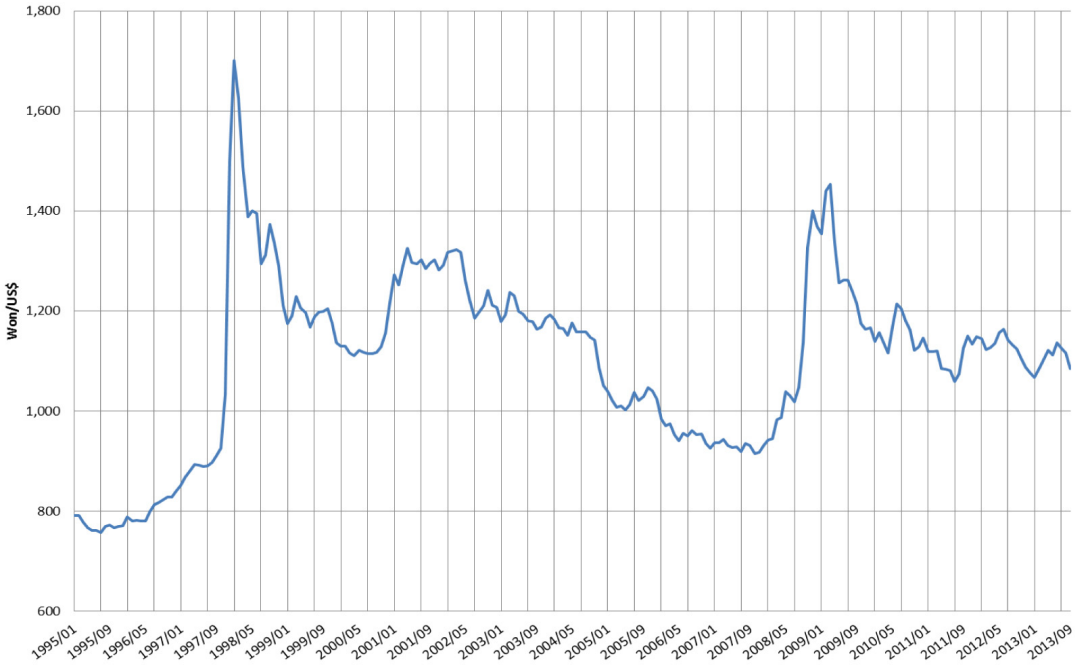
Meanwhile, we show the changes of Won/dollar exchange rates in <Figure 2>. The Won/$ exchange rate maintained values below 1,200Won/$ from May 2003 on once the East Asian financial crisis has subsided and it remained below 1,000Won/$ between January 2006 and April 2008. However, it began to soar after the Lehmann Brothers bust in September 2008 and reached 1,453Won/$ in March 2009. Accordingly, the knock-in clause of call option has been enacted and the KIKO contract buyer companies were forced into position to sell twice the contract amount of dollar at much lower exercise price, e.g. at 1,100Won/$, than the then spot price to the counterparty banks.

analysis of what happened to KIKO contract buyers, we calculate the exchange rate volatility using standard deviation with monthly Won/$ exchange rate data up until August 2007 when the KIKO contract began to increase rapidly. We consider two sub-periods; 1) Period I spans from August 2001 to July 2007 for 72 months and 2) Period II spans from August 1995 to July 2007 for 144 months. Only the second period covers the East Asian financial crisis. <Table 1>summarizes the base statistics of exchange rates.

<Table 1> Statistical characteristics of monthly Won/dollar nominal exchange rate

Period	Average	Standard deviation	Kurtosis	Jarque-Vera
Period I: August 2001~July 2007 (72 months)	1,108Won/$	127Won/$	1.65	5.49
Period II: August 1995~July 2007 (144 months)	1,100Won/$	188Won/$	2.86	0.51

Source: Bank of Korea (2014).



Source: Bank of Korea (2014).

<Figure 2> Time series of monthly Won/dollar nominal exchange rates

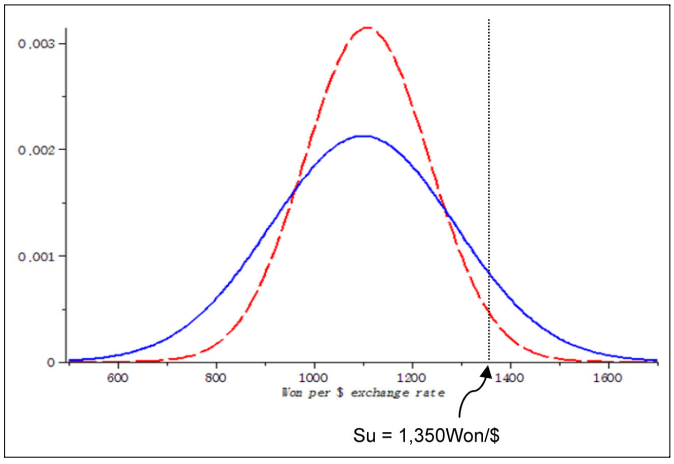
We may define the size of exchange risk as below.

Exchange risk = Exchange exposure x Exchange rate volatility (1)

For example, if the contract volume is 1 million dollar, the company incurs an exchange loss of 2 x $1,000,000 x (1,453Won/$ - 1,100Won/$) = ₩706 million. To begin with the

We can see in <Table 1> that average exchange rate is only slightly higher during Period I but its volatility in terms of standard deviation is much higher by about 48% during Period IIthan during Period I. Meanwhile, according to the kurtosis and Jarque-Vera statistics, we may say that Period I data indicate quite a big difference from a normal distribution while Period II

data show fairly close proximity to a normal distribution. Theoretically, normal distribution has a kurtosis of 3 (Ryu, 2013). We show in <Figure 3> the normal distribution approximation of Period I and Period II exchange rate distributions with corresponding averages and standard deviations as given in <Table 1>.



<Figure 3> Normal distribution approximation of exchange rate distributions

The dashed curve in <Figure 3> is the pdf (probability density function) for Period I and the solid curve is the pdf for Period II. If firms base their expectations of future prospects of exchange rates on relatively short Period I, then the probability of exceeding the upper limit of 1,350Won/$ equals a small size of p(z≥(1,350-1,108)/127) = p (z≥1.906) = 2.8%. In contrast, the probability based on the longer Period II becomes much larger at p(z≥(1,350-1,100)/188) = p (z≥1.33) = 9.2% instead. Hence, we have to consider the danger of greatly increasing the forecasting error depending on which period we use as a criterion when we predict future course of exchange rates based on past data. If we set the upper limit at 1,250Won/$, then the probabilities rise to 13.2% based on Period I data and 22.2% based on Period II data. That is to say, firms need to notice the danger of underestimating the possibility of future exchange rates exceeding the upper limit and thereby enacting the call option exercise and incurring exchange loss.

4. Results and Discussion: Foreign Exchange Risk Control

Companies may export or import goods and services, raw material and parts to and from abroad. They may also import final products from abroad to sell them at home. Firms may carry out foreign direct investment (FDI) or get foreign funds from international capital market. These firms may experience unexpected changes in their revenue in terms of domestic currency coming from their international business operation depending on the fluctuating exchange rates. On the other hand, pure domestic firms competing with imported goods or with other domestic companies which procure material and parts from abroad may also be affected indirectly by the changes in exchange rates. I consider three patterns of international trade to analyze the potential foreign exchange risk; 1) Firms produce final products at home and exports them to foreign countries, 2) Firms import raw material and intermediate parts from abroad and produce and sell final products at home, and 3) Firms import final products from abroad and sell them at home.

4.1. Exporters of Final Product

We consider first firms that produce final products at home and export them to foreign countries.

4.1.1. Foreign exchange risk pattern

We can illustrate flows of cost and revenue in home and foreign currencies as in <Figure 4> and the corresponding equations as below, ignoring interest costs between time t1 and time t3. The numbers in the second digit indicate timing of incidence.

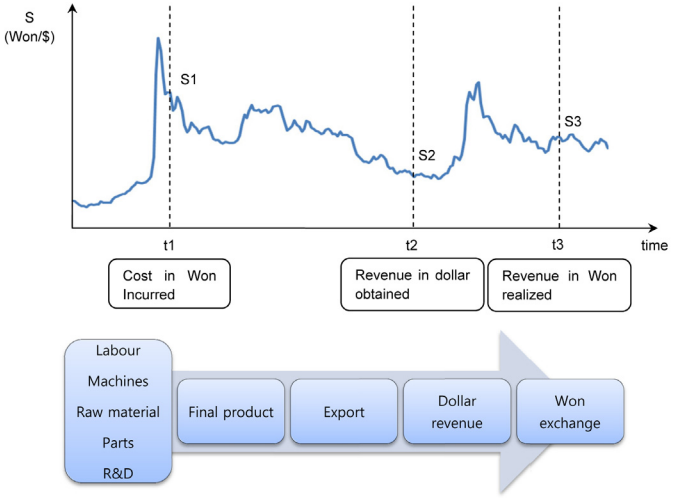
Cost in domestic currency (Won) = C1

Revenue in foreign currency ($) = R2

Revenue in domestic currency (Won) = R2 x S3

Realized profit in domestic currency (Won) = $\Pi 3 = R2 \times S3 - C1$ (2)

We can see in equation (2) that realized profit of firms is jointly determined by domestic currency cost C1 at time t1, foreign currency revenue R2 at time t2, and spot exchange rate S3 at time t3. Consequently, the realized profit of an exporting company depends not only on the primary business activities such as production and sales but also on the changing exchange rates depending on the timing of contract, production, receiving of foreign currency proceedings, and exchange of foreign currency into domestic currency.



<Figure 4> Exporters of final product

4.1.2. Foreign exchange risk control measures

4.1.2.1. Forward selling

If the foreign currency revenue R2 is fixed at time t1 and the firm wants to solidify the amount of realized profit in domestic currency, then firms may sign a contract of forward selling of R2 dollars at time t1 with maturity of t3. Supposing the striking price of exchange rate of the forward contract at the maturity to be F3, the realized revenue at t3 is as in equation (3). This means that the firm is holding dollar revenue R2 from t2 to t3. We can alternatively think of a case to make a forward contract of maturity t2 but here we show a typical example as an illustration of exchange risk hedging. We may also have to consider interest rate differences between home and abroad to make the comparison complete but we restrict the analysis to the core factors of forward or option prices for a clearer implication.

$$\Pi 3 = R2 \times F3 - C1 \quad (3)$$

In this case, if the spot exchange rate S3 at t3 is higher than F3, then the firm would make a loss of (S3 - F3) x R2 compared to pre-contract situation. On the contrary, if S3 is lower than F3, then the firm would make a gain of (F3 – S3) x R2 at the maturity date t3.

4.1.2.2. Purchase of currency put option

Under the same condition as in the forward selling case above, firms may purchase a currency put option of amount R2 dollars at a premium of H1 at time t1 with striking price P3 and maturity t3. If the spot exchange rate S3 at t3 turns out to be higher than P3, then the firm does not exercise the right of the put option and simply changes the dollar revenue into Won at the going spot exchange rate. Otherwise, the firm exercises the right of the put option and changes the dollar revenue R2 into Won at P3. Realized profits are as below.

$$\Pi 3 = R2 \times (S3 - H1) - C1 \quad \text{if} \quad S3 > P3 \quad (4)$$

$$\Pi 3 = R2 \times (P3 - H1) - C1 \quad \text{if} \quad S3 \le P3 \quad (5)$$

We can see in equations (4) & (5) that the option premium H1 is an irrecoverable sunk cost for the option buyer firm. We need to note the key differences between the two methods. Forward contract creates an obligation on both sides of the contract. That is to say, one party in short position (= seller)has to sell the amount of the foreign currency at a pre-specified exchange rate and the other party in long position (= buyer)has to buy the same amount at the same pre-specified exchange rate at the maturity, irrespective of the realization of the underlying exchange rate S3. In contrast, a call option(alternatively, a put option) buyer has the right but not the obligation to enact the contract to buy from (alternatively, to sell to) the other party in short position (= writer of the option) pre-specified amount of foreign currency at a pre-specified exchange rate. Option holder (= buyer) may exercise the right at the maturity for a European option and anytime up to the maturity for an American option (Kim & Rhee, 2013). In return, the buyer of an option has to pay an option premium to the seller. On the other hand, the writer (= seller)of an option has an obligation to accept the exercise of the option by the option buyer. To put it simply, the call option (or, put option) writer has to sell (or, buy) the foreign currency at the pre-specified strike price to (or, from) the buyer of the option if the latter party wishes to exercise the option to buy (or sell) the currency. Carefully examining equations (2) ~ (5), we can get the best risk control measures as in <Table 2>.

<Table 2> Foreign exchange risk control measures for an exporter of final good

Case	Condition	Best risk control measure	Revenue (Won) confirmation timing
1)	F3 > P3 – H1 > E1(S3)	Sell Forward	t1
2)	F3 > E1(S3) > P3 – H1	Sell Forward	t1
3)	P3 – H1 > F3 > E1(S3)	Buy Currency Put Option	t3
4)	P3 – H1 > E1(S3) > F3	Buy Currency Put Option	t3
5)	E1(S3) > F3 > P3 – H1	Do Nothing	t3
6)	E1(S3) > P3 – H1 > F3	Do Nothing	t3

* Time of choice of the 'best risk control measure' is always at t1. Because firms do not know yet the future spot exchange rate S3 at time t1, they need to predict its value using information known at t1. E1(S3) denotes conditional expectation of S3 at time t1 based on information available at t1. Revenue (Won) confirmation timing tells when the actual revenue in domestic currency term is fixed.

In cases 1) and 2) in <Table 2> where the forward price F3 is greater than the difference 'P3–H1' and also the expected future spot exchange rate E1(S3), the best risk control measure to choose at time t1 is 'Sell Forward' and the final revenue in domestic currency as of t3 is fixed immediately at time t1. In cases 3) and 4) where 'P3–H1' is greater than F3 and E1(S3), the best choice is 'Buy currency put option' although the actual revenue in domestic currency is revealed only at time t3. However, in cases 1) to 4), if the expectation of the future spot exchange rate S3 turns out to be wrong, i.e. if S3 ≠ E1(S3), then firms may incur unexpected losses of either the difference 'S3–F3' or option premium H1. In cases 5) and 6) where the expected future spot exchange rate E1(S3) is higher than F3 and 'P3-H1', the best choice is 'Do nothing' because this strategy gives the highest 'expected revenue' in terms of domestic currency to the firm.

4.2. Importers of Raw Material and Intermediate Parts

We consider here firms that import raw material and intermediate parts from abroad, and produce and sell final goods at home.

4.2.1.Foreign exchange risk pattern

We can illustrate flows of cost and revenue as in <Figure 5> and the corresponding equations as below.

Cost in domestic currency (Won) = C1

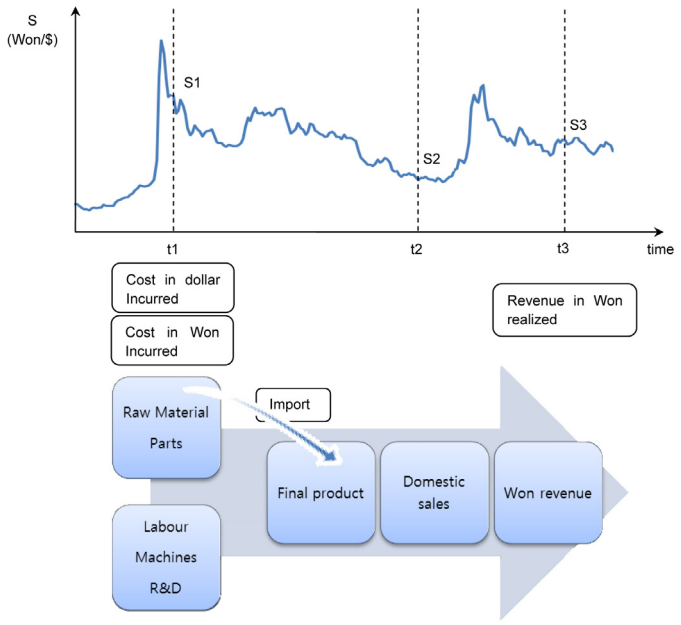
Cost in foreign currency ($) = D1

Revenue in domestic currency (Won) = R3

Realized profit in domestic currency (Won)

$$= \Pi 3 = R3 - C1 - D1 \times S1 \quad (6)$$

We can see in equation (6) that realized profit of firms is jointly determined by domestic currency cost C1, foreign currency cost D1, and spot exchange rate S1 all at time t1, and domestic currency revenue R3 at time t3.



<Figure 5> Importers of Raw Material and Intermediate Parts

4.2.2. Foreign exchange risk control measures

In this case, we have a critical difference from subsection 4.1. As the import cost payment D1 occurs at t1, exchange rate changes do not affect firm revenue in domestic currency at t3. However, if the firm borrows D1 in foreign currency from a bank in order to pay the import cost and repay the foreign currency debt at t3, then the exchange rate changes may affect the firm revenue. If this is the case, we need to consider interest payments over the period t1 to t3 and exchange rate fluctuations. Firms in consideration may use the measures such as 'Buy forward' or 'Buy currency call option' in order to avoid exchange risk.

4.2.2.1. Forward buying

Firms may sign a contract of forward buying of D1 x [1 + (t3 - t1)·r*] dollars at time t1 with maturity of t3 where r* is foreign interest rate. If the striking price of exchange rate at the maturity equals F3, then the realized revenue at t3 will be as below.

$$\Pi 3 = R3 - C1 - D1 \times [1 + (t3 - t1) \cdot r^*] \times F3 \quad (7)$$

4.2.2.2. Purchase of currency call option

Firms may purchase a currency call option of amount D1 x [1 + (t3-t1)·r*] dollars with maturity t3 and strike price C3 with an option premium B1. If the spot exchange rate S3 at t3 turns out to be higher than C3, then firms exercise the right of the call option and buy the contracted amount of dollar at C3 and repay the foreign currency debt. Otherwise, firms do not exercise the call option but buy the dollars at the spot price S3 and repay the dollar loan. Realized profits will be as below.

$$\Pi 3 = R3 - C1 - D1 \times [1 + (t3 - t1) \cdot r^*] \times (C3 + B1) \quad \text{if} \quad S3 > C3 \quad (8)$$

$$\Pi 3 = R3 - C1 - D1 \times [1 + (t3 - t1) \cdot r^*] \times (S3 + B1) \quad \text{if} \quad S3 \le C3 \quad (9)$$

Evaluating equations (6) ~ (9), we can get the following best risk control measures as in <Table 3>.

<Table 3> Foreign exchange risk control measures for an importer of raw material & parts

Case	Condition	Best risk control measure	Revenue (Won) confirmation timing
1)	F3 < C3 + B1 < E1(S3)	Buy Forward	t1
2)	F3 < E1(S3) < C3 + B1	Buy Forward	t1
3)	C3 + B1 < F3 < E1(S3)	Buy Currency Call Option	t3
4)	C3 + B1 < E1(S3) < F3	Buy Currency Call Option	t3
5)	E1(S3) < F3 < C3 + B1	Do Nothing	t3
6)	E1(S3) < C3 + B1 < F3	Do Nothing	t3

* Time of choice of the 'best risk control measure' is always at t1. Because firms do not know yet the future spot exchange rate S3 at time t1, they need to predict its value using information known at t1. E1(S3) denotes conditional expectation of S3 at time t1 based on information available at t1. Revenue (Won) confirmation timing tells when the actual revenue in domestic currency term is fixed.

4.3. Importers of Final Product

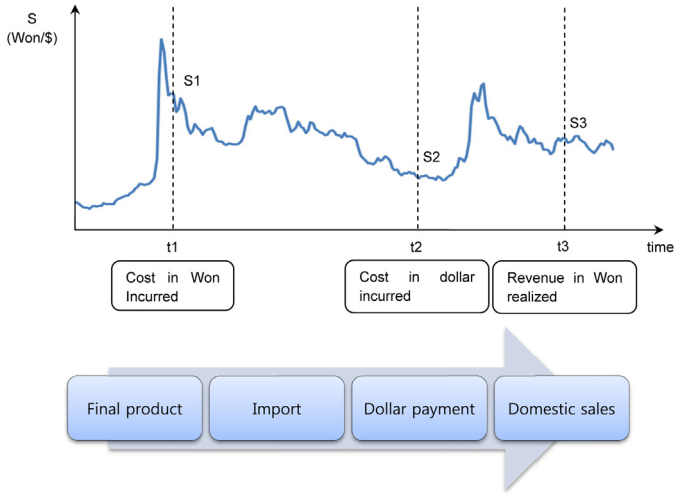
As a third case, we consider firms that import final products from abroad and sell them at home.

4.3.1. Foreign exchange risk pattern

We can illustrate flows of cost and revenue as in <Figure 6> and the corresponding equations as below, assuming that the importer firm has to pay the foreign currency price for the import of final products at time t2.

Cost in domestic currency (Won) = C1
Cost in foreign currency ($) = D2
Revenue in domestic currency (Won) = R3
Realized profit in domestic currency (Won)
= $\Pi 3 = R3 - C1 - D2 \times S2$ (10)

We can see in equation (10) that realized profit of firms is jointly determined by domestic currency cost C1 at time t1, foreign currency cost D2 and spot exchange rate S2 at time t2, and domestic currency revenue R3 at time t3.



<Figure 6> Importers of final product

4.3.2. Foreign exchange risk control measures

In this case, the exchange rate fluctuations during t1 to t2 may affect the final revenue in domestic currency. The main concern for the importer firm is to fix the value of dollar payment D2 at time t2 in terms of Won as early as at time t1 in order to avoid any exchange risk over the period t1 to t2.

4.3.2.1. Forward buying

Firms sign a forward buying contract of D2 dollars at time t1 with maturity t2 and strike price F2. Then, the realized revenue at t3 will be as follows.

$\Pi 3 = R3 - C1 - D2 \times F2$ (11)

4.3.2.2. Purchase of currency call option

Firms purchase a currency call option of amount D2 dollars at a premium of B1 at time t1 with maturity t2 and striking price C2. If the spot exchange rate S2 at t2 turns out to be higher than C2, then firms exercise the right of the call option and buy D2 dollars at the striking price C2 and repay the debt. In contrast, if S2 is lower than C2, then firms do not exercise the call option, and simply buy D2 dollars at spot exchange rate S2 and repay the foreign currency debt at t2. Realized profits will be as follows.

$\Pi 3 = R3 - C1 - D2 \times (C2 + B1)$ if S2 > C2 (12)

$\Pi 3 = R3 - C1 - D2 \times (S2 + B1)$ if S2 ≤ C2 (13)

Comparing equations (10) ~ (13), we can get the best risk control measures as in <Table 4>.

<Table 4> Foreign exchange risk control measures for an importer of final good

Case	Condition	Best risk control measure	Revenue (Won) confirmation timing
1)	F2 < C2 + B1 < E1(S2)	Buy Forward	t1
2)	F2 < E1(S2) < C2 + B1	Buy Forward	t1
3)	C2 + B1 < F2 < E1(S2)	Buy Currency Call Option	t2
4)	C2 + B1 < E1(S2) < F2	Buy Currency Call Option	t2
5)	E1(S2) < F2 < C2 + B1	Do Nothing	t2
6)	E1(S2) < C2 + B1 < F2	Do Nothing	t2

* Time of choice of the 'best risk control measure' is always at t1. Because firms do not know yet the future spot exchange rate S2 at time t1, they need to predict its value using information known at t1. E1(S2) denotes conditional expectation of S2 at time t1 based on information available at t1. Revenue (Won) confirmation timing tells when the actual revenue in domestic currency term is fixed.

5. Conclusion and Limitations

5.1.Summary of Study Results

This paper has studied several aspects of foreign exchange risk with a special reference to the so-called KIKO currency option contract that has damaged financial statements of hundreds of small & medium sized Korean firms. I could get the following key aspects of foreign exchange risk management based on past 12 years data of Korean Won per US dollar exchange rates. First, we need to consider longer time span of past experience reflecting major events such as East Asian financial crisis in 1997~1998 when we predict future developments of financial variables including exchange rate. Forecasting based on the only recent period data can be greatly misleading. Second, we must analyze not only level values but also variability (or, volatility) of key variables that may affect overall corporate revenue when assessed in terms of domestic currency. Third, we may use various financial measures such as 1) forward contract or 2) currency options, depending on the pattern of firms' international operation, in order to avoid or reduce exchange risk.

In order to derive probable foreign exchange risk control

measures, I considered three types of production patterns with foreign exchange transactions: 1) exporters of final product, 2) importers of raw material and intermediate parts and 3) importers of final product. I found the following results. First for the exporters of final product, when the forward price is sufficiently high, higher than put option exercise price less option premium or the expected future spot exchange rate, currency forward selling is the preferred measure. In contrast, if the put option exercise price less premium is higher than the forward rate or future expected spot exchange rate, then purchase of currency put option is the right risk control measure. In other cases, taking no risk control measure is the correct action. Second for the importers of raw material and intermediate parts, when the forward rate is sufficiently low, lower than call option exercise price plus option premium or expected future spot exchange rate, the purchase of currency forward is the suitable measure. If the call option exercise price plus premium is lower than forward rate or expected future spot exchange rate, then we should choose to buy currency call option. Otherwise, doing nothing is the best choice. Third, for importers of final product, if currency forward rate is lower than call option exercise price plus option premium or expected future spot exchange rate, then purchase of currency forward is the appropriate risk hedging measure. If call option exercise price plus premium is lower than forward rate or expected future spot exchange rate, then purchase of currency call option is desirable. In other occasions, doing nothing is the right action.

5.2. Expected Effects and Implications of the Study

Currently, international capital market is closely integrated globally and international flow of foreign capital is not any more just a curiosity. Exchange rate fluctuations are ever more expanding and no single country can be immune to international financial market disturbances. Firms could easily erode the value of their hard-won foreign exchange revenue from exports of steel, cars, ships, IT & petrochemical products, and machines because of the changes in domestic currency value caused by exchange rate variations. This issue matters not only for the large corporations directly engaged in exports/imports or foreign direct investment but also for small & medium sized firms without any international operations but nonetheless competing with foreign imports in the domestic market. Proper exchange risk control is now a matter of survival especially for modest sized companies without much margin in operating capital. These firms typically lack financial experts, channels of stable fund raising, and information about economic situation.

We may suggest a few remarks for firms that undertake international business operations. First, proper foreign asset and liability management is a minimum requirement in a world of free-flowing capital movements and turbulent exchange rates. Second, firms even without any international operation need to pay attention to the overall international economic situations and key financial variables such as interest rates, inflation rates, or exchange rates both at their levels and change rates. Third, small & medium sized companies in particular lacking human resources or financial knowledge may utilize the public resources provided by governmental research institutes, academic institutions, or internationally accredited financial media. One special lesson from the KIKO episode is that firms should not use financial derivatives of which they do not have much knowledge as a mean of gaining profit but use them only as a risk-hedging measure in a prudential way.

5.3. Study Limitations and Future Tasks

This paper also has limitations. I have considered only forward contract and currency options as measures of exchange risk control. Firms may also use other methods such as asset/liability management, leading & lagging, netting, matching, price adjustment, mixed-currency invoicing, or money market hedging. More fundamentally, firms may take strategic measures on marketing, production process and financial management. We can also utilize VaR (value at risk) method to limit the size of foreign exchange loss.

As a future research, we may extend empirical studies with business survey on actual foreign exchange risk control practices of Korean and foreign companies, especially of medium sized ones. Appropriate risk management methods will vary depending on the procurement, production, payments procedures and also on macroeconomic conditions such as monetary policy stance, inflation rates and foreign exchange transactions control set by the governments. Econometric data analysis based on past data and surveys may reveal more compelling and unexpected lessons. International comparisons of foreign exchange risk management at firm levels or even at country level would also be highly beneficial.

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