Customer Suitability Risk in Structured Products: A Text-based Analysis of Japanese ADR Cases of FX Derivatives*

Yuji Sakurai†

June 10, 2018

Abstract

In this paper, I propose a new model to quantify customer suitability risk that arises from overhedging with structured products. In the model, a firm hedges its exposure to a macroeconomic factor by purchasing a structured product from a derivative-selling bank. A firm effectively shorts a put option and longs a forward for a product. A new feature is that a firm may misunderstand an embedded short position of the put option and excessively hedge its exposure. A firm's unintentional deviation from its optimal hedging amount creates a customer suitability risk to a derivative-selling bank. I consider that customer suitability risk has two different effects. First, it increases the probability of derivative-triggered default through increased leverage. Second, it reduces the recovery rate of the bank's exposure due to compliance risk. Using the model, I study the optimal design of the structured products. Also, I discuss how such a customer suitability risk can be incorporated into derivatives pricing. Finally, I apply the model to the financial distress of Japanese importers caused by their derivative contracts during the 2010-2014 period. Using a hand-collected dataset, I conduct a text-based analysis for 1,429 Alternative Dispute Resolution (ADR) cases and estimate model parameters.

Keywords: Exotic derivatives, Structural credit risk model
Text mining; Behavioral Financial Engineering
JEL Classification Numbers: F31, G01, G15, G32.

*The author deeply appreciates Goya Furukawa, Yasuko Koyama, Yuki Tanaka for their excellent research assistance. I also thank Ehud Peleg for his detailed comments. The paper is a very preliminary draft and please do not cite without the author's permission. The views expressed in this paper are those of the author and do not necessarily reflect the position of the Federal Reserve Bank of Richmond or the Federal Reserve System.

†Corresponding author. Federal Reserve Bank of Richmond, Charlotte Office, 530 E Trade St, Charlotte, NC, 28202, USA;
E-mail address: yswasquant@gmail.com

1 Introduction

Derivatives play an important role in financial risk management for firms to mitigate their exposure to macroeconomic risks. Non-financial firms in a tradable good sector often use derivatives to hedge their foreign exchange (FX) risk.[1] Unfortunately, however, there have been many cases where those firms which use derivatives for their hedging mis-perceive a variety of risks embedded in their derivative contracts and hedge excessively. Ironically, overhedging leads to the firm's financial distress due to their derivatives contract when the unexpected economic outcome is realized. Consequently, derivative sellers are sometimes criticized and sued since their transactions do not meet customer suitability.

Customer suitability risk is important not only from the perspective of bank-level risk management but also from a systemic risk perspective. In the report published by the European Systemic Risk Board, Bukart and Bouveret (2012) report that structured products may generate systemic risks if they are used for the funding of financial institutions. Dodd (2009) conducts a cross-country analysis of the cases where inappropriate use of structured products created concern for financial stability.[2] He shows that the cost to end-user firms from derivatives losses based on the sum of national estimates is \$530 billion. He also finds that roughly 50,000 firms in at least 12 countries are impacted by structured products. These facts suggest that it is important to have a quantitative model to capture risks caused by the misuse of structured products[3].

In this paper, I propose a new model to quantify the risk of customer (un)suitability in structured products. I consider that customer suitability risk has two different effects: default risk, or more broadly financial distress risk caused by the loss from derivatives and compliance risk.

First, derivative-triggered default risk is defined as the risk of having a higher default probability due to overhedging using derivatives. I define a derivative-triggered default when the firm's total asset value is below the debt level that is determined by the mark-to-market value of derivatives[4]. In the model, a firm hedges its exposure to a macroeconomic factor by purchasing structured products from a derivative-selling bank. The firm effectively takes a short position in a put option combined with a forward via its derivatives position. In other words, derivatives function as additional leverage for the firm. A key feature of the model in this paper is that a firm may not correctly take into account an embedded short position of a put option

[1] Bae et al. (2018) empirically study use of currency derivatives by Korean firm. They find that currency derivatives function as hedging instruments and protect firm values under low and manageable exposures.

[2] Note that Dodd (2009) uses the terminology "exotic derivatives" instead of structured products. Exotic derivatives are derivatives which payoff are not standardized. Examples of exotic derivatives are barrier options, look back options and American options. It contrasts with vanilla derivatives which payoff is simple and standardized. In this paper, I use the terminology "structured products".

[3] Basel Committee on Banking Supervision (2008) provides a detailed survey of regulatory requirements for retail financial products

[4] Huang and Yildirim (2008) also incorporate a derivative into a liability side of a firm's asset in a structural credit risk model. Their motivation is to explain a short-term credit risk.

in evaluating the risk of the derivative and thus overhedges its exposure[5]. More unintended higher leverage increases the probability of default. That is modeled in a structural credit risk model.

Second, compliance risk is defined as the risk of having a lower recovery rate at default of the end-user firm from the perspective of the derivative-selling bank. A firm's unintentional deviation from its optimal hedging amount creates compliance risk to a derivative-selling bank. Once compliance risk is realized, the assumption is that the derivative-selling bank needs to share the loss with their end-user firms.

Using the model, I study the optimal design of the structured products. What is interesting is the following: Optimal leverage is lowered when the end-user firm is less risk-averse. The mechanism behind this is that a less risk-averse end-user firm purchases more of the structured product given misunderstanding of the payoff. As a result, the default risk of the firm increases. The derivative-selling bank takes such a negative effect into account when the bank designs the structured product. Thus, the leverage embedded in the structured product is lowered to mitigate the negative effect.

As a by-product, I discuss the effect of product market competitions among derivative-selling banks on customer suitability risk. What I theoretically find is that the competition might be harmful from the perspective of customer suitability, if competition lowers the fee of structured product. The intuition is that a lower fee leads to more overhedging and thus creates a higher default risk.

Also, I discuss how such a customer suitability risk can be incorporated into derivatives pricing. What I show is as follows: When the price of the structured product does not reflect customer suitability risk, the price of the structure product is lowered as embedded leverage is increased. This is because a larger benefit of selling a short put option makes the price of this hedging instrument cheaper. However, when the price reflects the customer suitability risk, the price is not lowered as in the previous case because the expected cost of customer suitability risk is reflected in the derivatives price.

As an application of the model, I study Japanese importers that have purchased a knock-out forwards that later became financially distressed due to overhedging. What happened to them is (1) they were effectively taking a short put option on the US dollar or Australian dollar against the Japanese yen and (2) After the devastating earthquake in March 2011, the Japanese yen strongly appreciated against these foreign currencies and caused losses through their short put option.

I manually collect 1,429 Japanese ADR cases of FX derivatives during 2010-2014[6]. For each report, I assign six integer variables that capture whether and to what extent derivative-selling banks have appropriately recommended that their end-user firms purchase structured products, which are FX forwards with an embedded short put. Using this hand-collected data, I conduct logit analyses to quantify the effect of customer (un)suitability on the bank's decision of sharing their customers' losses. To the best of my knowledge, this paper is the first study to both theoretically

[5]Breuer and Perst (2006) study structured products from the view of behavioral finance. They call such an approach "Behavioral Financial Engineering". This paper mathematically formulates their idea.

[6]Alternative dispute resolution (ADR) is a procedure to settle disputes outside courts.

and empirically analyze a customer suitability issue of derivatives in a quantitative model.

The remaining sections of this paper are organized as follows. Section 2 provides a literature review. Section 3 formulates a firm's hedging problem and analyzes how overhedging happens. Section 4 explains the modeling of customer suitability risk. Section 5 discusses how to incorporate customer suitability risk into derivatives pricing. Section 6 gives a text-based analysis of customer suitability risk for the Japanese ADR cases. Section 7 concludes.

2 Literature review

This paper contributes to four strands of the literature.

First, it contributes to extensions of structural credit risk model proposed by Merton (1974). Structural credit risk models have been used to analyze the default probability of financial institutions and various extensions are made. For example, Capponi and Civitanić (2009) propose a structural credit risk model for defaultable securities of a firm under the effect of misreporting done by insider of the firm. Huang and Yildirim (2008) incorporate value of derivatives into a liability side of a firm's asset in a structural credit risk model in order to capture a short-term credit risk. Yet, none of these studies discuss the leverage of non-financial firms due to structured products sold by derivative-selling banks and its potentially negative effect on those banks' default. This paper proposes a structural credit risk model with an explicit focus on overhedging and derivative-triggered defaults.

Second, this paper contributes to a theoretical analysis of firm's hedging behavior with a focus on foreign exchange rate risk. Lioui and Poncet (2002) investigate optimal hedging policy in which firms can use either forwards or futures contracts. They discuss differences between these two contracts for hedging. Michenaud and Solnik (2008) apply regret theory to derive closed-form solutions to optimal currency hedging choices. They find that results are in sharp contrast with traditional expected utility, loss aversion and disappointment aversion theories. Frechette (2000) studies the optimal hedging portfolio with futures and vanilla options. Different from these studies, I focus on hedging problem with non-vanilla hedging instruments under the possibility of misunderstanding of the payoff.

Third, this paper contributes to an application of a text-based analysis to study th derivatives market. A text-based analysis is now widely used in both asset pricing and corporate finance. For example, in empirical asset pricing, Garcia (2013) study the frequency of negative words in two columns of financial news from New York Times in order to study the effect of a positive and negative sentiment on stock returns. In empirical corporate finance, Hadlock and Pierce (2010) conduct a text-based analysis of financial constraints for US firms using their annual reports to investors. In the context of customer suitability, Célérier and Vallée (2015) study structured products using a text analysis and document that complexity of these products increased during the period between 2002 and 2010 and argue that banks used complexity to cater to search-for-yield retail investors. This paper makes the first step to incorporate a text-based analysis to an otherwise standard derivatives pricing framework.

Finally, the paper contributes empirical studies of structured products. Structured product is non-standard derivatives products sold to non-financial firms. Due to the limited availability of data of structured products, there are a few number of studies such as Wilkens, Erner and Roder (2003), Stoimenov and Wilkens (2004), Andreas and Wohlwend (2005) and Wallmeier and Diethelm (2009). These studies are mainly concerned about fairness of pricing of structured products. For example, Stoimenov and Wilkens (2004) find that those banks issuing structured products charge a large premium in the German primary market of equity-linked structured notes. Other than these studies, Allayannis *et al.* (2010) examine the impact of FX derivatives on firm values and find that those firms with strong governance use FX derivatives for hedging, not for speculation, and thus increase firm value. By contrast, this paper focuses on customer suitability risk and default risk induced by derivatives sold to non-financial firms.

3 Modeling firm's hedging problem

In this paper, I consider a firm imports intermediate goods from a foreign country and thus faces the foreign exchange risk in valuating their cost. If the value of its domestic currency relative to a foreign currency depreciates, the firm's cash flow converted into the domestic currency is decreased.

I focus on the case of importing firms without loss of generality. For an exporting firm, it is easy to see that a firm exports its products to a foreign country and thus it is exposed to the foreign exchange risk in valuating their profits[7]. Also, I focus on FX forward combined with short position of put options because it is one of the most popular structured products purchased by end-user firms to hedge the foreign exchange risk.

3.1 Payoff structure of structured products

Let us denote the value of one unit of foreign currency expressed in units of the US dollar at time t with X_t. A mark-to-market value of the option embedded in the structured product at time t is D_t. The underlying of the option is spot exchange rate, X_t. The payoff at maturity T is specified as

$$\text{Payoff}_T = X_T - K - \gamma D_T, \tag{3.1}$$

where γ is units of options combined with one unit of forward contracts. γ is often interpreted as leverage embedded in structured products taken by a firm. In pricing this structured product, a derivative-selling bank sets K so that the mark-to-market value of the derivative is equal to zero:

$$\mathrm{E}_t^Q[X_T - K - \gamma D_T] = 0. \tag{3.2}$$

$$\Leftrightarrow \quad K = F_0 - e^{r_d T}\gamma D_0, \tag{3.3}$$

[7] In the case of exporting firms, (3.6) becomes $A_T = -S + MX_T + N(-X_T + K + \gamma D_T)$. In this case, the exporting firm sells a foreign currency. Notice that the exporting firm should take a short position in a put option to make its strike price more favorable to the firm.

where $D_0 = e^{-r_d T}\mathrm{E}^Q_{t=0}[D_T]$. F_t is the value of a vanilla forward at time $t = 0$. As it is well known, $F_0 = e^{(r_d - r_f)T}X_0$. The strike K is constant over the maturity of the derivative contract $[0, T]$, once it is fixed at the start of the trade $t = 0$. The strike K is higher than the strike of at-the-money (ATM) vanilla forward F_0 since the firm shorts a down-in put option and obtains a premium of the option $e^{r_d T}\gamma D_0$ to finance the higher strike price K. Note that the structured product above is reduced to a vanilla (plain) forward when there is no embedded leverage ($\gamma = 0$).

I consider that an embedded option is ATM put option:

$$D_T = \max(X_0 - X_T, 0). \tag{3.4}$$

Then, the payoff at maturity T is given by

$$\mathrm{Payoff}_T = \begin{cases} (1+\gamma)X_T - \gamma X_0 - K & \text{if} \quad X_T < X_0, \\ X_T - K & \text{if} \quad X_T \geq X_0. \end{cases} \tag{3.5}$$

Figure 1 depicts the payoff structure explained above. One can see that higher leverage γ lowers the strike. It means that the firm can sell the foreign currency with a higher price and makes more profit if the spot exchange rate remain at the same level at the maturity. Yet, if the spot exchange rate goes below the certain level, the firm loses more in the case of structured product ($\gamma \neq 0$), than in the case of a vanilla forward ($\gamma = 0$).

In this section, I assume that the ATM put option has no barrier feature for expository simplicity. In the real world, it is common that the ATM put option has knock-in (KI) and knock-out (KO) features. For expository simplicity, we consider that the embedded ATM put option has no knock-in feature.

3.2 Firm's optimal hedging and overhedging

In my model, an importing firm purchases M amount of intermediate goods which value is denominated in a foreign currency and makes a constant sales S in a domestic currency. X_t is the domestic currency price of a unit of the foreign currency at time t. The firm can enter an exotic currency forward contract to hedge her foreign exchange risk by purchasing it from her bank who acts as a derivative dealer. The firm's total asset value is given by

$$A_t = S - MX_t + N(X_t - K - \gamma D_t - f), \tag{3.6}$$

where f is the fee paid to the derivative-selling bank.

The firm purchases N amount of exotic currency forward contract. I assume that the firm In other words, the firm solves mean-variance problem at time $t = 0$ and never re-optimizes it. Hereafter, I drop the subscript $t = 0$ from the expectation operator for expository simplicity. The firm's optimization problem is formulated as follows:

$$\max_N \left(\mathrm{E}^P[A_T] - \lambda \mathrm{Var}^P[A_T]\right) \tag{3.7}$$

Let us first consider that a firm correctly understands a payoff profile of a hedging instrument. In this case, the optimal amount is obtained as

$$N^* = cM + \frac{\mathrm{E}^P[X_T] - K - \gamma \mathrm{E}^P[D_T] - f}{2\lambda \mathrm{Var}^P[X_T - \gamma D_T]}, \tag{3.8}$$

where c is defined as

$$c = \frac{\mathrm{Var}^P[X_T - \gamma D_T] - \gamma^2 \mathrm{Var}^P[D_T] + \gamma \mathrm{Cov}[X_T, D_T]}{\mathrm{Var}^P[X_T - \gamma D_T]} \tag{3.9}$$

Next, consider the cases where the firm misunderstands or lack the information on payoff of a hedging instrument and, consequently, the firm unintentionally abstracts the embedded short position of the option, $-\gamma D_t$. The amount of derivatives is given by

$$N^{**} = M + \frac{\mathrm{E}^P[X_T] - K - f}{2\lambda \mathrm{Var}^P[X_T]}. \tag{3.10}$$

A key implication of (3.10) is following: Recalling (3.3), the strike K is lowered as the embedded leverage γ increases. The numerator in the second term of (3.10) indicates that the firm benefits from an embedded option as the strike K is lowered. Yet, the firm does not take into account the risk associated with the short position of the option, because D_T does not appear in the denominator. By contrast, (3.8) has D_T in the denominator of the second term.

The following inequality holds:

$$N^{**} > N^*. \tag{3.11}$$

The proof of (3.11) is available in Appendix. It shows that an end-user (importing) firm over-hedges its exposure to the foreign currency if it does not correctly understand a payoff structure of the structured product. The intuition behind this inequality that the end-user firm overestimates the benefit of the structured product by unintentionally abstracting the additional risk due to the embedded short position of the option.

Figure 2 shows how the embedded leverage γ impacts the amount of hedging N^* and N^{**}, under correct understanding of the payoff and misunderstanding, respectively. There are two key observations:

(1) As the embedded leverage increases, the non-optimal amount of hedging N^{**} increases. This is because end-users can get more profits from selling more put options without taking the risk into account, when they expect that the foreign currency is enough appreciated against the domestic currency beyond the strike and the fee $(K + f)$. This effect arises from the second term of N^{**} which captures subjective expectations of the end users.

(2) By contrast, the optimal amount of hedging N^* decreases, as the embedded leverage γ increases under plausible parameters. This is because those end users who correctly understand the payoff recognize additional variance from embedded leverage. This effect arises from the first term N^*. Note that the first term in N^* captures the same effect as the first term in N^{**} does. However, unless their subjective (optimistic) expectations on the appreciation of the foreign currency are large enough, the effect from the second term dominates the one from the first term.

3.3 When can a derivative-selling bank identify end-user's overhedging?

It is natural to ask whether and when derivative-selling banks can identify end-user's overhedging. The answer is following: A derivative-selling bank cannot distinguish whether the client firm correctly understands the payoff profile of structural products unless the bank knows end-user firm's risk aversion parameter λ as well as the firm's exposure to foreign exchange risk M.

To see this, suppose that the bank does not have information on the risk aversion parameter of the end-user firm $\lambda^{correct}$. It is realistic to assume that the bank can observe the hedging amount $N^{observed}$ which the end-user firm purchased based on misunderstanding of the payoff. In other words, $N^{observed}$ is obtained based on (3.10).

$$N^{observed} = N^{**}(\lambda^{correct}). \tag{3.12}$$

Now let us consider that the bank (mistakenly) assumes that the end-user firm *correctly* understands the risk and return of the product. Thus, the bank calculates the optimal amount N^* based on (3.8) which leads to overhedging. Then, there always exists an incorrect risk aversion parameter $\lambda^{incorrect}$ that satisfies

$$N^*(\lambda^{incorrect}) = N^{observed}. \tag{3.13}$$

The proof is given in the appendix.

This result indicates that unless the bank has information on the risk preference of the end-user firm, the bank cannot exclude the possibility that the firm has purchased the excessive amount of a derivative product based on misunderstanding of the payoff.

The similar argument holds for the cases where the bank cannot obtain accurate estimate of the amount of intermediate goods M.

3.4 Should an end-user firm always avoid structured products for hedging?

It is interesting to theoretically investigate whether an importing firm should always purchase vanilla FX forwards rather than structured products using the model discussed so far. To study this issue, I slightly extend the firm's optimization problem (3.7) as follows.

$$\max_{\gamma} \max_{N} \left(\mathrm{E}^P[A_T] - \lambda \mathrm{Var}^P[A_T] \right) \tag{3.14}$$

In 3.14, an end-user firm is allowed to adjust embedded leverage γ. For example, if $\gamma = 0$ is obtained as a solution, it indicates that the firm purchases a vanilla FX forward.

When the firm correctly understands the payoff of an exotic currency forward, the first-order condition yields

$$\gamma = \frac{e^{r_d T} D_0 - \mathrm{E}^p[D_T]}{2\lambda N^* \mathrm{Var}^P[D_T]} + \frac{\mathrm{Cov}[X_T, D_T]}{\mathrm{Var}^P[D_T]} \frac{N^* - M}{N^*}. \tag{3.15}$$

The first term is risk-adjusted benefit from selling a put option. It is positive if the firm expects that the domestic currency is enough depreciated against foreign currency. Note that (1) $\mathrm{E}^p[D_T]$ in the first term is based on the firm's subjective expectations and (2) a larger risk-aversion parameter λ lowers the first term. The second term captures risk of embedded leverage. The sign of the second term depends on the amount of hedging $N^* - M$ since $\mathrm{Cov}[X_T, D_T] < 0$. If N^* is larger than M, the second term is negative. In summary, the optimal embedded leverage γ can be positive if the first term is positive and large enough compared to the second term.

Therefore, it is theoretically possible that an end-user firm chooses the structured product ($\gamma > 0$) as a hedging instrument instead of vanilla FX forwards ($\gamma = 0$) even if the firm correctly understands the payoff. Yet, it is noteworthy that such a choice is impacted by subjective expectations of foreign exchange rate and risk aversion of end-user firms.

4 Modeling customer suitability risk

In this section, I first incorporate the mark-to-market value of derivatives into the balance sheet of the firm that has purchased it. In doing so, I explicitly model the financial distress (or default) induced by overhedging with derivatives. I then consider the derivative-selling bank's optimization problem.

4.1 The first component of customer suitability risk: derivative-triggered default risk

Recalling (3.6) and (3.3), a firm's total asset value is given by

$$A_t = S - MX_t + N(X_t - F_0 + \gamma e^{r_d(T-t)} D_0 - \gamma D_t). \tag{4.1}$$

Suppose that the firm has debt level L that is constant over time. The firm defaults if the total asset of the firm A_T is below the debt level L ($A_T \leq L$) at the expiry of hedging instrument. The condition is equivalent to that $X_T \leq X_T^{DD}$ where the default-triggering level of foreign exchange rate X_T^{DD} is defined as

$$X_T^{DD} = \frac{N((1+\gamma)F_0 - \gamma e^{r_d(T-t)} D_0) - (S - L)}{(1+\gamma)N - M} \tag{4.2}$$

$$= \frac{N(\gamma F_0 + K) - (S - L)}{(1+\gamma)N - M}. \tag{4.3}$$

The derivative-triggered default probability is defined as

$$p_t^{DD} = \Pr(A_T < L) = \Pr(X_T < X_T^{DD}). \tag{4.4}$$

It is easy to see that a higher level of default-triggering foreign exchange rate X_s^{DD} increases the probability of derivative-triggered default.

Alternatively, we can allow the derivative-triggered default to happen before the expiry due to mark-to-market loss. In this case, a timing of derivative-triggered default is defined as a first hitting time of X_t to the default-triggering foreign exchange rate level X_t^{DD} which functions as time-dependent boundary. An explicit formula for the default-triggering foreign exchange rate level X_t^{DD} is not available for $t < T$. This is because $D_t(X_t)$ is a non-linear function of X_t. For $t < T$, the boundary X_t^{DD} should solve

$$S - MX_t^{DD} + N(X_t^{DD} - F_0 + \gamma e^{r_d(T-t)} D_0 - \gamma D_t(X_t^{DD}) = L. \tag{4.5}$$

The derivative-triggered default probability is modified as

$$p_t^{DD} = \Pr(\inf_{s>t} A_s < L) = \Pr(\inf_{s>t} X_s < X_s^{DD}). \tag{4.6}$$

In what follows, I focus on the definition of 4.4 for expository simplicity.

(4.3) and (4.4) (or (4.6)) are useful to understand the relationship between overhedging and the default risk. For example, a larger amount of the hedging instrument N increases the level of derivative-triggering foreign exchange rate X_s^{DD} and thus the firm's default probability p_t^{DD}, given that the initial value of an embedded short put option D_0 is smaller than a certain level $\bar{D}_0$:

$$\frac{\partial X^{DD}}{\partial N} > 0, \text{ if } D_0 < \bar{D}_0 = \frac{e^{-r_d T}}{\gamma} \left(\frac{(1+\gamma)(S-L) - (1+\gamma)F_0}{M} \right). \tag{4.7}$$

If the firm does not hedge its foreign exchange rate exposure at all ($N = 0$), the firm defaults if the exchange rate X_T is higher than a certain level X_{CD} ($X_T > X_T^{CD}$) where X_T^{CD} is given by

$$X_T^{CD} = \frac{S-L}{M}. \tag{4.8}$$

In this case, the importing firm defaults when the domestic currency is depreciated against the foreign currency, as naturally understood. In the following analysis, I do not investigate the above case since we are primarily interested in the cases where overhedging by exotic derivatives leads to unintentional default of end-user firm.

4.2 The second component of customer suitability risk: compliance risk

Once a firm is financially distressed due to its derivative contract, the firm investigates whether the structured product was appropriately sold by the derivative-selling bank or not. If the court or other authority confirms that the product was not suitable for the firm, the bank cannot receive back a full amount of a positive exposure that the firm owes to the bank. The recovery rate is specified as:

$$R = \begin{cases} R^{NS} & \text{with probability } p^{NS} \\ R^{S} & \text{with probability } p^{S} = 1 - p^{NS} \end{cases} \tag{4.9}$$

where $p^{NS} = \Pr[R = R^{NS} | t = \tau^D]$. p^{NS} is the probability that end-user firms find that the derivative products they purchased were not suitable for them. When the bank had a customer suitability issue, it is natural to have that the bank can receive back less than otherwise he would. Thus, I assume $R^{NS} < R^S$.

Let us model the relationship between the firm's over-hedging and the probability of realization of customer suitability risk. I specify the relationship as logistic function.

$$\log\left(\frac{p^{NS}}{1-p^{NS}}\right) = \alpha_0 + \alpha_1 \Delta N \Leftrightarrow p^{NS} = \frac{e^{\alpha_0+\alpha_1\Delta N}}{1+e^{\alpha_0+\alpha_1\Delta N}}, \tag{4.10}$$

where α_1 should be positive. ΔN is defined to captures to what extent firm's hedging amount under misunderstanding or the lack of the information of the payoff deviates from the optimal hedging amount,

$$\Delta N = N^{**} - N^{*}. \tag{4.11}$$

One issue about using (4.11) for empirical analysis is that econometricians cannot observe the optimal hedging amount N^{**} unless the information on the risk aversion parameter λ and the amount of intermediated goods M is publicly available. Thus, ΔN is not observable. Hence, for my empirical analysis, I need to assume that the deviation of the firm's hedging amount from its optimal amount is captured by observable proxies of overhedging x_i $(i = 1, \cdots, N_x)$. For example, if a firm states that they understand details about the structured product is understood, the probability of being involved in ADR case should be lowered. I assume that the relationship between ΔN and x_i is specified as follows.

$$\Delta N = \sum_{i=1}^{N_x} \beta_i x_i \tag{4.12}$$

Substituting (4.12) for (4.10), we obtain

$$\log\left(\frac{p^{NS}}{1-p^{NS}}\right) = \alpha_0 + \alpha_1 \sum_{i=1}^{N_x} \beta_i x_i \Leftrightarrow p^{NS} = \frac{e^{\alpha_0+\alpha_1\sum_{i=1}^{N_x}\beta_i x_i}}{1+e^{\alpha_0+\alpha_1\sum_{i=1}^{N_x}\beta_i x_i}}, \tag{4.13}$$

Not that α_1 is set to 1 due to its redundancy without loss of generality. The specification (4.13) will be used for text-based analysis in Section 6.

4.3 Optimizing design of structured products

So far, I have discussed the optimization problem for those end-user firms which purchase the structured product for hedging. In this section, I consider profit-maximization problem for a derivative-selling bank.

First, suppose that there are only those end-user firms which misunderstand the payoff of exotic currency forwards and thus overhedge their exposure. A derivative-selling bank maximizes expected net profit π by optimizing embedded leverage γ.

$$\max_{\gamma} \pi = \max_{\gamma} \left(N^{**} f - N^{**} L\right). \tag{4.14}$$

where expected loss per unit of the structured product L is defined as

$$L = p^{DD} p^{NS}(1 - R^{NS})(-X_0^{DD} + K + \gamma D(X_0^{DD})). \tag{4.15}$$

In (4.14), the first term is total profit from selling structured products. The second term is is total expected loss.

Recall that the optimal hedging amount N^* increases with the embedded leverage γ. If the recovery rate R^{NS} is constant, the profit increases as the leverage increases. In such an extreme case, the optimal leverage $\gamma = +\infty$. This suggests that the derivative-selling bank faces a trade-off between (1) a higher profit from a stronger demand of the structured product and (2) a higher risk arising from customer suitability issue, when the bank increases embedded leverage in the structured product.

Table 1 shows value of each model parameter used in numerical analysis below. Three parameters are important but difficult to set. The first one is the recovery rate of the derivatives with a customer suitability issue R^{NS}. There is no publicly available information about how much amount of loss derivative-selling banks shared with their end-user firms. Yet, some information information indicates it is fifty-fifty. Thus, I set $R^{NS} = 0.5$. For the recovery rate of the derivative without any customer suitability issue R^S, again, there is no publicly available information on this parameter although it is reasonable to imagine $R^S > R^{NS}$ considering that derivative-selling banks have collateral posted from their end-user firms. Hence, it is assumed that $R^S = 1$.

The remaining two parameters which are difficult to set are a_0 and a_1 in compliance risk probability p^{NS}. For qualitative analysis in this section, I assume $a_0 = 0$ and $a_1 = 1$. In Section 6, I estimate parameters β_i in 4.13 instead of a_1 in (4.10).

Figure 3 and 4 show the relationship between embedded leverage and expected net profit for a derivative-selling bank. In both figures, expected net profit π decreases more strongly as the leverage γ increases, when compliance risk is considered. This is because of negative sensitivity of compliance risk probability to the amount N^{**} ($\frac{\partial p^{NS}}{\partial N} < 0$).

These two figures also show that the relationship between embedded leverage and expected net profit is inverse U-shaped. In Figure 3, the optimal leverage is $\gamma^* = 0.7$. In Figure 4, the optimal leverage is $\gamma^* = 0.2$. It is interesting to notice that optimal leverage is lowered when end-user firm's is less risk-averse. The mechanism behind this is that less risk-averse firm purchases the structured product more given misunderstanding of the payoff. As a result, the default risk of the firm increases. The derivative-selling bank takes such a negative effect into account when the bank designs the structured product. Thus, the leverage embedded in the structured product is lowered to mitigate the negative effect.

4.4 The effect of competition among derivative-selling banks

Both (3.8) and (3.10) indicate that smaller fee f increases the demand for the structured product N^{**} and N^*. Figure 5 shows such a relationship. This is simply because the structured product is cheaper as a hedging instrument if the fee is lowered. As a result, the end-user firm purchases the product more.

Now let us consider its implications for the effect of derivative-selling banks' competition. If more intense competition among derivative-selling banks reduces fee, it could increase customer suitability risk. Figure 6 shows the negative relationship between fee and derivative-triggered default probability as well as compliance risk probability. If derivative-selling banks do not internalize such an effect, they face higher risk of end-user's default risk and customer suitability risk. In other words, competition can be harmful in this model.

5 Pricing customer suitability risks in derivatives

5.1 How can we price customer suitability risk?

In this section, I explain how customer suitability risk can be incorporated in derivatives pricing. First, consider that payoff at the expiry is given by

$$\begin{aligned}\text{Exposure}_T(K) &= (1-1_{CS})(-X_T+K+\gamma D_T)\\ &\quad +1_{CS}\left(R^{NS}\max(-X_T+K+\gamma D_T,0)+\min(-X_T+K+\gamma D_T,0)\right),\end{aligned}\tag{5.1}$$

where $1_{CS}=1$ if the event of customer suitability issue happens. The first term is the payoff when no customer suitability issue occurs. The second term is the payoff when customer suitability issue occurs. The reason why there are max and min in the second term is that (1) when the firm owes the bank and the customer suitability issue occurs, the bank cannot obtain a full payment and faces low recover rate ($R^{NS}<1$). (2) By contrast, when the bank owes the firm, the bank needs to pay a full payment and the recovery rate is 1.

In (5.1), the expected payoff is rewritten as

$$\begin{aligned}\mathrm{E}_t^Q[\text{Exposure}_T(K)] &= \mathrm{E}_t^Q[-X_T+K+\gamma D_T]\\ &\quad -p^{DD}p^{NS}(1-R^{NS})\mathrm{E}_t^Q[\max(-X_T+K+\gamma D_T,0)|1_{CS}=1].\end{aligned}\tag{5.2}$$

Note that $\mathrm{E}[1_{CS}]=p^{DD}p^{NS}=$ is used. In (5.2), the first term is same as the left-side of the equation (3.2), although we see this term from the bank's view here. The second term can be interpreted as valuation adjustment for the structural product due to customer suitability risk.

Similar to (3.3), a derivative-selling bank sets K so that the mark-to-market value of the derivative is zero at the start of trade:

$$\mathrm{E}_t^Q[\text{Payoff}_T(K^{adj})]=0.\tag{5.3}$$

No analytical solution of K^{adj} for (5.3) is available due to no linearity of the second term in (5.2). Thus, K in (5.3) is numerically solved.[8]

[8] One technical issue is that the strike K appears in the default probability p^{DD}. For computational tractability, I consider that p^{DD} is based on the non-adjusted strike K, not adjusted strike K^{adj}.

5.2 Numerical analysis

The value of each parameter is same as the one used in the previous section, except $f = 0.1$.[9] Table 1 shows value of each model parameter used in numerical analysis here.

Figure 7 shows the relationship between embedded leverage γ and the price of the structured product (strike price K). When the price of the structured product does not reflect customer suitability risk, the strike price K is lowered as embedded leverage γ is increased. This is because a larger benefit of selling a short put option makes the price of this hedging instrument cheaper. However, when the price reflects customer suitability risk, the strike price K is not lowered as in the previous case, with an increase in the embedded leverage γ. This is because the strike price reflects the expected cost of customer suitability risk.

6 Text-based analysis of Japanese ADR cases

6.1 Data

I manually collected data of ADR cases of FX derivatives among Japanese firms during 2010-2015 and conducted text-based analysis. I obtained the data from the website of the Japanese Bankers Association. During this time period, the Japanese Bankers Association facilitated end-user firms to use ADR. From the website, I download the quarterly reports of the ADR cases and investigated the following aspects:

- (1) Overhedging: whether end-user firms mentioned whether the amount of their derivative contract was excessive or not.
- (2) Explanation (firm): whether firms mentioned that their bank selling derivatives did not fully explain the details of the derivative contract or not.
- (3) Explanation (bank): whether derivative-selling banks admitted that they did not completely explain the details of the derivative contract or not.
- (4) Analysis (bank): whether derivative-selling banks admitted that they did not accurately evaluate the amount of derivative contracts necessary and sufficient for the end-user firms' hedging.
- (5) Com (bank): whether derivative-selling banks admitted that they did not communicate well the results of the risk evaluation of derivative contract with their end-user firms.
- (6) Loan: whether firms mentioned that they were explicitly or implicitly forced to purchase derivative contracts to be able to roll over their loans. If firms mentioned they were explicitly forced to do so, they were assigned an integer code 3. If it was implicit, I assigned an integer code 2. If firms simply

[9]This modification for the value of f is made only for computational tractability. The result does not change if we use $f = 0.05$ as in Table 1.

mentioned that they needed to keep a good business relationship with their lender bank, I assigned an integer code 1. If there were no explicit or implicit comments regarding this issue, the number was set to zero.

Figure 8 shows the evolution of the US dollar to the Japanese yen as well as the number of ADR cases in each month. Since most of the derivatives associated with these ADR cases made end-user importers short a put option on the Japanese yen against the US dollars, ADR cases increased when the US dollar depreciated against the Japanese Yen.

Figure 9 depicts an evolution of the actual Japanese yen against the US dollar and survey-based value. The survey-based one-year ahead forecasts of the Japanese yen against the US dollar is obtained from the Bank of Japan's Tankan data set. The survey is conduced for the Japanese large manufacturing firms. One can see that the Japanese firms anticipated weaker Japanese yen until December of 2011. This belief is consistent with the popularity of the exotic currency forward that we have discussed so far. This pattern is reversed and they have been anticipating the stronger Japanese yen since September 2012.

Figure 10 and 11 depict empirical distributions of time as related to decisions on condition of reconciliation and breakdown, respectively. It is clear that there is a considerable uncertainty when banks agree to share their customer's loss, whereas they quickly deny to do so in cases of breakdown.

6.2 Summary statistics

Table 2 shows summary statistics of the reports of ADR cases. There are some notable observations. First, one can see that end-user firms complain their over-hedging in 1228 cases out of 1429 cases that accounts 86% of total cases. Second, the derivative-selling banks rarely admit that they have provided insufficient explanations of their derivatives products (0.4%) although end-users argue so (94%). Instead, banks often admit that they did not conduct a detailed analysis to determine an appropriate amount of hedging (67%). Finally, 77% cases end up with reconciliation between banks and their end-user firms.

Table 3 shows the correlations between text-based integer variables. It is clear that these variables are not highly correlated with each other.

6.3 Logit analysis

I conduct a logit analysis using the data described in the previous section. Table 4 shows estimated coefficients in the regression (4.13). Two coefficients are statistically significant: The lack of explanation argued by an end-user firm and the lack of a detailed analysis mentioned by a bank[10].

These estimated parameters allow us to conduct some counter-factual analysis. For example, if a bank provided a detailed analysis of an appropriate amount of

[10]Interestingly, implicit or explicit enforcement by a bank shows a negative sign although it is not significant. That indicates that end-user firms may exaggerate their issues. Since the relationship between a lender bank and a borrower firm is not main issue here, I will not dive into this issue.

hedging, the compliance risk probability is lowered roughly by 37.1%.

Given estimates of the parameters, one can adjust the price of the structural product (strike price K) by replacing (4.10) with (4.13) as a specification of compliance risk probability in the pricing formula (5.3).

7 Conclusion

In this paper, I proposed a new model to quantify a customer suitability risk arising from overhedging using structured products. In the model, a firm hedges its exposure to a macroeconomic factor by purchasing a structured product from a derivative-selling bank. A firm effectively shorts a put option and longs a forward in the product. A new feature is that a firm may misunderstand an embedded short position of the put option and excessively hedges its exposure. A firm's unintentional deviation from its optimal hedging amount creates a customer suitability risk to a derivative-selling bank.

I consider that customer suitability risk has two different effects: derivative-triggered default and compliance risk. First, it increases the probability of derivative-triggered default through an increased leverage. Second, it reduces a recovery rate of the bank's exposure due to compliance risk. To capture these effects, I integrate firm's hedging model with Merton-type structural credit risk model.

Using the model, I study the optimal design of the structured products. Interestingly, the optimal leverage is lowered when end-user firm is less risk-averse. The mechanism behind this is that a less risk-averse end-user firm purchases the structured product more due to misunderstanding of the payoff. Consequently, the derivative-triggered default risk increases. The derivative-selling bank takes such a negative effect into account when the bank designs the structured product. Thus, the leverage embedded in the structured product is lowered to mitigate the negative effect.

Also, I discuss how such a customer suitability risk can be incorporated into derivatives pricing. What I show is that: When the price of the structured product does not reflect customer suitability risk, the price of the structure product is lowered as embedded leverage is increased. This is because a larger benefit of selling a short put option makes the price of this hedging instrument cheaper. However, when the price reflects the customer suitability risk, the price is not lowered as in the previous case. The intuition is that the expected cost of customer suitability risk is reflected in the derivatives price.

Finally, I apply the model for financial distress of Japanese importers caused by their derivative contracts during the 2010-2014 period. Using a hand-collected dataset, I conduct a text-based analysis for 1,429 Alternative Dispute Resolution (ADR) cases and estimate model parameters.

In this paper, I made several simplifying assumptions for expository simplicity and computational tractability. For example, I assumed that firm's objective function is mean-variance utility. In reality, firm's hedging behavior is more complicated. With respect to the empirical analysis this paper, I focused on one specific structured product sold in Japan. More comprehensive research is needed to better understand the customer suitability risk. These are left for future research.

References

Allayannis, G., Ugur, U., Miller, D.P., 2012. "The use of foreign currency derivatives, corporate governance, and firm value around the world," *Journal of International Economics*, 87(1), 65-79.

Bae, S., Kim, H., Kwon, T., 2018. "Currency derivatives for hedging: New evidence on determinants, firm risk and performance," *Journal of Futures Markets*, 38(4), 446-467.

Basel Committee on Banking Supervision, 2008. "Customer suitability in the retail sale of financial products and services." Report.

Breuer, W., Perst, A., 2007. "Retail banking and behavioral financial engineering: The case of structured products," *Journal of Banking and Finance*, 31(3), 827-844.

Bukart, O., Bouveret, A., 2012. "Customer suitability in the retail sale of financial products and services," European Systemic Risk Board.

Célérier, C., Vallée, B., 2015. "The motives for financial complexity: an empirical investigation," Working paper.

Capponi, A., Civitanić, J., 2009, "Credit risk modeling with misreporting and incomplete information," *International Journal of Theoretical and Applied Finance*, 12(1), 83-112.

Dodd, R., 2009. "Exotic derivatives losses in emerging markets: Questions of suitability, concerns for stability." IMF Working paper.

Frechette, D., 2001, "The demand for hedging with futures and options," *Journal of Futures Markets*, 21(8), 693-712.

Garcia, D., 2013, "Sentiment during recession," *Journal of Finance*, 68(3), 1267-1300.

Grünbichler, A., Wohlwend, H, 2005. "The valuation of structured products: empirical findings for Swiss market," *Financial Markets and Portfolio Management*, 19(4), 361-380.

Hadlock, C., Pierce, J., 2010. "New evidence on measuring financial constraints: Moving beyond the KZ index," *Review of Financial Studies*, 23(5), 1909-1940.

Huang, H., Yildirim, Y., 2008. "Leverage, options liabilities, and corporate bond pricing," *Review of Derivatives Research*, 11(3), 245-276.

Lioui, A., Poncet, P., 2002. "Optimal currency risk hedging," *Journal of International Money and Finance*, 21, 241-264.

Michenaud, S., Solnik, B., 2008. "Applying regret theory to investment choices: currency hedging decisions," *Journal of International Money and Finance* 29(12), 677-694.

Merton, R., 1974. "On the pricing of corporate debt: the risk structure of interest rates," *Journal of Finance*, 29(2), 449-70.

Stoimenov, P., Wilkens, S., 2005. "Are structured products 'fairly' priced? An analysis of the German market for equity-linked instruments," *Journal of Banking and Finance* 29(12), 2971-2993.

Wallmeier, M., Diethelm, M., 2009. "Market pricing of exotic structured products: the case of multi-asset barrier reverse convertibles in Switzerland," *Journal of Derivatives* 17(2), 59-72.

Wilkens, S., Erner, C., Röder, K., 2003. "The pricing of structured products in Germany," *Journal of Derivatives* 11(1), 55-69.

A Proof of (3.11)

Here, I show that $N^{**} > N^*$. There are two steps to prove this statement. The idea is to compare two terms in N^* and N^{**}

The first step is to show $c < 1$. Recall that c is represented as

$$\begin{aligned} c &= \frac{\mathrm{Var}^P[X_T - \gamma D_T] - \gamma^2 \mathrm{Var}^P[D_T] + \gamma \mathrm{Cov}[X_T, D_T]}{\mathrm{Var}^P[X_T - \gamma D_T]} \\ &= 1 - \frac{\gamma^2 \mathrm{Var}^P[D_T] - \gamma \mathrm{Cov}[X_T, D_T]}{\mathrm{Var}^P[X_T - \gamma D_T]} \end{aligned} \tag{A.1}$$

In the numerator above, it is obvious that the first term $\gamma^2 \mathrm{Var}^P[D_T]$ is always positive. The second term $\gamma \mathrm{Cov}[X_T, D_T]$ is negative because D_T is defined as $D_T = \max(X_0 - X_T, 0)$ and thus it is negatively correlated with X_T. Thus, it is proved that c is smaller than 1. Given $c < 1$, one can easily see that the first term in N^{**} is larger than N^*.

The second step is to compare the second term in N^* and N^{**}. We would like to prove the following inequality:

$$\frac{\mathrm{E}^P[X_T] - K - f}{2\lambda \mathrm{Var}^P[X_T]} > \frac{\mathrm{E}^P[X_T] - K - \gamma \mathrm{E}^P[D_T] - f}{2\lambda \mathrm{Var}^P[X_T - \gamma D_T]}. \tag{A.2}$$

(1) With respect to the numerator, it is clear that left side of the inequality from N^{**}) is larger because it does not have $\gamma \mathrm{E}^P[D_T]$.
(2) With respect to the denominator, $\mathrm{Var}^P[X_T] < \mathrm{Var}^P[X_T - \gamma D_T]$ because embedded leverage increases variance. Recall the payoff structure.

Given these discussions, it is shown that $N^{**} > N^*$.

B Proof of (3.13)

We would like to show that there always exists an incorrect risk aversion parameter $\lambda^{incorrect}$ that satisfies

$$N^*(\lambda^{incorrect}) = N^{observed}, \tag{B.1}$$

where N^* is given by

$$N^* = cM + \frac{\mathrm{E}^P[X_T] - K - \gamma \mathrm{E}^P[D_T] - f}{2\lambda^{incorrect} \mathrm{Var}^P[X_T - \gamma D_T]}, \tag{B.2}$$

Simple algebra leads to

$$\lambda^{incorrect} = \frac{\mathrm{E}^P[X_T] - K - \gamma \mathrm{E}^P[D_T] - f}{2(N^* - cM) \mathrm{Var}^P[X_T - \gamma D_T]} \tag{B.3}$$

Thus, it is clear that a unique solution $\lambda^{incorrect}$ exists.

C Proof of (3.15)

We would like to show that optimized leverage is represented as

$$\gamma = \frac{e^{r_d T} D_0 - \mathrm{E}^p[D_T]}{2\lambda N^* \mathrm{Var}^P[D_T]} + \frac{\mathrm{Cov}[X_T, D_T]}{\mathrm{Var}^P[D_T]} \frac{N^* - M}{N^*}. \tag{C.1}$$

Let us denote the objective function with $F(N, \gamma)$.

$$F(N, \gamma) = \mathrm{E}^P[A_T] - \lambda \mathrm{Var}^P[A_T]. \tag{C.2}$$

Before diving into the details, notice that $\frac{\partial F}{\partial N^*} = 0$ where N^* is the optimized amount N. Hence, we have

$$\frac{\partial F}{\partial \gamma} = \frac{\partial F}{\partial N^*}\frac{\partial N^*}{\partial \gamma} + \frac{\partial F}{\partial \gamma} = \frac{\partial F}{\partial \gamma}. \tag{C.3}$$

Given this fact, let us compute each term in the objective function.

$$\frac{\mathrm{E}^P[A_T]}{\partial \gamma} = -N^*(e^{r_d T} D_0 - \mathrm{E}^p[D_T]), \tag{C.4}$$

$$\frac{\mathrm{Var}^P[A_T]}{\partial \gamma} = 2\gamma N^{*2} \mathrm{Var}^p[D_T] - 2(N^* - M) N \mathrm{Cov}^p[X_T, D_T]. \tag{C.5}$$

Hence, the first order condition is given by

$$-N^*(e^{r_d T} D_0 - \mathrm{E}^p[D_T]) - 2\lambda\gamma N^{*2} \mathrm{Var}^p[D_T] + 2\lambda(N^* - M) N \mathrm{Cov}^p[X_T, D_T] = 0. \tag{C.6}$$

Simple algebra leads to $(C.1)$.

Table 1: Base-case parameter values used in the analysis of optimal design of structural products

	Parameter	Value
Firm's liability level	L	0.2
Firm's sales	S	1.0
Firm's importing cost	M	0.5
Domestic interest rate	r_d	0.02
Foreign interest rate	r_f	0.03
Fee per amount N	f	0.05
Recovery rate with suitability issue	R^{NS}	0.5
Recovery rate without suitability issue	R^S	1.0
Constant compliance risk	p^{NS}	0.77
Constant term of compliance risk to hedging amount	a_0	0.00
Sensitivity of compliance risk to hedging amount	a_1	1.00
Maturity of exotic currency forward	T	2
Volatility of foreign exchange rate	σ_X	0.1
Subjective expected change in foreign exchange rate	μ	0.05
Risk-aversion parameter	λ	1

Table 2: Summary statistics of Japanese ADR Cases of FX derivatives during 2010-2014: For each column, I show the sum of integer codes. Each integer variable means the following: (1) Overhedge: whether an end-user firm perceives the amount of their derivatives purchase is overhedging or not. (2)Exp (firm): whether an end-user firm perceives that their derivative-selling bank has clearly explained the payoff of the products or not. (3) Exp (bank): whether a bank perceives that they have clearly explained the payoff of the products or not, (4)Analysis: whether appropriate analysis is provided by derivative-selling banks to their end-user firm or not, (5) Com: Results of bank's analysis is provided or not. (5)Loan: whether end-user firm perceived their purchase of derivatives are implicitly or explicitly linked to their borrowing from derivative-selling bank. (6) Result: whether derivative-selling banks admit the violation of customer suitability or not. Please refer to detailed descriptions of these variables in the main text. Sample is the number of ADR cases of FX derivatives in each month.

	Sample	Overhedge	Exp (firm)	Exp (bank)	Analysis	Com	Loan	Result
2010	30	26	28	0	20	5	33	21
2011	452	386	399	4	353	3	85	387
2012	745	630	733	1	485	3	26	572
2013	195	180	183	1	100	2	39	120
2014	5	5	2	0	1	0	6	2
Not Clear	2	1	1	0	0	0	0	0
Total	1429	1228	1346	6	959	13	189	1102
(percentage)	(100%)	(86%)	(94%)	(0.4%)	(20%)	(5%)	(33%)	(77%)

Table 3: Correlation matrix of text-based integer variables from Japanese ADR Cases of FX derivatives during 2010-2014: Each integer variable means the following: (1) Overhedge: whether an end-user firm perceives the amount of their derivatives purchase is overhedging or not. (2)Exp (firm): whether an end-user firm perceives that their derivative-selling bank has clearly explained the payoff of the products or not. (3) Exp (bank): whether a bank perceives that they have clearly explained the payoff of the products or not, (4)Analysis: whether appropriate analysis is provided by derivative-selling banks to their end-user firm or not, (5) Com: Results of bank's analysis is provided or not. (5)Loan: whether end-user firm perceived their purchase of derivatives are implicitly or explicitly linked to their borrowing from derivative-selling bank. (6) Result: whether derivative-selling banks admit the violation of customer suitability or not. Please refer to detailed descriptions of these variables in the main text. Sample is the number of ADR cases of FX derivatives in each month.

	Overhedge	Exp (firm)	Exp (bank)	Analysis	Com	Loan
Overhedge	100%	-3%	-10%	15%	-2%	5%
Exp (firm)	-	100%	-3%	-1%	-1%	-19%
Exp (bank)	-	-	100%	-7%	-1%	-1%
Analysis	-	-	-	100%	-4%	3%
Com	-	-	-	-	100%	5%
Loan	-	-	-	-	-	100%

Table 4: Estimated coefficients in the regression of the ADR case results on text-based integer variables: For each column, I show the coefficients. Each integer variable means the following: (1) Overhedge: whether an end-user firm perceives the amount of their derivatives purchase is overhedging or not. (2)Exp (firm): whether an end-user firm perceives that their derivative-selling bank has clearly explained the payoff of the products or not. (3) Exp (bank): whether a bank perceives that they have clearly explained the payoff of the products or not, (4)Analysis: whether appropriate analysis is provided by derivative-selling banks to their end-user firm or not, (5) Com: Results of bank's analysis is provided or not. (5)Loan: whether end-user firm perceived their purchase of derivatives are implicitly or explicitly linked to their borrowing from derivative-selling bank. (6) Result: whether derivative-selling banks admit the violation of customer suitability or not. Please refer to detailed descriptions of these variables in the main text. Sample is the number of ADR cases of FX derivatives in each month.Numbers in parenthesis are standard deviations for each estimate. Intcpt is an estimate of intercept β_0 in equation (4.13).

	Overhedge	Exp (firm)	Exp (bank)	Analysis	Share	Loan	Intcpt
Coefficient	0.689	0.185	14.39	1.615	1.00	-0.039	-0.425
	(0.177)	(0.298)	(347.08)	(0.138)	(0.81)	(0.131)	0.332

Figure 1: Payoff of vanilla forward and exotic forward

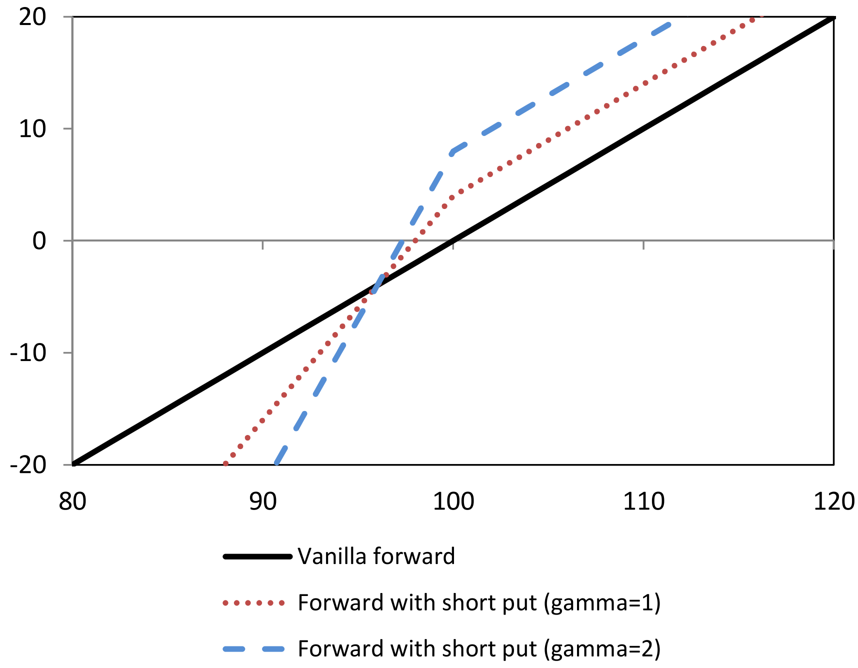

Figure 2: The relationship between embedded leverage and optimal amount of hedging under two cases: correct understanding of payoff structure vs. misunderstanding

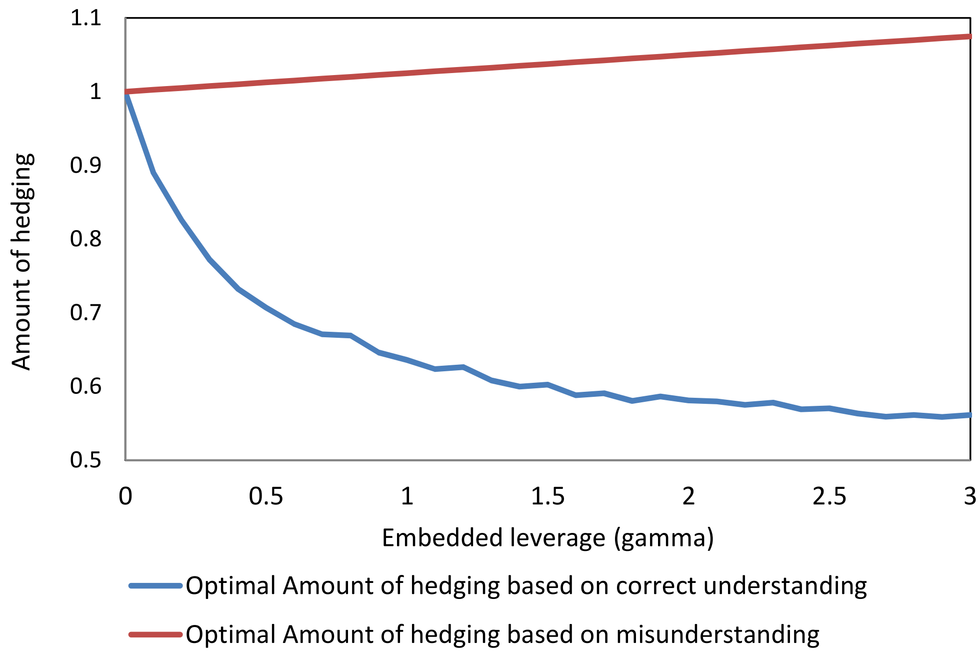

Figure 3: The relationship between embedded leverage and expected net profit when firm the risk aversion parameter $\lambda = 5$ (Firm is relatively more risk-averse)

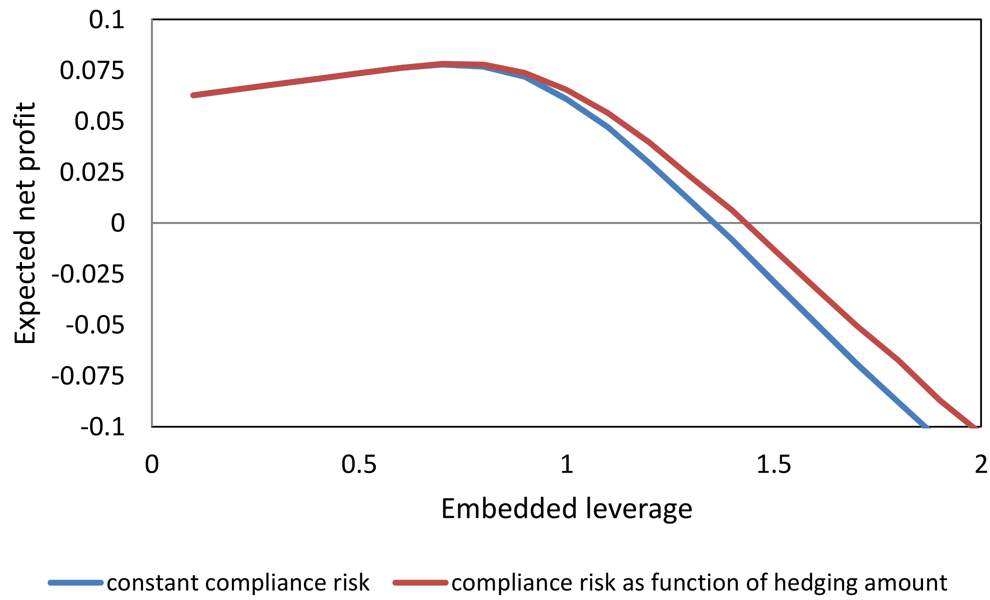

Figure 4: The relationship between embedded leverage and expected net profit when firm the risk aversion parameter $\lambda = 1$ (Firm is relatively less risk-averse)

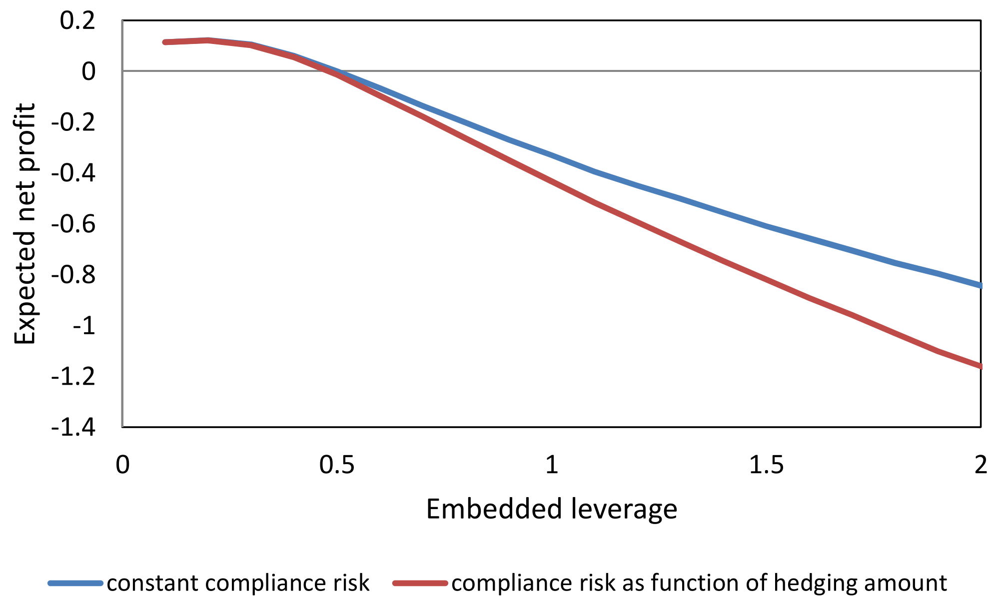

Figure 5: The relationship between fee per notional of structured product f and amount of hedging instrument

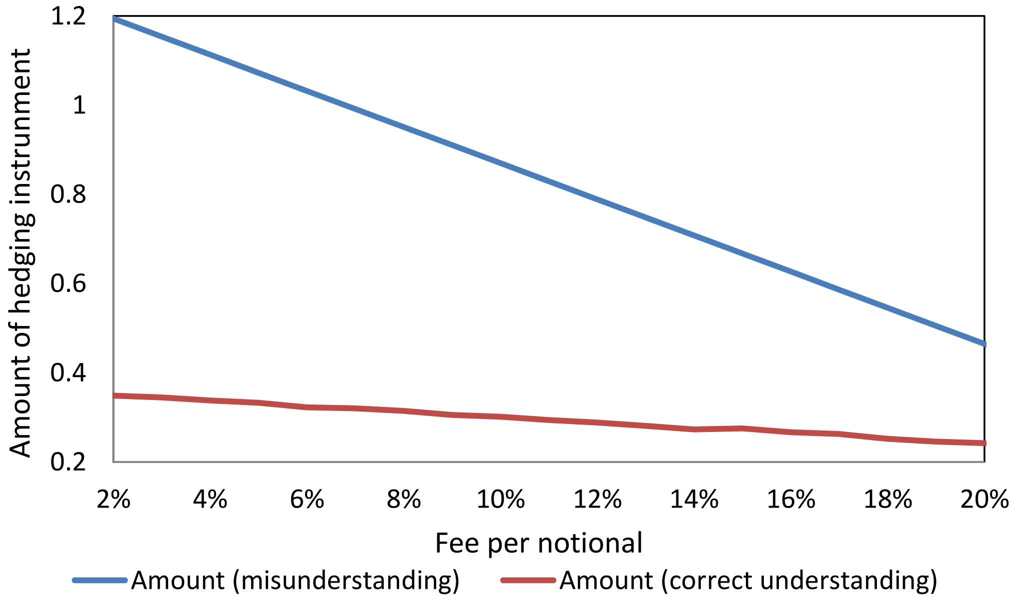

Figure 6: The relationship between fee per notional of structured product f and default probability and compliance risk probability

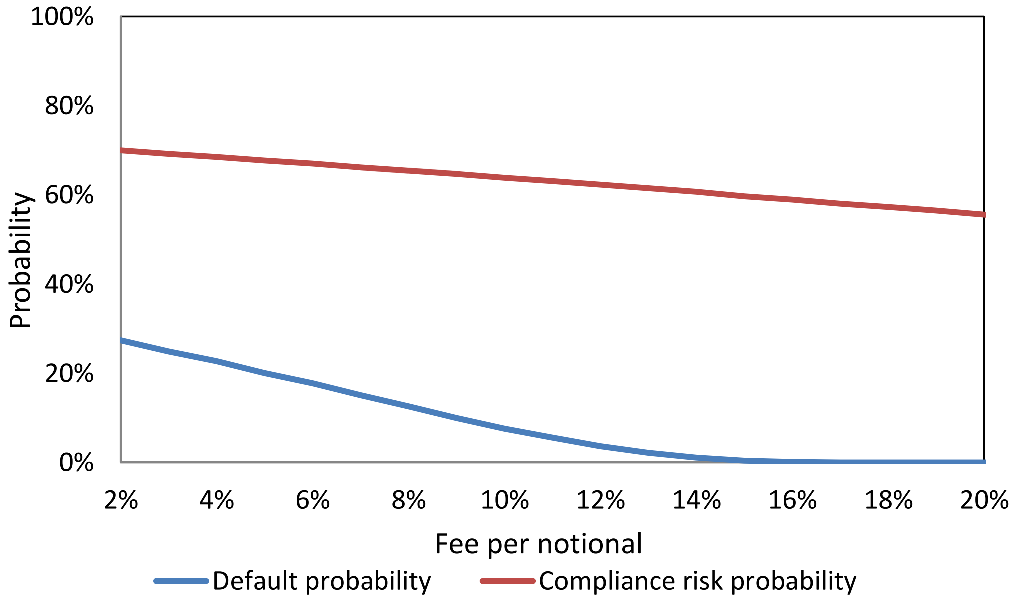

Figure 7: The relationship between embedded leverage and adjusted strike

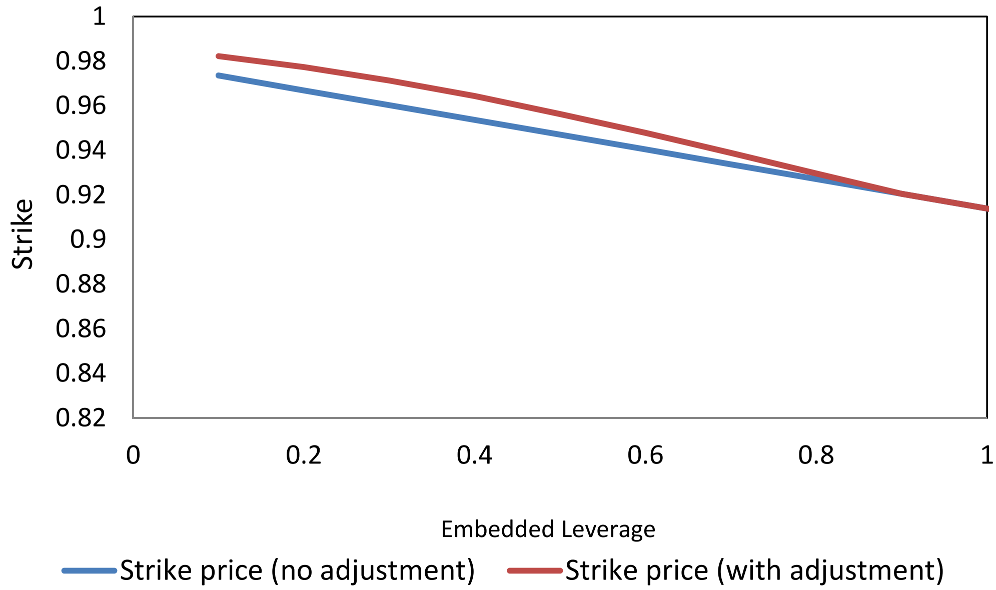

Figure 8: Evolution of the number of ADR cases and the US dollar against Japanese yen during the 2010-2015 period. Data source is the website of Japanese Bankers Association.

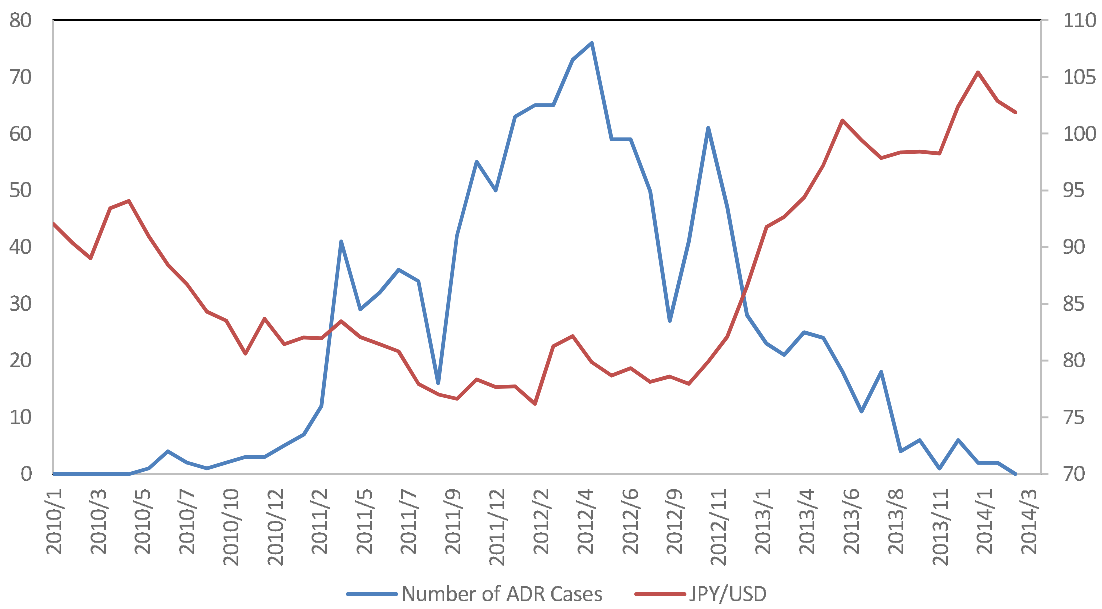

Figure 9: Evolution of the Japanese Yen against the US dollar: Spot and Survey-based values. The survey-based exchange rates are from the Bank of Japan. The survey is conducted for large manufacturing firms.

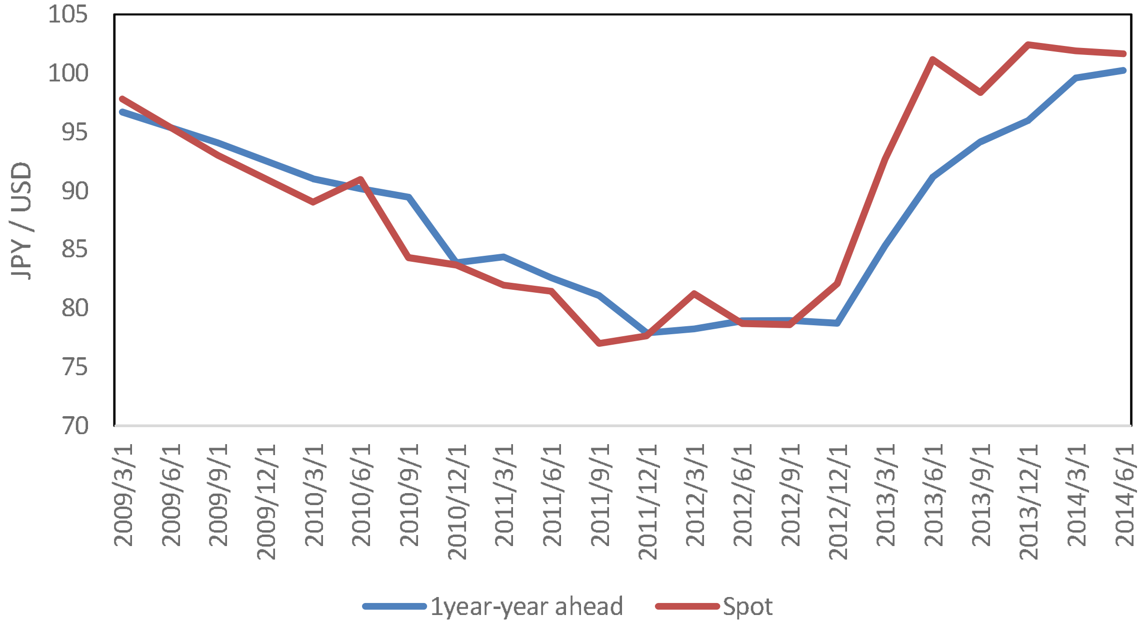

Figure 10: Empirical distribution of time to decision conditioning on reconciliation in ADR cases

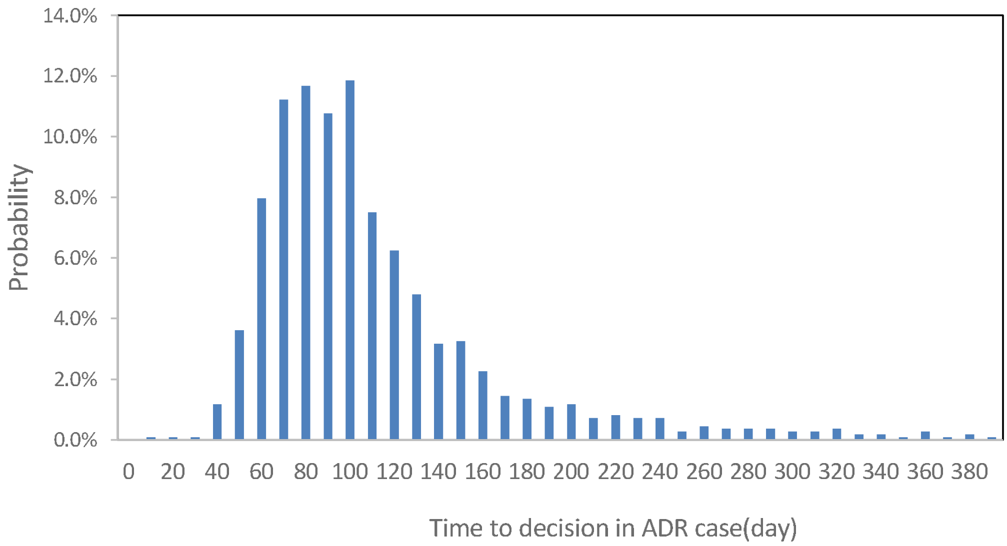

Figure 11: Empirical distribution of time to decision conditioning on breakdown in ADR cases