Foreign exchange risk management with hedging

DND counterfactual hedge results 2009 – 2013

David W. Maybury
Defence Economics Team

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Defence R&D Canada
Centre for Operational Research and Analysis

Defence Economics Team
Assistant Deputy Minister (Finance and Corporate Services)

National Defence Défense nationale

Canada

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Principal Author

Original signed by David W. Maybury

David W. Maybury

Approved by

Original signed by R.M.H. Burton

R.M.H. Burton
Section Head (Joint Systems Analysis)

Approved for release by

Original signed by P. Comeau

P. Comeau
Chief Scientist

Abstract

Using foreign exchange transaction data from eight Department of Defence (DND) managed projects from fiscal year 2009 to fiscal year 2013, we counterfactually apply four derivative based hedging scenarios to mitigate foreign exchange transaction risk. The total foreign currency exposure represented by the eight projects amounts to $3 billion USD. We focus the study on zero cost structures for hedge performance comparison. Over the five fiscal years considered, we find that the hedge performs within 3% of spot purchases, but the hedge comes with a maximum cost for the US dollar within each fiscal year. If DND can translate the more stable cash flows that a foreign exchange hedge offers into better management, then a foreign exchange hedge can help DND increase the value of national defence offered to Canada.

Résumé

À la lumière des données sur les opérations de change effectuées au cours des exercices 2009 à 2013 dans le cadre de huit projets gérés par le ministère de la Défense nationale (MDM), quatre stratégies de couverture faisant appel aux produits dérivés sont appliquées hypothétiquement afin de réduire le risque de change. L'exposition au risque de change des huit projets totalise 3 G$ US. L'étude est axée sur les stratégies d'option à prime zéro aux fins de la comparaison de l'efficacité de couverture. Au cours des cinq exercices examinés, les stratégies de couverture donnent des résultats se situant dans une fourchette de 3% par rapport aux achats au comptant, sauf que la couverture est assortie d'un coût maximal dans le cas du dollar américain à chaque exercice. Si le MDN peut améliorer sa gestion grâce à la stabilisation des flux de trésorerie qu'offre la couverture du risque de change, alors les stratégies de couverture permettront au Ministère d'accroître la valeur des services de défense nationale offerts au Canada.

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Executive summary

Foreign exchange risk management with hedging

David W. Maybury ; DRDC CORA TM 2013-205; Defence R&D Canada – CORA; December 2013.

We counterfactually apply four different hedging strategies using two scenarios to mitigate foreign exchange transaction risk in eight Department of National Defence (DND) projects from fiscal year 2009 to fiscal year 2013. The total foreign currency obligation contained in the eight projects amounts to $3 billion USD. For hedging we use, forward contracts, risk reversals, forward extras, and vanilla call options matched to payments within each fiscal year. In Scenario A, we hedge 99% of the foreign exchange obligations while in Scenario B we apply the hedge to 50% of the obligations.

In Table 1 we see the hedging performance of each strategy under both scenarios. In the table, we have listed the USD obligation and the cost of the spot purchase. Under the listed spot purchase price, we show the profit and loss, relative to the spot purchase, of each strategy in nominal Canadian dollars and percentage. In the final column we show the nominal hedging performance across the five fiscal years. Over fiscal years 2009 – 2013, we see that the hedging performance ranges from -3% to $+0.3\%$ and thus the hedge performance across all strategies and scenarios did not lead to large departures from the spot purchase costs. We should expect this result – the purpose of instituting a hedge is not to generate profits, but to gain cash flow predictability and allow management to focus on more productive tasks. The first two years of the counterfactual study represent a period of profound market stress associated with the financial crisis and the tepid recovery that followed. In fiscal year 2009 we see that the hedge performs well, paying off like and insurance contract in the depths of the financial crisis. The following year paints a different picture as the recovery resulted in a strengthening Canadian dollar – the hedges all underperformed spot purchases. In April of 2009, the uncertainty surrounding a possible recovery remained extremely high and the high volatility of the Canadian dollar at that time reflected the market's inability to gauge the severity of a possible continued slide. Hedging in early 2009 would have worked as pure insurance against the most extreme outcomes, which in the end, did not materialize.

A foreign exchange hedge within DND can provide a benefit by stabilizing cash flows and mitigating financial risk if DND managers can realize comparative advantages in other aspects of project management. If managers can better focus on the procurement risks that they can control by removing the foreign exchange risk within projects, then hedging will increase the value of national defence offered to Canadians.

Table 1: Hedge performance for strategies under Scenario A (99+% hedged) and Scenario B (50% hedged)
FX: Forward, RR: Risk Reversal, FE: Forward Extra, VC: Vanilla Call.

	Fiscal Years											
Hedge scenario	FY09		FY10		FY11		FY12		FY13		Nominal Totals	
Scenario A												
USD obligation	$445,316,696	-	$609,613,637	-	$773,818,593	-	$638,571,757	-	$444,089,771	-	$2,911,410,454	-
Spot purchase	$494,126,888	-	$645,634,791	-	$785,479,585	-	$634,531,371	-	$446,248,989	-	$3,006,021,626	-
FX(P/L)	$37,657,379	7.6%	−$120,150,090	−18.6%	$3,514,457	0.45%	$16,341,286	2.6%	$4,426,547	1.0%	−$58,210,421	−1.9%
RR(P/L)	$18,639,930	3.8%	−$59,203,584	−9.2%	$396,044	0.05%	$251,671	0.04%	$669,719	0.15%	−$39,246,220	−1.3%
FE(P/L)	$18,639,930	3.8%	−$11,932,429	−1.8%	$396,044	0.05%	$251,671	0.04%	$669,719	0.15%	$8,024,935	0.3%
VC(P/L)	$13,076,171	2.6%	−$15,122,004	−2.3%	−$9,287,542	−1.2%	−$6,377,167	−1.0%	−$4,134,921	−0.93%	−$21,845,463	−0.7%
Scenario B												
USD obligation	$208,539,016	-	$289,065,884	-	$382,267,689	-	$307,529,703	-	$251,991,300	-	$1,439,393,592	-
Spot purchase	$221,072,210	-	$302,764,071	-	$385,913,056	-	$303,645,723	-	$254,099,493	-	$1,467,494,553	-
FX(P/L)	$7,423,998	3.4%	−$60,219,744	−19.9%	−$491,560	−0.12%	$6,182,296	2.0%	$3,521,983	1.4%	−$43,583,027	−3.0%
RR(P/L)	$0	0%	−$29,968,216	−9.9%	$0	0%	$0	0%	$389,532	0.15%	−$29,578,684	−2.0%
FE(P/L)	$0	0%	−$11,452,942	−3.8%	$0	0%	$0	0%	$389,532	0.15%	−$11,063,410	−0.8%
VC(P/L)	−$2,619,792	−1.2%	−$7,485,207	−2.5%	−$4,878,783	−1.3%	−$2,943,736	−0.97%	−$2,080,067	−0.9%	−$20,007,585	−1.4%

Sommaire

Foreign exchange risk management with hedging

David W. Maybury ; DRDC CORA TM 2013-205 ; R & D pour la défense Canada – CARO ; décembre 2013.

Quatre stratégies de couverture différente sont appliquées de façon hypothétique suivant deux scénarios, en vue de réduire le risque de change dans huit projets du ministère de la Défense nationale (MDN) au cours des exercices 2009 à 2013. Les obligations en devises totalisent 3 G$ US pour l'ensemble des huit projets. À des fins de couverture, nous utilisons des contrats à terme de gré à gré, des tunnels, des forward extras et des options d'achat classiques en contrepartie des paiements au cours de chacun des exercices. Suivant le scénario A, 99% des obligations en devises font l'objet d'une couverture, comparativement à 50% dans le cas du scénario B. Le tableau 2 montre l'efficacité de chacune des stratégies de couverture suivant chacun des deux scénarios. Y sont indiqués les obligations en devises et le coût de l'achat au comptant. Sous le prix au comptant coté est présenté le gain ou la perte correspondant à chacune des stratégies, par rapport à l'achat au comptant, en dollars canadiens nominaux et en pourcentage. La dernière colonne indique l'efficacité de la couverture en termes nominaux à chacun des cinq exercices. Au cours des exercices 2009 à 2013, l'efficacité de la couverture s'est située entre -3% et $+\ 0{,}3\%$. Ainsi, il n'y a pas eu de grandes variations par rapport au coût de l'achat au comptant, quelle que soit la stratégie et quel que soit le scénario pris en considération. Ce résultat n'a pas de quoi étonner, étant donné que l'objectif des mesures de couverture n'est pas de générer des gains, mais bien d'accroître la prévisibilité des flux de trésorerie et de permettre à la direction de se concentrer sur des tâches plus productives. Les deux premières années prises en considération dans l'étude hypothétique coïncident avec de profonds bouleversements sur les marchés, qui ont connu une crise financière puis une reprise timide. L'étude montre que, au cours de l'exercice 2009, les stratégies de couverture fonctionnent bien, agissant comme une police d'assurance au plus fort de la crise financière. La situation est bien différente l'exercice suivant, au cours duquel la reprise s'est traduite par une hausse de la valeur du dollar canadien - de sorte que les stratégies de couverture sont toutes défavorables par rapport aux achats au comptant. En avril 2009, l'éventualité d'une reprise demeurait très incertaine, et la valeur du dollar canadien a reflété l'incapacité du marché à jauger la gravité d'une éventuelle poursuite de la dégringolade. En 2009, les stratégies de couverture auraient purement agi comme des assurances contre les pires résultats, lesquels ne se sont au bout du compte jamais matérialisés.

La couverture de change au sein du MDM peut permettre de stabiliser les flux de trésorerie et de réduire le risque financier, ce qui peut être avantageux dans la mesure où les gestionnaires du MDM peuvent réaliser des avantages comparatifs dans d'autres aspects de la gestion de projets. Si les gestionnaires peuvent se concentrer davantage sur les risques qu'ils peuvent gérer en ce qui a trait aux approvisionnements, du fait que le risque de

change est retiré des projets, alors la couverture permettra d'accroître la valeur des services de défense nationale offerts aux Canadiens.

Tableau 2: Efficacité des stratégies de couverture suivant le scénario A (99+% de couverture) et le scénario B (50% de couverture) FX : Forward, RR : Risk Reversal, FE : Forward Extra, VC : Vanilla Call.

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Table of contents

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1 Introduction

Those who have knowledge, don't predict. Those who predict, don't have knowledge.
— Lao Tzu, 6th Century BCE Chinese Poet

In program delivery and procurement contracts, the Department of National Defence expends approximately 10% of its annual budget in foreign currency, and current fiscal policy dictates that DND buys foreign currency as needed in the spot market. DND projects assume the risk of adverse currency fluctuations within their appropriations and project managers mitigate this risk by using a contingency reserve. By the end of each fiscal year, senior leadership expects project managers to have expended their appropriation with minimal remaining contingency. In addition to inherent project risks, fluctuating exchange rates impose added challenges for project managers – they must simultaneously spend their allocation while protecting against cost over-runs in an highly uncertain environment.

While the current policy relies on self-insurance for foreign exchange, the risk of an adverse currency fluctuations remains inside each project. Management has limited resources to mitigate fiscal project risk – any remaining contingencies at the end of a fiscal year creates a lapsed funding problem, while an overage raises serious concerns among senior management. In effect, the foreign exchange self-insurance policy uses a decentralized process in which the risk rests with the entity least capable of handling an adverse currency fluctuation – the individual project. In 2010, senior leadership in ADM(Mat) and ADM(Fin CS) participated in a corporate risk prioritization review. Both assistant deputy ministers concluded that foreign exchange risk represents a high risk element for DND, stating that "*increased financial pressure due to external factors represents one of the highest risk factors among all corporate activities at DND*" [1].

The current self-insurance policy creates managerial overhead within DND projects. If DND project management can realize efficiencies by removing most or all of the foreign exchange risk within projects, thereby simplifying at least one aspect associated with managing contingency reserves, we have an opportunity to improve the business of national defence. One method for removing foreign exchange risk from individual projects involves trading the unwanted risk to those more capable of holding it. We can accomplish this trade by using a financial intermediary to construct a foreign exchange hedge.

1.1 Background

Monetary and fiscal authorities in Canada do not impose a Canadian dollar exchange rate target but instead rely on market forces to determine the value of the Canadian dollar [2]. By using a floating exchange rate regime, the Canadian dollar adjusts automatically, reflecting Canada's economic fundamentals, fiscal and monetary policy, and trade balances

with the rest of the world. The Bank of Canada will directly intervene in foreign exchange markets to stabilize the Canadian dollar only under the most extreme of circumstances.

Over the last five years, DRDC CORA has helped senior DND decision makers understand the risks that foreign exchange transactions present to operational planning and military procurement [3]. In 2007, ADM(Mat) tasked DMGOR (Directorate Materiel Group Operational Research) to examine new approaches to foreign exchange risk management within DND projects. DMGOR analyzed the value-at-risk (VaR) associated with foreign exchange transactions for both the National Procurement and Capital accounts [4] and established departmental foreign exchange loss thresholds over time horizons matched to spending. The DMGOR model uses generalized autoregressive conditional hetroskedasticity techniques (GARCH) applied to foreign exchange spot rates in conjunction with time series analysis of actual DND foreign currency expenditures [5]. Following VaR analysis, senior decision makers within ADM(Mat) also sought from DMGOR counterfactual studies to understand possible risk mitigation strategies. In 2011, DMGOR provided a complete counterfactual hedging example for ADM(Mat)'s US dollar obligations over a short time window, November 2009 to July 2010 [3]. Using in-house derivative pricing expertise, the study demonstrated hedging performance using six derivative based strategies with the corresponding reduction in budget variance.

The hedging work conducted by the DMGOR follows on a 2005 example [6] in which Essaddam et al. examined hedging DND's foreign exchange risk using forward contracts[1] using two simple hedging rules with data from April 1990 to October 2002. They found that the forward contract hedging strategy surpassed DND's status quo no hedge policy while offering lower volatility. Following the Essaddam et al. study, Director Strategic Finance and Costing (DSFC 7) examined foreign exchange risk in DND and concluded that DND should develop a well-defined foreign exchange risk mitigation strategy involving the Department of Finance [7].

1.2 Scope

ADM(Fin CS) requires a summary of counterfactual hedging performance of foreign exchange risk over a multi-year time window. In this paper we provide:

- the counterfactual performance of foreign exchange hedging strategies applied to eight ADM(Mat) projects with US dollar exposure over five fiscal years (2009 - 2013);
- a comparison of four broadly popular hedging techniques within the counterfactual study; and

[1] Foreign currency forwards are derivative contracts that obligate the parties to exchange currencies at a predetermined fixed price at a predetermined maturity date.

- a scenario comparison in which we apply the counterfactual hedge to only half of the foreign exchange obligation.

2 Model application

Given Canada's increasing commitments to overseas operations along with a procurement renewal program consistent with the Canada First Defence Strategy, DND's foreign exchange expenditures constitute a significant budget liability. Future procurements – including the recently announced shipbuilding program and the next generation fighter aircraft acquisition – will continue to amplify DND's exposure to foreign exchange transaction risk in the years to come. Unlike the public sector, corporate Canada has engaged in financial hedging for decades, a process whereby firms enter contracts to insure against unwanted financial risks. Hedging represents relatively new ground for government departments since the public sector tends to view hedging as a risky form of speculation[6]. Used in the same way as corporate Canada, hedging foreign exchange risk within DND projects offers the possibility of smoother and more stable cash flows, which can help management during planning processes.

We must emphasize that on its own hedging **cannot** affect the valuation of a firm. At its most basic level, hedging repackages cash flows that a firm owns from its investments and repackaging alone cannot change valuation. Increased firm value arises through better management of existing risks and processes, or through the development of new opportunities. That hedging by itself cannot change a firm's value is a reflection of the famous Modigliani-Miller theorem (see [8] for details) on the irrelevance of capital structure. In a complete market, if an investor wished to remove certain risks from her asset position in a firm, she could accomplish the risk repackaging herself by entering an appropriate derivative contract without the use of the corporate treasurer. Given hedging's zero-sum role in affecting the value of a firm, a firm's decision to hedge must rest in comparative advantages that the hedge separately creates. Used incorrectly, a hedging scheme can amplify the firm's risks by behaving like a proprietary trading desk married to the firm's other activities. The trading activity will lead to higher returns for the firm but only because the firm has made its cash flows more risky. Corporate treasurers must guard against turning a hedge into a risk amplification tool in the quest for higher returns. The 1994 bankruptcy of Orange County[2] provides an excellent example of caution for both governments and private firms in this regard.

In general, a hedge behaves as an insurance contract against targeted risks within the firm. Strictly, insurance is an inferior good – the more wealth an agent has, the less insurance she demands. The scenario in which a wealthy agent elects to forgo insurance, but instead decides to use her own wealth to protect against loss is called self-insurance. Since the

[2]In the early 1990s the Treasurer of Orange County, Robert Citron, used interest rate derivatives (specifically he constructed yield curve plays that involve taking long and short positions in debt maturing at different times) to help manage Orange County's budget. His investments proved so successful that Citron's trading profits became a significant portion of Orange County's revenue. After further expansion of his strategies, in 1994 his positions finally turned against him – he lost the county over $1.5 billion which by December of 1994 resulted in Orange County filing for bankruptcy protection.

government of Canada has the deepest pockets in the country, in principle DND could look to the government for self-insurance. Unfortunately, the federal budget process does not allow for DND to use government coffers as a general source of pooled insurance funds for use in case of an unexpected budget shortfall. The government and DND expects managers to stay within their appropriations which in effect places the responsibility of self-insurance within each project management office. Thus, while the government of Canada could in principle globally self-insure all military procurement and operational budgets, the realities of government funding make this approach untenable. At present, DND absorbs unexpected budget shortfalls, often leading to delayed or cancelled procurement. In such an environment, DND does not have sufficiently deep pockets to self-insure major financial risks.

A foreign exchange hedge within DND can provide a benefit by stabilizing cash flows and mitigating financial risk if DND managers can realize comparative advantages in other aspects of project management. If by removing the foreign exchange risk within projects managers can better focus on the risks that they can control thereby protecting DND from delayed or failed procurement, then the hedge will increase the value of national defence offered to Canadians.

3 Derivatives and the economics of risk exchange

Asset markets facilitate risk sharing. Through trading, market participants create portfolios with risks commensurate with their ability to bear the consequences. To help ensure that all participants can acquire the appropriate level of risk, markets employ specialized contracts whose value depends on a set of underlying variables or assets connected to the risks that participants wish to trade. These contracts are called derivatives (for more details on derivatives and derivative pricing, see [9], [11], [10]) and the name arises from the sense in which the contract's value is *derived* from its underlying features. In a foreign exchange context, some of the underlying variables that determine a derivative contract's price include the foreign and domestic interest rates, the spot exchange rate, and the exchange rate volatility.

Derivatives allow participants to gain or eliminate risk exposure efficiently, and as a result they are widely traded around the globe. Market participants find derivatives useful because they behave like insurance contracts in a market where traditional pooled premium insurance does not exist. Globally, derivative trading is divided between exchanges and the over-the-counter (OTC) market. In the exchange traded derivative market, the exchange (e.g., Chicago Board Options Exchange) lists derivatives, uses a clearinghouse and margin accounts to ensure the performance of all parties, and standardizes derivative contracts, resulting in an ordered market. By contrast, the OTC market involves participants who deal

directly with financial institutions to create highly flexible and tailored derivative contracts to address a specific need. The OTC market deals with sophisticated investors and traders, usually at a corporate level.

Like all traded assets, supply and demand ultimately determines derivative prices, but derivatives come with an additional constraint: the derivative's price must also reflect the underlying variables that determine the derivative's payoff. If the link between the price and the underlying variables breaks, the market will allow someone to make a riskless profit, call arbitrage[3], by directly trading the derivative against the underlying variables. Thus, derivative pricing becomes an intricate mathematical problem, the solution of which ensures arbitrage-free prices.

The derivative market is composed of three types of participants:

1. **Speculators** enter the market by taking risky positions to obtain profits. Based on their understanding and interpretation of market conditions, speculators make bets on the timing and direction of market moves. Speculators use derivatives to acquire risk.

2. **Hedgers** seek market positions that reduce or eliminate risk. In effect, hedgers use derivatives as insurance contracts by trading risk away to other market participants. Corporate treasurers often fill the role of hedgers.

3. **Arbitrageurs** take market positions in an attempt to capture profits by exploiting hypothesized price inconsistencies. In practice, arbitrageurs exploit opportunities that involve a high probability of making a profit even though a small probability of an often large loss remains. Since a loss is always possible, these opportunities are not strictly arbitrage and in reality they form a specialized type of speculation. Many hedge funds participate in this type of trading.

To understand the economic purpose of derivative markets, economists have applied equilibrium analysis to risk itself. A central idea in economics concerns the concept of Pareto efficiency: an allocation of goods is Pareto efficient if there is no other allocation in which some agent is better off and no agent is worse off. A Pareto efficient allocation represents an allocation that cannot be improved. Clearly, Pareto efficiency seems to be a desirable trait in an economy – if two agents can be made better off by trading without hurting anyone in the process, it seems reasonable to let them trade. The concept of Pareto efficiency centers strongly in the First and Second Welfare Theorems, which roughly state, under suitable assumptions, that: 1) all competitive market equilibriums are Pareto efficient and 2) all Pareto efficient allocations can be achieved by a competitive market.

[3]The absence of arbitrage implies that all portfolios with payoffs that are almost surely non-negative, which also have a positive probability of a positive payoff, must come with a positive price.

Pareto efficiency also applies to the allocation of risk in an economy. Imagine a two period market (t = 0 and t = 1) which attaches prices to a set of goods for each possible state of the world and imagine that we can trade our endowment of goods at t = 0 with their state of the world prices. In this idealized scenario, we imagine that all the market participants assemble at a giant auction at which the auctioneer asks for bids on all goods for all states of the world. For example, the auctioneer might ask for bids on "one bushel of wheat for $6.50 if there is a drought in Saskatchewan, but not in Alberta, and the Toronto Maple Leafs win the Stanley Cup". The market participants come to the auction with their endowments of goods and the market clears (although, we suspect that no one would buy the contract that requires the Toronto Maple Leafs to win the Stanley Cup!). These goods are called contingent goods and we see that if we have M actual goods and N states of the world, we have M×N contingent goods to trade. Arrow and Debreu showed that by trading in the contingent goods at t = 0, an equilibrium is reached which is Pareto efficient and satisfies the First and Second Welfare Theorems. In this sense, risk becomes optimally allocated. In reality, we cannot trade contingent goods directly, but by extending the analysis to the trading of a special type of security – called an Arrow security – which pays one unit of wealth in only one state of the world at t = 1 and nothing in all other states of the world, a more general multi-period result establishes that in complete markets (no missing insurance contracts) the equilibrium will be Pareto efficient. Risk, as captured through the use of contingent goods and Arrow securities, can be Pareto optimally allocated in the economy through an idealized competitive market.

If a market is not complete, there is an incentive to introduce securities that satisfy the missing insurance demands, thereby creating the possibility of Pareto improving trades among market participants. This is the role of the derivative industry. By adding a sufficient number and type of derivative instruments to the market place, more insurance demands become met. The financial innovation and growth in the derivative industry over the last 30 years suggests that the market has responded to these incentives leading to more complete and efficient markets. In effect, financial innovation results in better risk sharing among market participants.

While better risk sharing and the introduction of derivatives improves the economy, it does not open the door to the possibility of earning excess risk adjusted returns. Well-constructed and mature markets, such as the developed world's stock markets and the global foreign exchange market, exhibit a high level of efficiency. Efficiency in this context stems from the Efficient Market Hypothesis (EMH) which roughly states that markets use all available information in setting asset prices for today. Since the market uses all available information at any given time, price adjustments arise from the arrival of new and unpredictable information. If the new information were predictable or could be anticipated, then the EHM tells us that that information has already been included in the asset price – i.e., public information provides no advantage to traders. Moreover, the EHM tells us that current market prices of securities represents the best estimate of value which further implies that asset prices should follow a random walk. Simply stated, past prices do not help

us predict future prices and no alleged soothsayer – academic, hedge fund manager, or government bureaucrat – can reliably predict the market. The idea that the market is unpredictable, and cannot be beaten without acquiring excess risk, forms the central tenet of the EMH. In this sense, derivatives do not offer us an opportunity to realize excess gains on a risk adjusted basis. Derivatives help complete the market which further drives the market toward greater levels of efficiency. At DND, Pareto improvements arises from an increased ability to plan, more stable and predictable budget cash flows, and a management team focused on the risks they can control. Again, we caution that we should not view derivative based hedging strategies as an opportunity to beat the market or gain excess profit. There is no such thing as a free lunch.

4 Structured products and strategies

4.1 Strategies

We counterfactually apply four popular derivative based hedging strategies to hedge DND's US dollar foreign exchange obligation in eight selected ADM(Mat) projects. Each strategy provides different levels of protection against foreign exchange risk. Three of the four strategies use zero cost structures – structured products that do not require a premium. For completeness, we include a strategy that uses only vanilla call options.

1. **The forward contract** obliges the contract holder to buy a predetermined amount of foreign currency at a fixed price on a specified delivery date. From the hedger's perspective, the future exchange rate becomes fixed to its unbiased forward estimate (under the risk neutral measure) at the time of contract writing and thus the forward removes all foreign exchange risk from the hedger's obligations. The fixed exchange rate that the forward sets is determined by the current spot rate and the interest rates in the two countries.

   The removal of currency fluctuations resulting from the application of a forward hedge can help managers plan. Using a strategy of forward contracts matched to each project's payments, a central authority could give budget managers exact exchange rates for all future purchases within the budget cycle. This strategy removes the guess work and the contingency planning required in the budget planning process. While the forward contract strategy stabilizes the cash flow, we see that the strategy has a rigid policy – all future exchange rates are known exactly and the hedger cannot take advantage of a strengthening domestic currency.

2. **A call option** behaves like a pure insurance contract. In exchange for a premium, the hedger receives absolute protection from the exchange rate moving above the call option's strike price. Unlike the forward or the structured products we will consider, this strategy requires payment of premiums.

   Option pricing requires more inputs than just the foreign and domestic interest rates. The pricing problem's solution rests on the ability to construct a replicating portfolio that matches the option's value at each point in time and with a replicating portfolio, the financial intermediary precludes the possibility of arbitrage.

   With this strategy the hedger knows the worst case exchange rate (the option's strike price) with full ability to participate in a strengthening domestic currency. From a planning perspective at DND, with option contract maturities matched to payments, the premium works like a trade from the project's contingency reserves to buy a worst case level with certainty.

3. **The risk reversal** is a structure product that provides the hedger with a collar on the exchange rate with no required premium. Unlike the forward contract, the risk

reversal affords the hedger a degree of participation in exchange rate movements. In some sense, the risk reversal behaves like a flexible forward. The risk reversal establishes a collar at zero cost by setting a maximum exchange rate in return for a minimum exchange rate and therefore the hedger is guaranteed a price for the foreign currency within the collar. Thus, while the hedger does not know the future price exactly, she knows the maximum and minimum range of all possible outcomes.

As a structured product, the risk reversal is constructed by buying an out-of-the money call option on the foreign currency while simultaneously selling an out-of-the-money put option on the same currency. The call option provides protection against an increase in the price of the foreign currency beyond the strike price, whereas the sale of the put option provides the necessary funds required to offset the premium associated with the call option. The strike price of the put option provides the lower bound on the collar, and the moneyness[4] of the call and the put determine the range of the collar. If, on the maturity date, the spot price lies between the two strike prices, the hedger purchases the foreign currency in the spot market as both options expire worthless.

4. **The Forward Extra** is a zero cost structured product that gives the hedger more flexibility than either the forward or the risk reversal. Like the risk reversal, the bonus forward establishes an upper bound and lower bound on the exchange rate for the hedger, but unlike the risk reversal the hedger must buy the foreign currency at the upper bound if the exchange rate touches the lower bound at any time during the life of the contract. Because the hedger takes the risk of having to buy the foreign currency at the highest rate within the structured product when the domestic currency is at its strongest, the lower bound of the bonus forward is substantially lower than the equivalent level with the risk reversal. Thus, the bonus forward allows the hedger to participant in more of the gains of a strengthening domestic currency than the risk reversal.

   To construct a forward extra, the hedger buys an out of the money call option and sells a knock-in barrier put option[5] with the same strike price as the call option. The barrier is set so that the premium of the knock-in barrier put exactly offsets the call option's premium. We see that if the exchange rate touches the barrier, we are left with a forward contract with a delivery price that sits at the (unfavourable) strike price.

The counterfactual application of these strategies illustrates the typical performance DND could have expected from hedging its foreign exchange risk. If we were to proceed with

[4]Moneyness measures distance of the option's strike from the spot price. In our study, we will focus on options with the most liquid moneyness (25% Delta).

[5]A knock-in barrier option behaves like a vanilla option only if the exchange rate touches the barrier during the life of the contract. If the exchange rate does not touch the barrier, the option expires worthless, that is, the option must knock-in to become alive.

hedging, we would rely on the market making expertise of the financial intermediary to help us select the appropriate hedging instrument, tailored to our needs.

As a government department, DND's hedging instrument selection must not convey an implied directional opinion. The Government of Canada cannot allow the appearance that DND has information which it is using to place bets on the Canadian dollar. In this regard, zero cost structures represent a neutral choice since they behave as pure hedging strategies. We add the vanilla call in the list of strategies with this study for completeness, but using this strategy runs the risk of appearing as a positional bet.

5 Results

We received foreign exchange transaction data from Director General Major Projects Delivery (DGMPD) in ADM(Mat) for the following projects:

- ACP-S (Airlift Capability Project - Strategic)
- ACP-T (Airlift Capability Project - Tactical)
- CCV (Close Combat Vehicle)
- JSS (Joint Support Ship)
- MHLH (Medium-to-Heavy Lift Helicopter)
- MHP (Maritime Helicopter)
- MSVS (Medium Support Vehicle System)
- TAPV (Tactical Armoured Patrol Vehicle)

Over the last five fiscal years, these projects expended over $3 billion USD – representing approximately 20% of DND's total foreign exchange obligation over that period. The high quality of the data on these projects easily lends itself to the counterfactual hedging study[6].

We make the following assumptions about the foreign exchange transaction data:

- the PMO knew the date and amount of all foreign exchange obligations at the beginning of the fiscal year;
- the PMO required the foreign currency on the date of the posted transaction; and
- the delivery date of the foreign currency to the contractor remained fixed.

According DGMPD, the PMO of each project knew the transaction date of each foreign currency obligation within each fiscal year by at least the beginning of the fiscal year. Thus, we apply each hedging strategy to each fiscal year, initiating the hedge for all obligations, match to the payment date, on 01 April. The application of the strategies use the following specifications:

- All historical financial data and derivative prices come from the Bloomberg electronic database via Bloomberg L. P. [12];

[6]We obtained the foreign exchange transaction data from Director General Major Project Delivery, Director Major Project Services (DGMPD DMPS).

- We set the top of the collar for the risk reversal, the strike of the forward extra, and the strike of the vanilla call at 25% Delta. We maintain the zero cost of the structured products by adjusting the bottom of the collar of the risk reversal and the barrier of the forward extra accordingly; and

- We match the tenor of each contract within each strategy for the day of posted transaction.

The data set contains over 900 transactions, some as small as $1,000 USD. We apply the hedging strategies under two scenarios,

- **Scenario A:** The hedge applies to all transaction days with obligations exceeding $1 million USD. We leave days with obligations less the $ 1 million USD unhedged. This restriction hedges more than 99% of the obligations within each fiscal year.

- **Scenario B:** The hedge applies to only 50% of the total obligation within each fiscal year. We apply the hedge to the minimal number of transaction days to achieve the 50% hedge.

In Table 3 we see the hedging performance of each strategy under both scenarios. In the table, we have listed the USD obligation and the cost of the spot purchase. Under the listed spot purchase price, we show the profit and loss, relative to the spot purchase, of each strategy in nominal Canadian dollars and percentage. In the final column we show the nominal hedging performance across the five fiscal years. Over fiscal years 2009 – 2013, we see that the hedging performance ranges from -3% to $+0.3\%$ and thus the hedge performance across all strategies and scenarios did not lead to large departures from the spot purchase costs. We should expect this result – the purpose of instituting a hedge is not to generate profits, but to gain cash flow predictability and allow management to focus on more productive tasks. The first two years of the counterfactual study represent a period of profound market stress associated with the financial crisis and the tepid recovery that followed. In fiscal year 2009 we see that the hedge performs well, paying off like an insurance contract in the depths of the financial crisis. The following year paints a different picture as the recovery resulted in a strengthening Canadian dollar – the hedges all underperformed spot purchases. In April of 2009, the uncertainty surrounding a possible recovery remained extremely high and the high volatility of the Canadian dollar at that time reflected the market's inability to gauge the severity of a possible continued slide. Hedging in early 2009 would have worked as pure insurance against the most extreme outcomes, which in the end, did not materialize.

We see the cash flow stability in Table 4. The zero cost structured product strategies and the vanilla call option in Scenario A guarantee a maximum effective exchange rate for each fiscal year which sits approximately 4 cents higher than the effective spot rate. Of course, the forward strategy locks in a fixed exchange rate near the spot rate at the beginning of the fiscal year with an adjustment for the foreign and domestic interest rates. Scenario

Table 3: Hedge performance for strategies under Scenario A (99+% hedged) and Scenario B (50% hedged)
FX: Forward, RR: Risk Reversal, FE: Forward Extra, VC: Vanilla Call.

	Fiscal Years											
Hedge scenario	FY09		FY10		FY11		FY12		FY13		Nominal Totals	
Scenario A												
USD obligation	$445,316,696	-	$609,613,637	-	$773,818,593	-	$638,571,757	-	$444,089,771	-	$2,911,410,454	-
Spot purchase	$494,126,888	-	$645,634,791	-	$785,479,585	-	$634,531,371	-	$446,248,989	-	$3,006,021,626	-
FX(P/L)	$37,657,379	7.6%	−$120,150,090	−18.6%	$3,514,457	0.45%	$16,341,286	2.6%	$4,426,547	1.0%	−$58,210,421	−1.9%
RR(P/L)	$18,639,930	3.8%	−$59,203,584	−9.2%	$396,044	0.05%	$251,671	0.04%	$669,719	0.15%	−$39,246,220	−1.3%
FE(P/L)	$18,639,930	3.8%	−$11,932,429	−1.8%	$396,044	0.05%	$251,671	0.04%	$669,719	0.15%	$8,024,935	0.3%
VC(P/L)	$13,076,171	2.6%	−$15,122,004	−2.3%	−$9,287,542	−1.2%	−$6,377,167	−1.0%	−$4,134,921	−0.93%	−$21,845,463	−0.7%
Scenario B												
USD obligation	$208,539,016	-	$289,065,884	-	$382,267,689	-	$307,529,703	-	$251,991,300	-	$1,439,393,592	-
Spot purchase	$221,072,210	-	$302,764,071	-	$385,913,056	-	$303,645,723	-	$254,099,493	-	$1,467,494,553	-
FX(P/L)	$7,423,998	3.4%	−$60,219,744	−19.9%	−$491,560	−0.12%	$6,182,296	2.0%	$3,521,983	1.4%	−$43,583,027	−3.0%
RR(P/L)	$0	0%	−$29,968,216	−9.9%	$0	0%	$0	0%	$389,532	0.15%	−$29,578,684	−2.0%
FE(P/L)	$0	0%	−$11,452,942	−3.8%	$0	0%	$0	0%	$389,532	0.15%	−$11,063,410	−0.8%
VC(P/L)	−$2,619,792	−1.2%	−$7,485,207	−2.5%	−$4,878,783	−1.3%	−$2,943,736	−0.97%	−$2,080,067	−0.9%	−$20,007,585	−1.4%

B proceeds similarly with the guarantee only applying to the 50% hedged position. Over the life of the counterfactual study, the hedge performance cost effectively represents the insurance cost of guaranteed protection against a project damaging currency fluctuation within each fiscal year.

The counterfactual results help us understand typical performance with these types of instruments. The period April 1, 2008 to March 31, 2013, represents an extraordinary time for the value of the Canadian dollar. The financial crisis of September 2008 and the recovery which followed saw the Canadian dollar lose more than 30% of its value inside of three weeks with a subsequent recovery over the next two years. We see that even in the face of these wild fluctuations, the hedging strategies performed approximately the same as the spot purchases over our study period, yet protected the cash flows from in-fiscal year fluctuations.

Table 4: Effective rates for the zero cost structured products.

	Fiscal Years				
Exchange rates (USDCAD)	FY09	FY10	FY11	FY12	FY13
Spot rate at fiscal year start	1.0213	1.2600	1.0086	0.9632	0.9906
Actual effective transacted rate	1.1096	1.0591	1.0151	0.9937	1.0049
Scenario A maximum effective rate	1.0871	1.3882	1.0728	1.0187	1.0479
Scenario B maximum effective rate	1.0859	1.3951	1.0747	1.0135	1.0431

6 Discussion

The hedging scenarios in this report inform decision-makers on typical performance that DND can expect from hedging foreign exchange risk. Using the counterfactual results of three different zero cost structures of increasing complexity along with the inclusion of a vanilla call option, DND can gain an understanding of which types of instruments mitigate foreign exchange transaction risk. Each hedging scenario provides DND with a form of insurance against financial loss arising from adverse foreign exchange fluctuations.

DND must fully understand all risks involved within procurement activities – financial and otherwise – and delineate those risks whereby DND would gain an advantage through externalization. Again, we stress that hedging alone cannot increase the value of national defence offered to Canadians. DND must translate cash flow stability into better management. From a corporate perspective, hedging allows firms to focus on their strengths and thus gives them confidence that risks beyond their control will not derail plans. Properly executed, hedging has the ability to provide DND with the protection that it needs for running smoother procurement processes. Risk management requires a sharp self assessment of strengths and weaknesses and DND must ensure that the risks it does assume lie within its area of expertise and control. Put simply, DND is in the business of managing human conflict and all of the associated uncertainty that it entails. If DND can gain an advantage in defence related activities by unloading foreign exchange transaction risk through a financial intermediary, then hedging will increase the value of national defence offered to Canada.

DND has entered a renewal phase whereby major procurements such as the acquisition of the Next Generation Fighter and the construction of new surface combatants will require adept and innovative management. Controlling procurement risk will feature centrally in DND's activities over the course of the next decade and we can expect amplified foreign exchange exposure to contribute to an already challenging planning environment. Foreign exchange risk, when coupled with other procurement risks such as the risk of property loss, and budget escalation risk, adds to a burden under which DND has no control or comparative advantage. In such circumstances, DND must clearly understand the potential benefits or hindrances associated with retaining these types of risks. If the status quo of no currency hedging remains as policy, DND must understand the gains of that policy relative to alternative actions. Given DND's limited ability to self-insure, a rigorous understanding of which risks to retain becomes of paramount importance. As we move forward in the 21st century, a better understanding of risk at DND and the application of new risk mitigation tools will help Canada achieve her best possible outcomes in an uncertain world.

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List of Acronyms

ADM(Fin CS)	Assistant Deputy Minister (Finance and Corporate Services)
ADM(Mat)	Assistant Deputy Minister (Materiel)
CAD	Canadian Dollar
CORA	Centre for Operational Research and Analysis
DGMPD	Director General Major Project Delivery
DMGOR	Directorate Materiel Group Operational Research
DMPS	Directorate Major Projects Services
DND	Department of National Defence
DRDC	Defence Research and Development Canada
GARCH	Generalized Autoregressive Conditional Hetroskedasticity
GDP	Gross Domestic Product
OTC	Over-the-counter
USD	United States Dollar
VaR	Value at Risk

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Using foreign exchange transaction data from eight Department of Defence (DND) managed projects from fiscal year 2009 to fiscal year 2013, we counterfactually apply four derivative based hedging scenarios to mitigate foreign exchange transaction risk. The total foreign currency exposure represented by the eight projects amounts to $3 billion USD. We focus the study on zero cost structures for hedge performance comparison. Over the five fiscal years considered, we find that the hedge performs within 3% of spot purchases, but the hedge comes with a maximum cost for the US dollar within each fiscal year. If DND can translate the more stable cash flows that a foreign exchange hedge offers into better management, then a foreign exchange hedge can help DND increase the value of national defence offered to Canada.

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