MEASURING GOVERNMENT SUPPORT TO THE CANADIAN BANKING SECTOR: A VALUATION OF IMPLICIT SUBSIDIES

By

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Abstract

The recent financial crisis has revealed the extent that governments are willing to go to preserve the nations banking sector in a time of turmoil. The true value of these bailout packages has since become a popular topic of debate. Using data on the Canadian banking sector, this paper measures the value of expected financial subsidies from the state to the Canadian financial system in order to avoid systemic collapse. Two methods of valuing these implicit subsides are explored; an option-price approach, and a historical approach. The option-price approach uses the standard Black-Scholes formula to measure the value of implicit subsidies, estimating the value to be between $633 million - $22.6 billion per year (measured in Canadian dollars). The historical approach uses the distribution of return on equity, estimated using past prices of bank equity, to value implicit subsidies. The estimated value for the historical approach ranges from $6.2 - $10.8 billion per year (measured in Canadian dollars).

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1 Introduction

The fear of systemic risk, and the consequential state support, has become a popular topic of debate in the wake of the resent financial crisis. Government support and the protection of banks considered "too big to fail" have negated the threat of insolvency, distorting financial systems to favour larger banks. The growing apprehension that government subsidies create negative distortions is a concern held by many, including Mark Carney, the Governor of the Bank of England, who said:

> "The expectation that systemically important institutions can privatize gains and socialize losses encourages excessive private sector risk-taking and can be ruinous for public finances. . . . Firms and markets are beginning to adjust to authorities' determination to end too-big-to-fail. However, the problem is not yet solved."

Anticipated government support allows large banks to take more risks at the expense of the public sector, leading to less accountability from banks, giving them a competitive advantage over smaller, less supported banks.

The objective of this paper is to measure the value of expected financial subsidies from the state to the financial system in order to avoid systemic collapse. This expected support is known as an implicit subsidy. Implicit subsidies occur because the government does not charge banks a premium for its eventual support in a time of financial need. A study of this nature has yet to be carried out regarding the Canadian financial sector, allowing for a unique opportunity for to shed some light on implicit subsidies in Canada within this paper. Two approaches will be used to estimate the value of implicit subsidies in Canada; an option-price approach, and a historical approach.

The remainder of this paper is organized as follows. First, a brief background into the literature will be provided, before moving on to discuss the implicit subsidy valuation methods. The estimation results are provided in the subsequent section, followed by some concluding remarks.

2 Background

Baker and McArthur (2009) were among the first to estimate implicit subsidies. They used differences in funding costs between large (assets exceeding $100 billion) and small (assets less than or equal to $100 billion) US banks to measure government subsides, assuming that all of the larger banks would be the sole receiver of subsidies. There study produces two implicit subsidy estimates (in USD); a "low scenario" estimate of $6.28 billion per year, and a "high scenario" estimate of $34.16 billion per year.

Li, Qu and Zhang (2011) expand on Baker and McArthur's methodology, introducing European banks into their study, as well as differing levels of risk across banks. They then compare their findings with a second method of valuation that compares the difference in Fair-value Spreads (FVS) and Credit Default Swap (CDS) spreads. They conclude that the top US financial institutes receive between $102 - $170 billion per year in implicit subsidies, and the top European financial institutes receive between $176 - $293 billion per year in implicit subsidies (both given in USD).

A report prepared by Oxera (2011) examines state support in the UK, treating implicit subsidies as put prices of European options. They use asset volatility and the standard Black-Scholes formula to estimate the present value of future state support. Total assets are used as the current price of the underlying asset, and an asset threshold to indicate systemic risk represents the strike price. Using this approach, they estimate government support to be £5.9 billion per year.

Noss and Sowerbutts (2012) criticize Oxera's "equity option-price approach" for using an inappropriately high risk-free rate, and for using a European put option, arguing that both lead to an undervaluation of implicit subsidies. Oxera employs a risk-free rate of

5%, which Noss and Sowerbutts argue is highly inflated, estimating its true value to be 1.2%. Their results show that this lowered rate yields an implicit subsidy estimate of £41 billion annually, a £35.1 billion increase from Oxera.

Noss and Sowerbutts also argue that Oxera's use of a European put option is incorrect, claiming an American put option is a more accurate method of pricing government support. A European put only measures the value at the time of expiry, in this case one year, but does not account for the possibility of assets falling below the threshold prior to this expiration date. An American put, on the other hand, will measure the total value falling below the threshold at anytime throughout the puts one-year horizon. The use of an American put over a European put produces an estimated implicit subsidy of £30.1 billion per year, a £24.2 billion increase from Oxera. Utilizing both a risk-free rate of 1.2% and an American put option leads to a government support valuation of £89.6 billion per year, generating an overall increase of £83.7 billion from the Oxera report.

Noss and Sowerbutts finally propose a new "historical approach" of valuation. This approach utilizes historical prices of equity to estimate a distribution of returns. They argue that this method decreases bias from investor risk preferences, as it does not require an underlying "evolution of assets" model. They do however admit that an initial shortcoming of this approach is a lack of information regarding size and likelihood of significant decreases in asset prices, an important aspect in measuring implicit subsidies. They solve for this issue by fitting a nonparametric empirical density function to the center of the distribution of returns and applying a Generalised Pareto distribution to the bottom fifth percentile of the distribution. By doing this they can observe rare negative shocks in the lower tail. Using this approach, Noss and Sowerbutts generate an implicit subsidy estimate of £30 billion annually. My paper will explore a similar historical approach as my second method of valuation.

Valuation of implicit subsidies in Canada is an interesting topic, as the Canadian banking sector is notorious for being highly concentrated. A 2014 IMF Global Financial

Stability Report states that the three largest banks in Canada, Royal Bank, Toronto Dominion and Scotiabank, control over 60% of all Canadian banking assets. This concentration is much higher than in the United States, where the top three banks hold less than 45% of the countries banking assets. This high concentration is a strong indication that large "too big to fail" banks are thriving within the Canadian financial system. Though this is the case, an adequate estimation of implicit subsidies in Canada has yet to be reported.

An IMF paper by Ueda and di Mauro (2012) use a credit rating approach to estimate government support for a variety of countries, including Canada. They apply Fitch support scores and given bank ratings to calculate a long-term support rating for each bank in their study. They do this by means of an ordered probit regression model. They then place banks into various categories of "support level" based on average debt spreads. Though Canada is included in some aspects of this study, a calculation of Canadian government support is not reported. This method of implicit subsidy calculation has been criticized due to its reliance on failure ratings from subjective agencies.

As previously stated, a concrete estimate of implicit subsidies to Canadian banks does not exist within the literature. Some would argue that it has never been estimated because there is no need to; Canada does not subsidize banks. Jim Flaherty, Canada's Finance Minister, supported this idea, making the following statement in a Canada-UK Chamber of Commerce speech:

> "…we have not had to put any taxpayers' money into our financial system in Canada, nor do I anticipate that we'll be obliged to do so."

Flaherty made other, similar comments suggesting that Canada's banking sector has no need for government support. However, ex post studies on the effects of the 2008 financial crisis in Canada share a different opinion.

The Canadian Centre for Policy Alternatives (CCPA) released a study in 2012 titled *The Big Bank's Big Secret*, which looks to quantify the bailout support received by Canadian banks during the recent financial crisis. The report contradicts the notion portrayed by the Canadian government that Canadian banks were financially stable throughout the turmoil of the crisis. The CCPA states that in March 2009, the peak of their borrowing, Canadian banks received $114 billion in government support. This equates to approximately 7% of Canadian GDP, and was received from three entities; 31% from the Bank of Canada, 25% from the U.S. Federal Reserve, and 44% from the Canadian Mortgage and Housing Corporation (CMHC). Below is a table recreated from the report, showing the peak support received from each of the five largest banks in Canada.

Table 1
Estimated Extraordinary Support Summary

Bank	Peak Support Date	Peak Support Value ($bil)	Peak Support to Company Value (Date of Peak)
CIBC	March 09	$21	148% (March 2009)
BMO	January 09	$17	118% (Feb 2009)
Scotiabank	January 09	$25	100% (Feb 2009)
TD Bank	September 09	$26	69% (Feb 2009)
Royal Bank	March 09	$25	63% (Feb 2009)

Source: CCPA.

The above table shows that the Canadian banking sector not only needed bailout support, but also needed a sizable amount of it. This displays the relevance of implicit subsidies to Canadian banks, thus providing motivation for this paper. The following section will describe the methods used to estimate the value of implicit subsidies.

3 Valuation of the implicit subsidy

This paper focuses on two approaches of valuing implicit subsidies, an “option-price” approach with a similar framework to Oxera (2011), and a “historical” approach motivated by Noss and Sowerbutts (2012). The paper will utilize data on the Canadian banking sector, with a focus on the six largest banks, to carry out the estimation and study of implicit subsidies.[1]

3.1 Threshold parameters

Both valuation methods require a threshold to indicate the losses that the Canadian financial system can withstand before the government must intervene. The threshold indicates the size of shock the financial system can absorb, and is contingent on liquidity, solvency and level of confidence in the system.

Tier 1 capital, defined by Basel III standards as predominantly common shares and retained earnings, will be defined as the total amount of "loss-absorbing capital" in the system. Tier 1 capital is an indicator of capital sufficiency and financial competence, and so the various thresholds used for this paper will be related to different levels of tier 1 capital. For robustness, four thresholds will be implemented for each valuation approach.

From 2008-2013, the total tier 1 capital in the Canadian financial system ranged from 4.5%-5.0% of total assets. The most extreme of the four thresholds applied will be a complete depletion of tier 1 capital. This means that the government would only subsidize the banking sector if total assets decreased by more than 4.5%-5.0%. For example, as of May 31, 2010, total assets in the Canadian financial system were $2,971,346,295,000 and tier 1 capital totaled $ 146,190,783,000, yielding a tier 1 capital to total assets ratio of 4.92%. So in the most extreme case, the government would supply subsidies only if total assets dropped 4.92%.

The government waiting to intervene until assets have dropped by total tier 1 capital is an unlikely case; especially given the tier 1 capital conditions enforced by the state. As a member of the Basel Committee of Banking Supervision, Canada has specific tier 1 capital requirements for banks within its financial system. These requirements have

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[1] The six largest banks in the country, Royal Bank, Toronto Dominion Bank, Scotiabank, Canadian Imperial Bank of Commerce, Bank of Montreal and National Bank of Canada control approximately 93% of all assets.

been established by Basel III: A global regulatory framework for more resilient banks and banking systems. As of 2013 the Basel III tier 1 capital requirements were a minimum of 4.5% of total assets. Given this capital restriction, three less sever thresholds will also be included.

The 2008 financial crisis has shown how quickly negative shocks can take hold of the banking sector, and it is not unreasonable to believe tier 1 capital could fall below set requirements before the government steps in. With that in mind, the second threshold has been established to represent the government intervening if assets drop by an amount greater than the buffer between actual and required tier 1 capital. This threshold is set to an asset decrease equivalent to a drop in tier 1 capital to half the required amount of 2.25%. Again looking at the 2010 example, if total tier 1 capital is 4.92%, a decrease of 2.67% would leave tier 1 capital at 2.25%. Therefore the threshold for government intervention is a total asset drop of 2.67%. This threshold allows for government support before all solvency is lost, with hopes maintaining a certain level of confidence within the sector.

It can be argued that minimum requirements for tier 1 capital have been put in place for a reason, and the government should support the sector if these requirements are at all breached. Taking this into consideration, the third threshold calls for state support if total assets fall by an amount equal to the buffer between actual and required tier 1 capital. In the 2010 example, this would mean that a decrease in total assets of 0.42%[2] would require government subsidies. Government intervention at this threshold would help sustain confidence in the banking sector, as it preserves the solvency requirements of a “healthy bank”.

The previous threshold looks at the Canadian financial system as a whole, but it only takes distress from one large bank to disrupt confidence in the entire sector. With that being said, the final threshold implemented in this study is a drop in total assets of

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[2] 4.92% - 4.5%.

the sector equal to the capital buffer of one of the big six banks in Canada. For simplicity, this amount will be set to the total capital buffer divided by six. Once again looking at the 2010 example, a decline in total assets of 0.07%[3] would lead to subsidy support from the government.

Issues may arise with the final two thresholds due to their diminutive size, but this will not always be the case. The Basel III timeline that Canada has set for its financial system calls for a rise in tier 1 capital requirements, as well as the introduction of a regulatory buffer in the coming years. The Office of the Superintendent of Financial Institutions (OSFI) released a report on Capital Adequacy Requirements (CAR) in April 2014 outlining capital requirement standards for the Canadian financial system. These guidelines require Canadian banks to sustain a tier 1 capital of, at minimum, 6% of total assets by 2015. These guidelines also implement a “capital conservation buffer” starting in 2016, at 0.625%. By 2019 OSFI aims to have this buffer up to 2.5%. Once these requirements come to fruition, the last two thresholds will play a more relevant role. Unfortunately for this study, these two thresholds remain small throughout the years reported on; showing unwillingness from banks to hold more than what is required of them. These thresholds are included for robustness and the forward looking hope that they will become more relevant and accepted in the future.

Below is a brief summary of the four thresholds that this paper adopts:

1. A reduction of total assets equal to total tier 1 capital;
2. A reduction of total assets equal to the difference between total tier 1 capital and half the required tier 1 capital;
3. A reduction of total assets equal to the capital buffer between total and required tier 1 capital;
4. A reduction of total assets equal to the capital buffer of one of the large six banks.

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[3] 0.42% / 6

3.2 Option-price approach

The option-price approach is similar to the methodology from Oxera (2011), and is comparable to pricing an insurance policy for banks. A European put option with one year to expiry is used to value implicit subsidies[4]; or the insurance premium. The option is valued using the standard Black-Scholes formula, with total assets of the Canadian banking sector acting as the underlying asset, and the threshold representing the strike price. The risk-free rate is set to the 3-month Treasury Bill rate.[5]

3.2.1 Standard Black-Scholes Formula

The Black-Scholes model, derived by Fischer Black and Myron Scholes in 1973, utilizes a partial differential equation to estimate the price of an option over time. This equation is known as the Black-Scholes equation, and takes the following form:

$$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + rS\frac{\partial V}{\partial S} - rV = 0 \quad (1)$$

where *V(S,t)* is the price of a derivative, and is a function of stock price, *S*, and time, in years, *t*. The term σ is the standard deviation of a stock's returns, and *r* is the risk-free rate (annualized and continuously compounded).

By solving for corresponding terminal and boundary conditions of the above equation, one can obtain the Black-Scholes formula. This formula can be used to calculate the prices of European puts and calls, the former being the key to estimating implicit subsidies for the option-price approach. The Black-Scholes put price formula is shown below:

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[4] A European Put option is used in this approach for the sake of simplicity. The benefits and drawbacks of this are discussed in section 4.

[5] Obtained from Federal Reserve Economic Data (FRED).

$$P(S,t) = N(-d_2)Ke^{-r(T-t)} - N(-d_1)S \tag{2}$$

$$d_1 = \frac{1}{\sigma\sqrt{T-t}}\left[ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T-t)\right] \tag{3}$$

$$d_2 = \frac{1}{\sigma\sqrt{T-t}}\left[ln\left(\frac{S}{K}\right) + \left(r - \frac{\sigma^2}{2}\right)(T-t)\right] \tag{4}$$

where *P(S,t)* is the price of a European put option, and $N(\cdot)$ is the cumulative distribution function of a standard normal distribution. *S* represents the spot price of the underlying asset, which is set as the value of total assets in the Canadian banking sector. The strike price, *K*, is the dollar value of the threshold for government support. The time to maturity, $T - t$, is set to one year. σ denotes annualized implied volatility.

The above Black-Scholes model is restricted by the following 5 assumptions:

1. Returns are normally distributed, and follow a geometric Brownian motion;
2. Markets are efficient; therefore there are no opportunities for arbitrage;
3. No commissions are charged, leading to a frictionless market;
4. Interest rates remain constant;
5. The stock does not pay a dividend.

The use of standard Black-Scholes as the instrument of valuation makes the implicit assumption that both positive and negative shocks have the same probability of occurring, with the possibility of high magnitude shocks at either end being very low. These results do not coincide with traditional financial returns data, which is usually characterized as having fat-tailed distributions. The kurtosis measures in Table 2 below show that the banking data used does in fact contain fat tails.

Table 2
Kurtosis Measures of Bank Market Value

Bank Market Value	
Bank	Kurtosis
BMO	12.317
CIBC	12.069
TD	9.730
BNS	10.263
RBC	12.287
NB	14.428

Note: Kernel density plots of log returns for each bank can be found in Appendix B.

A kurtosis of greater than 3 is observed in each case, confirming the presence of fat tails in the data. This brings about a potential undervaluation in implicit subsidies when using the option-price approach. The historical approach in section 3.3 aims to address this issue.

3.2.2 Volatility of assets

The option-price approach requires implied volatility of assets for the Canadian financial system as a whole in order to use the standard Black-Scholes formula for valuation. This volatility will help determine the likelihood of a downward swing in total assets within the system.

The volatility of assets depends on the asset volatility of each bank, as well as the correlation between banks. Asset volatility is calculated by first calculating the volatility of equity in the system, and then multiply that by the ratio of equity to total assets.

Daily implied volatility from 2008-2013 is used to calculate an average annual implied volatility for the six largest banks in Canada: Bank of Montreal, Canadian Imperial Bank of Commerce, Toronto Dominion, Scotiabank, Royal Bank of Canada and National Bank of Canada.[6] The overall volatility is then calculated using the following variance formula:

[6] Source: Datastream.

$$\sigma_E^2 = \sum_i w_i^2 \sigma_i^2 + \sum_i \sum_{j \neq i} w_i w_j \sigma_i \sigma_j \rho_{ij} \tag{5}$$

where w_i is the portion of overall equity bank i controls, $\sigma_i$is the average annual implied volatility of bank i and ρ_{ij} is the observed covariance between bank i and bank j. Once the volatility of equity is calculated, it is multiplied by the following equity to assets ratio:

$$\sigma_A = \sigma_E \frac{E}{A} \tag{6}$$

where E is total equity in the system, and A is the total assets.

For robustness, six different asset volatilities are calculated, five annual volatilities, running from June to May of 2008-2009 to 2012-2013, and one overall asset volatility from June 2008 – May 2013. These volatilities are presented in Table 3.

Table 3
Asset Volatility Estimates

Years	Asset Volatility (%, annual)
2008-2009	2.17
2009-2010	1.16
2010-2011	0.95
2011-2012	0.85
2012-2013	0.65
2008-2013	1.12

Source: Datastream

As would be expected, the volatility is highest in 2008-2009, and continuously decreases through to 2013. An estimation of results from the option-price approach can be found in section 4.1.

3.3 Historical approach

The second approach in this paper estimates the value of implicit subsidies using past prices of bank equity. Data ranging from January 1, 1996 to March 31, 2014 on the largest six banks in Canada is used to estimate a historical distribution of returns on bank equity prices.[7] For robustness, two different methods are used in calculating the distribution of returns, an original, unaltered distribution, and a distribution with a Generalized Pareto lower tail similar to the methods used by Noss and Sowerbutts (2012). The volatility from these distributions is used to run a Monte Carlo Asian put option model in order to estimate implicit subsidies.

3.3.1 Distribution of returns

Noss and Sowerbutts argue that negative shocks occur very rarely in historical data, and therefore do not lead to an accurate prediction of future implicit subsidies. They correct for this by implementing a two-part distribution, fitting a nonparametric empirical density function to the center of the distribution of returns and applying a Generalised Pareto distribution to the bottom fifth percentile of the distribution. They then use this "altered" distribution to calculate the volatility. A recreation of this "altered" distribution using Canadian data will act as one of the distributions explored with the historical approach. To do this, Noss and Sowerbutts' two-part distribution method is applied to the distributions of log returns on market value for each of the big six banks in Canada. The volatility from each distribution is then used to calculate an overall historical volatility.

As stated in the previous section, high kurtosis is present within the data, which indicates the existence of fat tails. High kurtosis could be seen as evidence against Noss and Sowerbutts' argument that tail events are too sparse, rendering their "altered" distribution irrelevant. For this reason, I also use the volatility from the original

[7] A cut off of May 31, 2013 is also explored for comparative purposes with the above option-price approach. Source: Datastream.

distributions of returns to calculate the overall historical volatility. Kernel density plots of log returns for each of the big six banks can be found in Appendix B.

In both cases, the overall historical volatility is calculated in a similar fashion as the previous option-price approach using equation 5. Table 4 below presents the estimated volatilities.

Table 4
Historical Volatility Estimates

Date[1]	Volatility[2]	
	Original	Altered
May 31, 2013	5.09	5.02
March 31, 2014	4.78	4.29

Note: [1] The date given is the last day of data used in calculating the historical distributions.
[2] %, annual.
Source: Datastream.

In both cases it can be seen that the volatility of the original distribution is larger than the volatility of the altered distribution. This would appear to give evidence that contradicts Noss and Sowerbutts' justification of an altered distribution.

Once the overall historical volatility is obtained, it is used to run an Asian put option Monte Carlo asset path simulation. The methodology used for this step is explained in the following section.

3.3.2 Asian option simulation

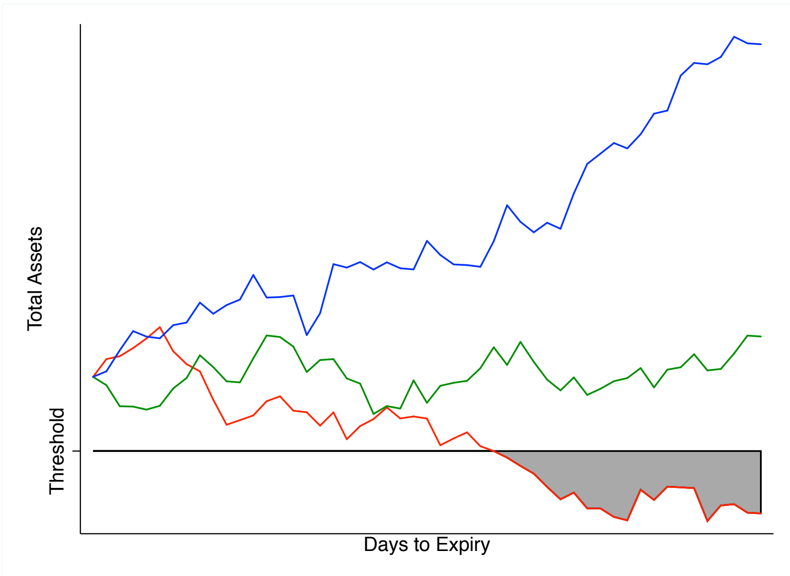
Asian options are a basic form of exotic options, as their payoff is defined by the average underlying price across a predetermined period of time. Asian options have an advantage over European options and American options, as they decrease the risk of market manipulation, and reduce the inherent volatility in the option. This results in Asian options being, on average, cheaper than European and American options.

To calculate the put price of an Asian option, I first run a Monte Carlo simulation to replicate potential asset paths. For each implicit subsidy estimation, one million asset paths are simulated, with two different time periods of expiry; 30 days and 50 days. An asset path is denoted $S(T_i)$, and is generated using the following:

$$logS(T_i) = \log S(T_{i-1}) + \left(r - \frac{\sigma^2}{2}\right)(T-t)/n + \sigma\sqrt{T-t/nx_i} \tag{7}$$

where x_i is an independent sequence of drawings from a standard normal distribution, $T - t$ is the total period to maturity (30 days or 50 days), and $i = 1, \dots, T$. Below is an example of three simulated asset paths.

Figure 1
Simulated Asset Paths



The option put price is then defined as the average value of each simulated asset path below the threshold value, and is calculated in the following manner:

$$P(T) = e^{-r(T-t)}\left[\frac{1}{N}\sum_{j=1}^{N} max_j\{K - A_j(T), 0\}\right] \tag{8}$$

$$A(T) = \frac{1}{T}\sum_{i=1}^{T} S(T_i) \tag{9}$$

where $A(T)$ is the average value of a single asset path simulation, K is the strike price, or threshold value in this case, and N is set to the number of simulations run, in this instance 1 000 000. For the historical approach, the risk-free rate is set to 1%.

4 Estimation results

A vast collection of inputs and time periods is used in this study, therefore a wide range of implicit subsidy values were estimated. Some valuations are more realistic than others, and will consequently be the focus of this section. As previously mentioned, some of the more improbable valuations are included for strength of argument, providing a full view of the implications of various solvency thresholds. A full table of results can be found in the appendices.

The threshold of focus in the proceeding sections will be the third threshold; a reduction of total assets equal to the capital buffer between total and required tier 1 capital. Tier 1 capital requirements play a significant role in the guidelines set out by Basel III, and therefore set a strong indicator of concern if not upheld; making the third threshold an ideal standard. This threshold will also be significant in follow up studies, once the required "capital conservation buffer" is implemented.

4.1 Option-price estimation results

The results of the option-price estimation across all thresholds range from a negative implicit subsidy estimation, to an estimation of $22 billion per year.[8] The following table shows the valuation of implicit subsidies for each year.[9]

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[8] All data and estimations are in Canadian dollars.
[9] Evaluated using the third threshold as described above.

Table 5
Option-Price Implicit Subsidy Valuation

Years[1]	Threshold (%)[2]	Risk-Free Rate (%)	Implicit Subsidy[3]
2008-2009	0.064	0.20	21567
2009-2010	0.420	0.43	4652
2010-2011	0.304	0.96	1306
2011-2012	0.012	1.01	1780
2012-2013	0.019	1.00	633
2008-2013	0.019	1.00	4374

Note: [1] Estimated over period of June to May for the given years.
[2] Threshold denotes percentage drop in total assets required for government to give support. [3] Implicit Subsidy given in CAD per year (in millions).
Source: Datastream, Federal Reserve Economic Data.

The estimated valuation of implicit subsidies is affected by two factors, the threshold value,[10] and the risk-free rate. The two factors both have adverse effects on the valuation of implicit subsidies; an increase in either will lead to a decrease in implicit subsidies. As shown in Table 5, the increase in risk-free rate overpowers the decrease in threshold value over time, leading to an overall decrease in implicit subsidies. A complete summary of results for the option-price approach can be found in Appendix A. The 2008-2009 implicit subsidy estimate comes to approximately $21.6 billion. This number is significantly smaller than the ex post estimation given by the CCPA of $114 billion. This could suggest that a threshold of intervention higher than the one used in this study is more realistic. It could also suggest that, at the time of the crisis, the government waited too long to step in with bailout support, leading to a more significant lose of confidence in the banking system than the implicit subsidy is designed to uphold.

[10] Measured as a percentage decrease in total assets.

4.2 Historical estimation results

Across all threshold values, the historical estimates range from an implicit subsidy valuation of zero, to an implicit subsidy valuation of $12 billion per year. Table 6 below shows the range of implicit subsidy estimates for the third threshold.

Table 6
Historical Implicit Subsidy Valuation

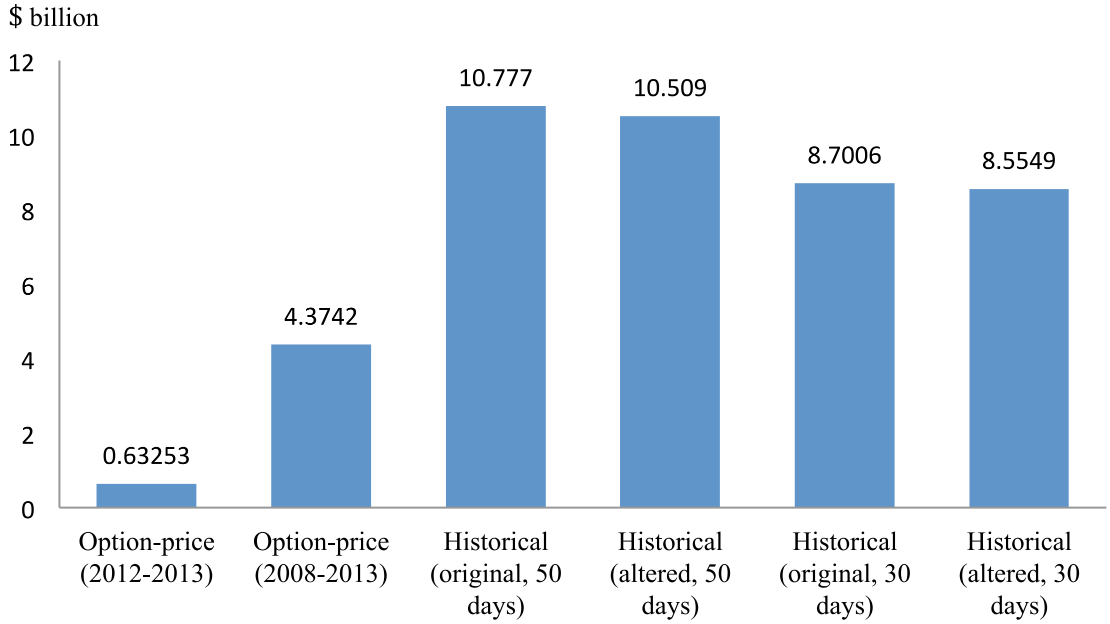
Date[1]	Days to Expiry	Volatility		Implicit Subsidy[2]
		Original	Altered	
May 31, 2013	30	✓		8701
	30		✓	8555
	50	✓		10777
	50		✓	10509
March 31, 2014	30	✓		7400
	30		✓	6203
	50	✓		9332
	50		✓	7822

Note: [1] The date given is the last day of data used in calculating the historical distributions. [2] Implicit Subsidy given in CAD per year (in millions).
Source: Datastream.

As expected, the larger the volatility, the greater the estimate of implicit subsidies. For the simulations with 30 days to expiry, the implicit subsidy estimates range from $6.2 billion to $8.7 billion. For the 50-day simulations, the implicit subsidy estimations range from 7.8 billion to $10.8 billion. A full analysis of historical results can be found in Appendix C.

As stated above, May 31, 2013 is chosen as one of the cutoff dates for historical calculation because it can be directly compared to the implicit subsidy estimation results from the option-price approach. Figure 2 shows the implicit subsidy estimates for all samples ending on May 31, 2013.

Figure 2
Implicit Subsidy Estimates
(As of May 31, 2013)



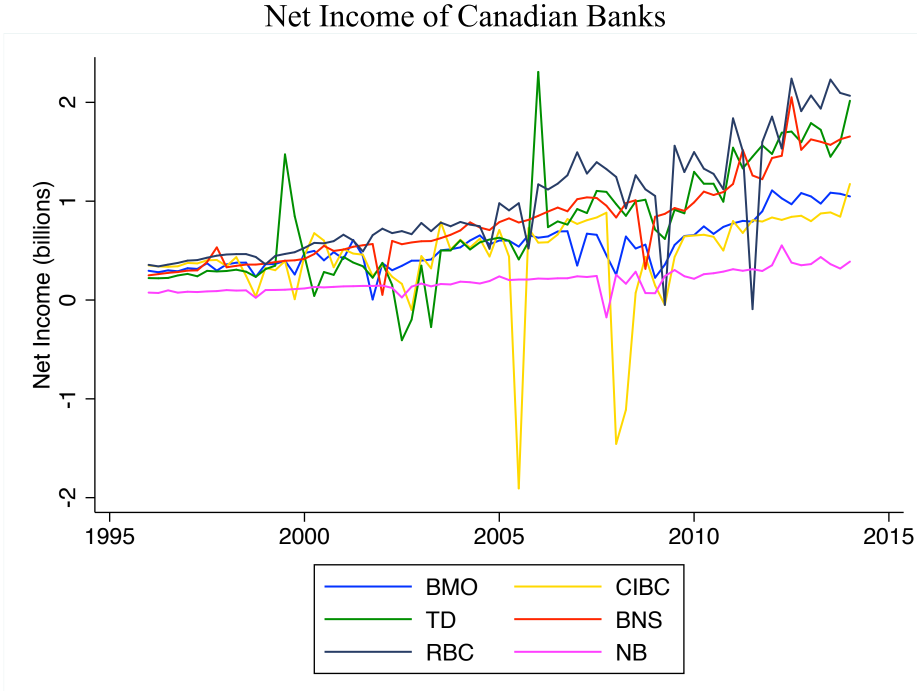
It can be seen that the historical approach yields much higher estimates, which can be attributed to higher volatilities. The option-price approach only uses small pockets of implied volatility, ranging either one year or six years. The historical approach, on the other hand, uses 18 years of data to estimate volatility. This wider breadth of data naturally results in a larger volatility, leading to higher estimates of implicit subsidies.

Another explanation for the inconsistency between the two approaches comes from Noss and Sowerbutts (2012). As previously mentioned, Noss and Sowerbutts claim that a European put option undervalues the implicit subsidy, as it only considers valuation at the time of expiry. This excludes the possibility of assets falling below the threshold, but recovering before the expiration date is reached, leading to an undervaluation of implicit subsidies. However, Oxera (2011) argues that any undervaluation brought about by the use of a European option is counterbalanced by offsetting assumptions, such as regulations that force banks to recapitalize when shocks occur. My study gives possible evidence against Oxera's claims of an even counterbalance of underestimation and overestimation.

4.3 Effects on Canadian banks

The above results look at the Canadian banking sector as a whole, giving an implicit subsidy estimate for the entire system. This does not, however, imply that each bank is equally responsible for creating the need for implicit subsidies. Looking back to the recent financial crisis, it is clear that some banks are more resilient than others when negative shocks occur. Figure 3 shows the net income of the six largest Canadian banks from 1996-2014.

Figure 3[11]
Net Income of Canadian Banks



[11] Figure 3 provided by Robert McKeown.

Figure 3 illustrates that not all banks perform equally, leading to different levels of associated risk. It can be seen that CIBC was the least stable during the financial crisis, incurring a net loss of almost $1.5 billion (CAD). On the other hand, Scotia Bank and TD continued to record profits throughout the crisis. The National Bank of Canada appears to be the least volatile of the six, remaining relatively consistent.

If an accurate valuation of implicit subsidies could be calculated and agreed upon, it would only be the first step in implementing an insurance policy for Canadian banks. The volatility of profits presented in the above data shows that each of the banks have varied levels of stability and profitability. It would require further study to break down the estimated subsidy into individual premiums for each bank according to their unique characteristics.

5 Conclusion

Large banks have been deemed necessities within society, shown by the government's implicit promise to bail them out if the fear of failure looms near. This guarantee has created distortions within the financial sector, as banks have begun to rely on these implicit subsidies. Measuring implicit subsidies in Canada, a previously unexplored topic, is an important step to holding banks accountable for their actions. As they are not strictly observable, an exact measure of implicit subsidies is difficult to agree upon. A reliable valuation could help shift the responsibility of providing implicit subsidies away from taxpayers, towards an insurance policy where banks pay the premium.

This paper investigates two approaches to measuring the value of implicit subsidies to Canadian banks, an option-price approach and a historical approach. The option-price approach uses the Black-Scholes formula to estimate implicit subsidies as a European put option. This approach is simple to calculate and utilizes future outlooks of banks, but runs the risk of undervaluing the implicit subsidy. The historical approach uses the historical distribution of returns on equity to simulate the valuation of implicit subsidies. This approach mitigates the undervaluation issue in the option-price approach, but relies solely on historical data to model future asset paths. Though a wide range of values is calculated, both approaches find agreement in the significant size of implicit subsidies.

Fortunately, initiatives have been implemented to reduce the size of these implicit subsidies. Canada's compliance with Basel III will lead to a significant increase in Canadian banks required holdings of tier 1 capital. This, along with the introduction of a mandatory buffer, should lead to a decrease in government support to the Canadian banking sector. An even stricter Basel 4 has recently been proposed as the next step in capital reserves standards, with hopes of further minimizing government support to financial systems.

6 References

Baker, Dean and McArthur, Travis. (2009). The Value of the “Too Big to Fail” Big Bank Subsidy. CEPR Reports and Issue Briefs 2009-36, Center for Economic and Policy Research (CEPR).

Basel Committee on Banking Supervision. (2010). Basel III: International Regulatory Framework for Banks. Bank for International Settlements. Retrieved July 21, 2014, from http://www.bis.org/bcbs/basel3.htm

Black, Fischer and Myron Scholes (1973). The Pricing of Options and Corporate Liabilities. Journal of Political Economy, 81 (3): 637–654.

Croucher, Shane. KPMG: UK Banks Facing New £50bn Capital Hole as 'Basel IV' Emerges. International Business Times. Retrieved July 21, 2014, from http://www.ibtimes.co.uk/uk-banks-capital-ratio-requirements-bank-england-505642

Goddard, Phil. Pricing an Asian Option in MATLAB. Goddard Consulting. Retrieved July 21, 2014, from http://www.goddardconsulting.ca/matlab-monte-carlo-asian.html

International Monetary Fund. (2014). Global Financial Stability Report—Moving from Liquidity- to Growth-Driven Markets. World Economic and Financial Surveys. Retrieved July 21, 2014, from http://www.imf.org/external/pubs/ft/gfsr/2014/01/pdf/c3.pdf

International Monetary Fund. (2011). United Kingdom: Financial System Stability Assessment. Monetary and Capital Markets and European Departments. Retrieved July 21, 2014, from http://www.imf.org/external/pubs/ft/scr/2011/cr11222.pdf

Kemna, A. G. Z. and Vorst, A. C. F. (1990). A Pricing Method for Options based on Average Asset Values. Journal of Banking and Finance, 14(1): 113-129.

Kleinert, H. (2009). Path Integrals in Quantum Mechanics, Statistics, Polymer Physics, and Financial Markets. World Scientific Publishing Company; 5th edition.

Kou, S. (2002). A jump-diffusion model for option pricing. Management Science, 48(8): 1086–101.

Li, Z, Qu, S and Zhang, J. (2011). Quantifying the Value of Implicit Government Guarantees for Large Financial Institutions. Moody's Analytics Quantitative Research group. Retrieved July 21, 2014, from http://www.bankofengland.co.uk/research/Documents/fspapers/fs_paper15.pdf

Macdonald, David. (2012). The Big Banks' Big Secret: Estimating government support for Canadian banks during the financial crisis. Canadian Centre for Policy Alternatives. Retrieved July 21, 2014, from https://www.policyalternatives.ca/publications/reports/big-banks-big-secret.

Noss, Joseph and Sowerbutts, Rhiannon. (2012). Financial Stability Paper No. 15: Implicit Subsidies of Banks. Bank of England. Retrieved July 21, 2014, from http://www.bankofengland.co.uk/research/Documents/fspapers/fs_paper15.pdf

Nystrom, K and Skoglund, J. (2002). Univariate extreme value theory, GARCH and measures of risk. Preprint, Swedbank. Retrieved July 21, 2014, from http://gloria-mundi.com/UploadFile/2010-2/knjsug.pdf

Office of the Superintendent of Financial Institutions. (2014). Capital Adequacy Requirements (CAR). Retrieved July 21, 2014, from http://www.osfi-bsif.gc.ca/Eng/fi-if/rg-ro/gdn-ort/gl-ld/Pages/CAR_chpt1.aspx

Oxera. (2011). Assessing Bank Support to the UK Banking Sector. Prepared at the request of The Royal Bank of Scotland. Retrieved July 21, 2014, from http://www.oxera.com/Oxera/media/Oxera/downloads/reports/Assessing-state-support-to-the-UK-banking-sector.pdf?ext=.pdf

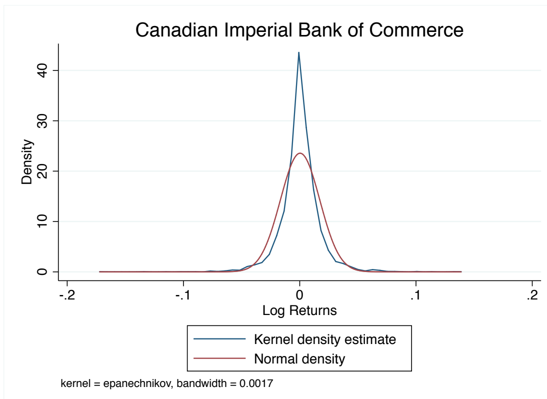
Ueda, Kenichi, and Beatrice Weder di Mauro. 2012 "Quantifying Structural Subsidy Values for Systemically Important Financial Institutions." IMF Working Paper.

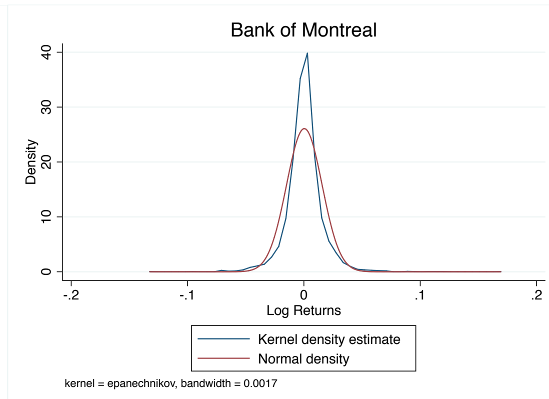
Appendix A: Option-price approach summary of results

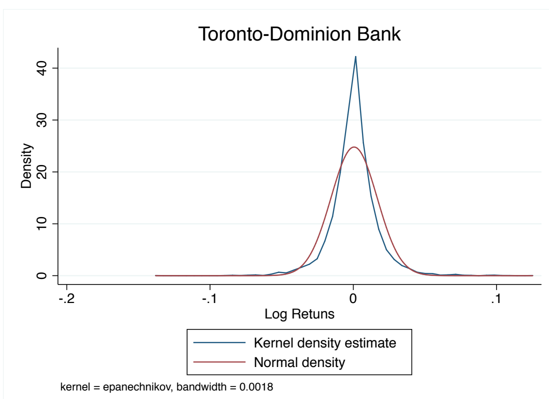
Years	Threshold	Equity Volatility (%, annual)	Gearing (%)	Asset Volatility (%, annual)	Total Assets[1]	Tier 1 Capital[1]	Threshold (%)	Threshold Value[1]	Risk Free Rate (%)	Implicit Subsidy[2]
2008-2013	I	23.66	4.75	1.12	3936.57	177.91	4.52	3758.66	1.00	0.00
	II	23.66	4.75	1.12	3936.57	177.91	2.27	3847.24	1.00	21.29
	III	23.66	4.75	1.12	3936.57	177.91	0.02	3935.81	1.00	4374.20
	IV	23.66	4.75	1.12	3936.57	177.91	0.00	3936.44	1.00	4490.90
2008-2009	I	44.89	4.83	2.17	2923.96	133.45	4.56	2790.51	0.20	262.67
	II	44.89	4.83	2.17	2923.96	133.45	2.31	2856.30	0.20	3706.60
	III	44.89	4.83	2.17	2923.96	133.45	0.06	2922.09	0.20	21567.00
	IV	44.89	4.83	2.17	2923.96	133.45	0.01	2923.65	0.20	22285.00
2009-2010	I	22.45	5.18	1.16	2971.35	146.19	4.92	2825.16	0.43	0.00
	II	22.45	5.18	1.16	2971.35	146.19	2.67	2892.01	0.43	36.24
	III	22.45	5.18	1.16	2971.35	146.19	0.42	2958.87	0.43	4652.10
	IV	22.45	5.18	1.16	2971.35	146.19	0.07	2969.27	0.43	7585.80
2010-2011	I	18.02	5.28	0.95	3233.72	155.35	4.80	3078.37	0.96	0.00
	II	18.02	5.28	0.95	3233.72	155.35	2.55	3151.13	0.96	0.69
	III	18.02	5.28	0.95	3233.72	155.35	0.30	3223.89	0.96	1305.50
	IV	18.02	5.28	0.95	3233.72	155.35	0.05	3232.08	0.96	2258.40
2011-2012	I	19.24	4.41	0.85	3793.37	171.14	4.51	3622.24	1.01	0.00
	II	19.24	4.41	0.85	3793.37	171.14	2.26	3707.59	1.01	0.37
	III	19.24	4.41	0.85	3793.37	171.14	0.01	3792.94	1.01	1780.00
	IV	19.24	4.41	0.85	3793.37	171.14	0.00	3793.30	1.01	1821.90
2012-2013	I	13.65	4.75	0.65	3936.57	177.91	4.52	3758.66	1.00	0.00
	II	13.65	4.75	0.65	3936.57	177.91	2.27	3847.24	1.00	0.00
	III	13.65	4.75	0.65	3936.57	177.91	0.02	3935.81	1.00	632.53
	IV	13.65	4.75	0.65	3936.57	177.91	0.00	3936.44	1.00	670.19

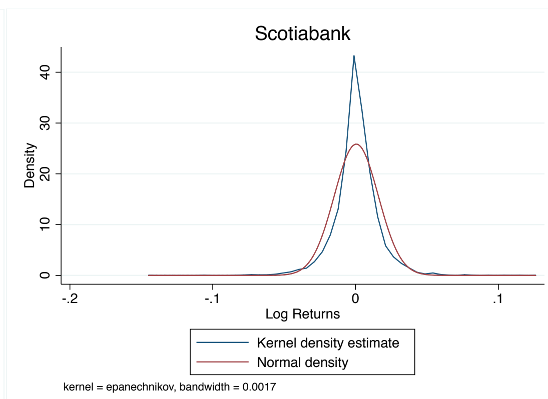
Note: [1] In CAD (in billions). [2] In CAD (millions).

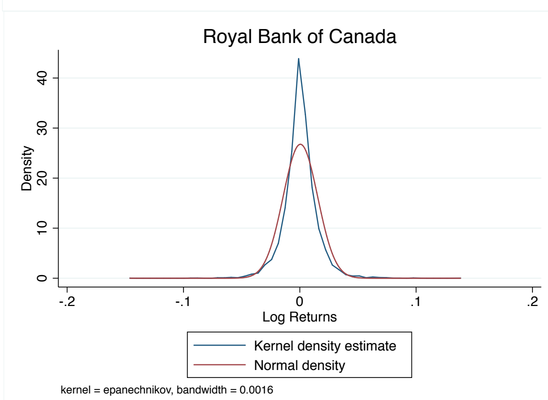
Appendix B: Kernel Density Plots

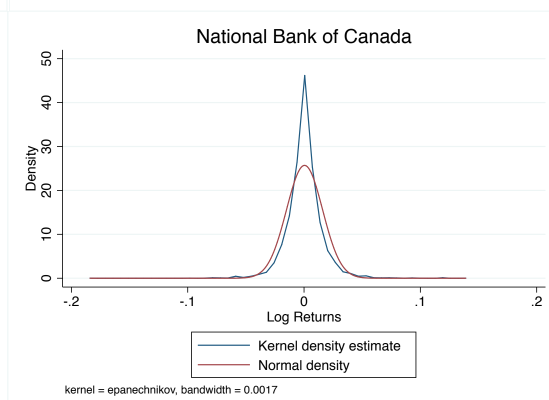












Appendix C: Historical approach summary of results

May 31, 2013

Total Assets[1]	Tier 1 Capital[1]	Threshold (%)	Threshold Value[1]	Days to Expiry	Volatility (%, annual) Original	Altered	Implicit Subsidy[2]
3936.57	180.76	4.59	3755.81	50	5.09	-	0.01
3936.57	180.76	2.34	3844.38	50	5.09	-	97.42
3936.57	180.76	0.09	3932.95	50	5.09	-	10777.00
3936.57	180.76	0.02	3935.97	50	5.09	-	11894.00
3936.57	180.76	4.59	3755.81	50	-	5.02	0.01
3936.57	180.76	2.34	3844.38	50	-	5.02	87.18
3936.57	180.76	0.09	3932.95	50	-	5.02	10509.00
3936.57	180.76	0.02	3935.97	50	-	5.02	11674.00
3936.57	180.76	4.59	3755.81	30	5.09	-	0.00
3936.57	180.76	2.34	3844.38	30	5.09	-	10.04
3936.57	180.76	0.09	3932.95	30	5.09	-	8700.60
3936.57	180.76	0.02	3935.97	30	5.09	-	9885.70
3936.57	180.76	4.59	3755.81	30	-	5.02	0.00
3936.57	180.76	2.34	3844.38	30	-	5.02	8.33
3936.57	180.76	0.09	3932.95	30	-	5.02	8554.90
3936.57	180.76	0.02	3935.97	30	-	5.02	9689.40

Note: [1] In CAD (in billions). [2] In CAD (in millions).

March 31, 2014

Total Assets[1]	Tier 1 Capital[1]	Threshold (%)	Threshold Value[1]	Days to Expiry	Volatility (%, annual) Original	Volatility (%, annual) Altered	Implicit Subsidy[2]
4106.39	190.95	4.65	3915.43	50	4.78	-	0.00
4106.39	190.95	2.40	4007.83	50	4.78	-	49.56
4106.39	190.95	0.15	4100.22	50	4.78	-	9332.40
4106.39	190.95	0.03	4105.36	50	4.78	-	11269.00
4106.39	190.95	4.65	3915.43	50	-	4.29	0.00
4106.39	190.95	2.40	4007.83	50	-	4.29	15.83
4106.39	190.95	0.15	4100.22	50	-	4.29	7822.30
4106.39	190.95	0.03	4105.36	50	-	4.29	9604.20
4106.39	190.95	4.65	3915.43	30	4.78	-	0.00
4106.39	190.95	2.40	4007.83	30	4.78	-	4.01
4106.39	190.95	0.15	4100.22	30	4.78	-	7400.00
4106.39	190.95	0.03	4105.36	30	4.78	-	9353.60
4106.39	190.95	4.65	3915.43	30	-	4.29	0.00
4106.39	190.95	2.40	4007.83	30	-	4.29	0.76
4106.39	190.95	0.15	4100.22	30	-	4.29	6202.60
4106.39	190.95	0.03	4105.36	30	-	4.29	8063.50

Note: [1] In CAD (in billions). [2] In CAD (in millions).