CIRANO
Centre interuniversitaire de recherche
en analyse des organisations

CGB: Poised for Takeoff

An Analysis of the Ten-Year Government of Canada Bond Future
Based on Intraday Trading Data

Bryan Campbell
CIRANO

Christopher Chung
CIRANO

September 2003

Background

The recent increase of activity in the CGB market may be a signal that this derivative product has entered a new phase of market maturity. This study proposes a closer look at the recent market development of this product, especially focusing on the period when the CGB has become available on an electronic platform.

Earlier studies of the CGB market, particularly one conducted by Dr. Louis Gagnon in the mid-nineties, quite correctly concentrated on the hedging effectiveness of the CGB (along with that of the BAX). The use of futures for risk management is their *raison d'être*. Moreover, the failure of earlier derivative products is directly related to their inability to outperform U.S. competitors in hedging interest rate risk.

On the other hand, it would certainly be unwise to overlook such issues as market efficiency and liquidity in assessing the CGB market. Investors, and certainly hedgers, must always feel secure that they can enter and exit the market quickly and at minimal cost. The introduction of automated trading does facilitate exchange but issues of efficiency and liquidity remain to be addressed.

One positive aspect of automated trading and electronic information dissemination is transparency. We live in an era where the evolution of individual markets can be tracked quite closely by market participants during the day.

Earlier studies did not have access to intra-day market activity. By contrast, we propose in this study to take as close a look as possible at the evolution of the CGB market by investigating the trade-by-trade pattern of activity of this market over the period that such information has become available.

Such a detailed study of intra-day trading by its nature generates its own volumes of numbers. Our purpose in this document is not to give a systematic statistical account of the trading and quoting activity on the CGB market. Rather the purpose of the document is to gain perspective on the big picture of the evolution of this market.

The study has three facets. We first look at issues of market efficiency through the lens of transaction costs as measured by spread. A second concern is market depth. Lastly, we look at the hedging effectiveness of the CGB relative to certain competitors.

A summary of the key findings of the study comprises the last section of the study.

The CGB Market
Just the Facts

The CGB, introduced on the Montreal Exchange in 1989, is certainly a success compared to its predecessor the Long-Term Canadian Government Bond future that traded on the Toronto Futures Exchange during the 1980s. By February 2003, the monthly volume of the CGB was approximately 330,000 contracts, representing a 75% increase over the previous year. Open interest at this time was double the previous year's number.

With respect to trading of the CGB, there appears to have been three distinct sub-periods over the last twelve years, and a fourth appears to be emerging-- hence the title of this study.

During the first sub-period, until 1994 or so, the volume of monthly contracts hovered around 50,000; over the next five years, the monthly figure moved around the 100,000 mark, and over the last several years rose again and moved around 150,000. Recently, there has been a jump to 250,000 and beyond. Open Interest has increased in step with these monthly adjustments. Figure 1 presents a graphical summary of the development of the CGB market over its history.

In September 2000, the Montreal Exchange moved from a traditional open outcry system to an automated electronic system. The move toward an electronic system follows a trend involving many of the other future exchanges around the world, particularly in Europe.

Prominent U.S. future exchanges have began using hybrid systems and are signaling a move towards the automated platform. The perceived benefits of the automated platform to the investor include increased market transparency, fairness, expanded access, enhanced liquidity, and rapid - order execution.

Intra-day transactions for the CGB are available since October 22, 2001. This study begins shortly thereafter on November 30 and continues to February 25, 2003 and uses recorded quotes reflecting the best bid/offer spread as well as all traded records. We look at some 700,000 records over a trading period covering 305 trading days. During this period, five contracts were the most active and we focus on these.

Table 1 gives the key daily trading statistics—average trade size, volume traded, number of trades—for the 5 contracts for which we have complete data.

- Observe that the daily volume for the March contract has increased by 40% in the last year.
- The daily number of trades has doubled from March 2002 to March 2003.
- Average trade size has diminished, an indication perhaps of an increase in program trading.

Diminishing Spreads

The quoted spread and its variants are static measures of transaction costs that are observable at the time of the trade. They are the most straightforward and commonly used estimates of transaction costs.

Here we report results for the *quoted half spread*, that is the spread divided by 2; and the *effective spread* that measures the difference between the trade price and the mid-point of the preceding quote.

Table 2 presents results for the quoted half spread for the 5 contracts under study. Results for intra-day spreads are also given.

- The average daily half-spread size has more than halved from March 2002 to March 2003.
- In general, the spreads increase from the morning period through the afternoon period.
- For the heavily-traded March 2003 contract, the spreads are tight throughout the day.

Effective spread may be a more accurate measure of transaction costs as it relates quote spread and trading price. Tables 3a, 3b presents results on effective spread throughout the trading day, as well as investigating the relationship between effective spread and trading size.

- The effective spread has diminished by 50% from March 2002 to March 2003.
- Effective spreads rise through the day but not as markedly as the quoted half spread.

Table 3a contains information concerning the total number of trades for a contract. Some 20,000 March 2002-contracts were purchased, and a year later sales increased one and half times. The increase has been pronounced relative to the latter period of 2002.

Table 3a also reveals that 60% of the trading activity is concentrated in the morning, 30% over lunch with 10% during the afternoon period. This result is robust across the contracts studied.

To consider the relationship between effective spread and trade size, we organized trades into four bins according to increasing contract size as indicated in Table 3b. For example, 70% of the trades in the March 2002 contract involved 10 contracts or less.

Regarding the size of trades, the striking feature of Table 3b is that the number of small trades has increased significantly at the expense of medium-sized trades. Some 83% of the trades of the March 2003 contract involved trades of 10 contracts or less compared to 70% a year earlier.

But it must be stressed that the effective spread has diminished considerably over this period and, as indicated by Table 3b, the effective spread for trades involving 11-25 contracts was smaller that for the other bin sizes.

Prices: In Passing

A plot of the spread measures that we have been using to study transaction costs shows that both quoted half spreads and effective spreads are quite variable. We have pursued the idea that this variability in spreads could be tied to price volatility of the CGB itself. A regression study [not reported here] shows this intuition to be correct: price volatility has a statistically significant positive impact on spread size.

Another avenue of investigation pursued in this study concerns the impact of a trade on future prices. In the finance literature, it is common to compare future prices to current quotes [more precisely, $(P_{30 \text{ minutes later}} - Q_{now})/ Q_{now}$]. The greater the disparity, the greater the impact of a current trade on future prices. The smaller the measure, the less the market reacts to a specific trade.

We summarize without presenting the tables the results of our price impact study for the CGB market:

- Price impact for the CGB market falls by 33% from March 2002 to March 2003.
- Over the day, largest *price impact* is observed in the morning when the market is processing overnight news.
- When relating price impact to trade size, we find that price impact for medium-sized trades is not much greater than that associated with small trades.

Issues in Liquidity

Up to this point we have studied the inside quote and several notions of spread relating to this quote. We now consider issues surrounding *ex ante* volumes bid and offered involving the full range of quotes confronted by the trader at any time during the day.

The automated trading platform for the CGB presents the trader with the five best quotes. These quotes indicate the number of contracts offered or demanded according to the five best prices on either side of the market submitted to the system. When a better quote is submitted or when a trade is made, the screen changes.

We study the depth of the market by computing for every screen the number of contracts that are available on the bid and offer side along with the corresponding price differentials for the inside and outside quotes.

Table 4 presents averages for these measures of order book depth for each contract and over the day. It appears that there is a slight diminution of contract depth over the last year. However, the standard errors (not reported here) suggest that the differences may not be statistically significant. By contrast, it is interesting to observe that quote price differentials have decreased significantly over the year by as much as 50% for some periods of the trading day.

Hedging

This part of the study investigates the ability of the CGB to neutralize the risk exposure of mid-term Canadian bond portfolios.

The bond indexes employed are the nine Scotia Capital bond market indexes, of mid-term maturity. The mid-term maturity indexes were chosen since their price changes relative to changes in interest rates will mimic most closely those of the hedging instruments that we are investigating.

We look at the relative performance of three instruments used to hedge these indexes: the Canadian 10-Year Bond Future [CGB], the Canadian 10-Year swap, and the U.S. 10-Year Future [T—Note]. We consider the latter in two ways according to which exchange rate risk is not hedged or it is hedged completely.

Users of futures contracts exchange one type of risk for another: hedgers exchange price risk of the underlying for basis risk. The key decision made by the hedger concerns the number of futures contracts required to offset anticipated changes in the price of the underlying. This number is the hedge ratio. Two different approaches to constructing the hedge ratio are followed: the analytical approach uses the durations of the index and the derivative product to determine the hedge ratio. The empirical approach is based on a regression analysis of past price movements of the index and the derivative product. Both approaches have their strengths and weaknesses. While there is a considerable academic literature on the statistical approach, practitioners tend to favour the duration-based approach. The comparison of these two approaches in the study is of independent interest.

We simulate dynamically a portfolio in real time using actual interest-rate data over the last three years. Portfolios in principle can be rebalanced on a daily basis. In this last regard, we extend the Gagnon study cited earlier that looked at statistical correlations over a fixed sample.

Technical talk: on the modified duration approach, the hedge ratio is obtained by dividing the modified duration on each of the indexes by the modified duration on the hedging instrument, where the modified duration calculation consisted of the prices and yields for both the CGB and the T-Note with an underlying 6% coupon for a maturity of 10 years. Modified duration figures for the nine Scotia Capital indexes are obtained electronically from the Scotia Capital Online website. The modified duration on the swap is computed as the modified duration on the fixed-rate component less the modified duration on the floating rate part.

More technical talk: The variance of a portfolio involving a variable number of futures on an underlying is minimized when this number is the beta in a regression of underlying price changes on futures price changes. An important issue concerns the sample over which the regression is estimated. Too short a sample will likely lead to an imprecisely estimated hedge ratio. On the other hand, the further the sample is extended in the past, the less likely we can maintain the assumption that the past is relevant for the present. In this study we take the position that six months of data [some 125 points of daily data] is appropriate. The daily hedge ratio is determined by a regression based on the most recent 125 trading days [rolling regression approach].

Hedging Results

Daily returns are calculated for all of the indexes and the hedging instruments. The daily portfolio position for the three portfolios that hold the index and the futures is simply the return on the index less the short position in the futures. It is calculated as the return on the index multiplied by the dollar value invested in the index, less the return on the future multiplied by the value of the future contract multiplied by the number of future contracts held.

The daily portfolio position for the portfolio which holds the index and the swap position is only different in the respect that we are not holding a short position in the swap contract but a long position. The daily portfolio position is then the return on the market index multiplied by the dollar value invested in the index, plus the return on the swap contract multiplied by the number of contracts being held.

From these calculations we obtain four separate series that correspond to the difference between the return on the indexes and the return on the hedging instrument. These differences are our gauge of relative performance.

Let's look at Table 5 immediately to get a flavour of the results. The portfolio is managed over a 3-year period. The performance is measured by the variance of the hedging portfolio where the hedge ratio is obtained by modified duration. This variance is then divided by the variance of the exposed position over the 3-year period. The naïve position is defined as one long contract offset by one instrument. *Daily* involves daily rebalancing using the duration hedge and *"Weekly"* involves rebalancing at effectively a weekly pace determined by a movement in the hedge ratio that exceeds a certain percentage [roughly, 2%]; we don't rebalance unless we must.

So, to take an example, for interest-rate risk management of the overall index, the naïve hedge involving the CGB reduces variance by 69% and by duration-based hedging by 83%.

There are three key results in Table 5.

- The CGB and Swaps perform comparably over the various Scotia fixed-income indices considered.
- Hedging based on the U.S. T-Note is badly outperformed by the two Canadian instruments.
- One can rebalance the portfolio at the rate of once a week to achieve comparable effects to daily rebalancing. The evolution of the hedge ratio will indicate when rebalancing is necessary.

Surprisingly, similar results are obtained by regression-based results including the rolling-regression technique and by more recent methods such as GARCH.

Table 6 presents relative hedging performance results using results based on ideas taken from the Value-at-Risk [VaR] methodology. According to this approach a 100 million dollar portfolio is hedged using the different

instruments. The dollar returns are computed and the size of the dollar value corresponding to the 1% worst [or 99% best] determined.

The results of Table 6 indicate that the duration-based approach using the CGB is the consistent winner. This results suggests that the dispersion of CGB hedging returns may not be as dispersed as those associated with swaps. This line of investigation merits further study.

Comparable results regarding hedging performance based on VaR are obtained when the regression methodology is used.

Bibliographical note: the methodology used in this study followed a recent Lehman Brothers study, "Hedging and replication of fixed-income portfolios," *The Journal of Fixed Income, 2002*.

Summary of Results

In this study we have looked at intra-day trading data on the CGB from November 30, 2001 through February 25, 2003. The period covers five contracts and 305 trading days. Only best quotes and trades are used when considering transaction costs; by contrast, all quotes available to the trader figure in the liquidity portion of the study; daily data is used in the hedging analysis.

With regard to *transaction costs and market depth* we have found over the sample:

- Trading activity as measured by the daily number of trades has increased by 75% over the sample.
- Transaction costs as measured either by the average quoted spread or the average effective spread [associated with trades] have gone down significantly [50%] over the sample.
- The dispersion of the effective spread has gone down significantly over the sample; spreads are tighter more often.
- The price impact of individual trades has gone down by 25% over the sample.
- Order book price differentials have decreased significantly on both the bid and ask sides of the market.

The March 2003 contract has been the star performer, a harbinger perhaps of future growth in the CGB market:

- Relative to the March 2002 contract, the number of trades is up by 125% and volume has increased by 40%.
- The quoted spread is the tightest among all the contracts. The *effective spread* shows the least dispersion over the day.
- The impact of trades on prices is smallest for this contract.
- Order-book price differentials are considerably lower.

The *hedging* portion of the study focused on the relative performance of the CGB, swaps, and U.S. Notes in hedging interest risk of Scotia fixed income indices. We found:

- When a Value at Risk measure was used to gauge hedging performance, the CGB edged swaps as the most effective hedging tool, and both outperformed the U.S. instrument.
- With variance reduction as the goal of hedging, the CGB and swaps showed comparable performance. Again both outperformed the U.S. instrument.
- Duration-based and regression-based hedging were comparable over the sample.
- A hedging portfolio need not be rebalanced daily to achieve maximum performance; once a week suffices.

Figure 1

CGB Price, Volume and Open Interest—
January, 1990 – March 2003 Monthly Values

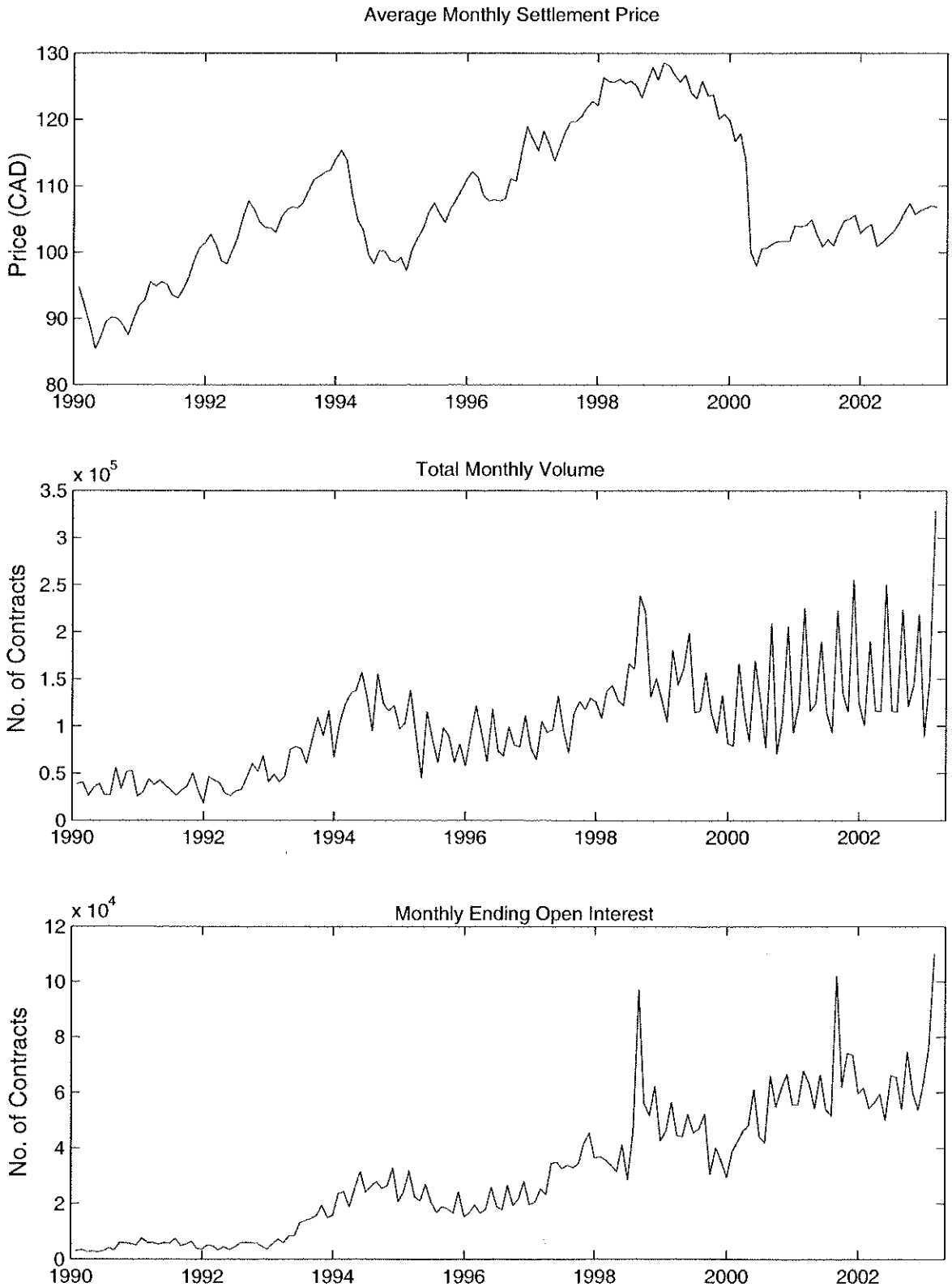

Table 1

CGB: Trading Statistics
November 30, 2001 – February 25, 2003

Contract Maturity	Daily Average Trade Size	Daily Volume Traded	Daily Number of Trades
March 2002	11.64	4114	354
June 2002	9.88	5084	521
September 2002	9.11	4930	543
December 2002	8.95	5334	610
March 2003	7.16	5629	792

The trading days associated with a given contract are determined by contract rollover by volume.

Table 2

Measures of Transaction Costs Based on Quoted Half-Spread
November 30, 2001 – February 25, 2003

Contract Maturity	8:20am – 11:00am	11:01am-1:59pm	2:00pm-3:00pm	All day
March 2002	3.39	3.92	3.56	3.51
	1.33	1.57	1.34	1.19
June 2002	2.18	2.52	2.66	2.27
	0.76	0.72	0.95	0.56
September 2002	2.03	2.65	2.74	2.26
	0.59	0.77	1.03	0.55
December 2002	1.97	2.38	2.73	2.13
	0.46	0.52	1.26	0.39
March 2003	1.52	1.50	1.88	1.56
	0.51	0.62	0.88	0.52

The Quoted Half- Spread is quoted in cents and calculated as the average of daily averages. Standard errors are given in the second row for each measure.

Tables 3a, b

Measures of Transaction Costs Based on Effective Half-Spread
November 30, 2001 – February 25, 2003

Contract Maturity	8:20am – 11:00am	11:01am-1:59pm	2:00pm-3:00pm	All day
March 2002	2.61 [57%]	2.76 [29%]	2.46 [14%]	2.60 [20,882]
	1.03	1.15	0.94	1.86
June 2002	1.86 [61%]	1.86 [28%]	1.87 [11%]	1.80 [33,892]
	0.89	0.54	0.64	0.44
September 2002	1.64 [61%]	1.81 [27%]	1.87 [12%]	1.69 [34,204]
	0.50	0.49	0.44	0.41
December 2002	1.56 [63%]	1.71 [28%]	1.85 [9%]	1.61 [34,150]
	0.44	0.42	0.69	0.37
March 2003	1.32 [54%]	1.30 [34%]	1.30 [12%]	1.32 [49,093]
	0.47	0.40	0.44	0.37

Contract Maturity	1 – 10 contracts	11-25 contracts	26-100 contracts	100+ contracts
March 2002	2.72 [70%]	2.35 [22%]	2.37 [8%]	2.36 [0.2%]
	0.98	0.67	1.04	2.36
June 2002	1.82 [77%]	1.77 [16%]	1.86 [7%]	2.70 [0.1%]
	0.46	0.52	0.62	4.28
September 2002	1.70 [80%]	1.61 [14%]	1.74 [7%]	4.88 [0.2%]
	0.45	0.32	0.61	7.67
December 2002	1.59 [81%]	1.69 [12%]	1.69 [6 %]	5.05 [0.3%]
	0.37	0.52	0.68	5.67
March 2003	1.31 [83%]	1.26 [12%]	1.54 [5%]	4.13 [0.1%]
	0.33	0.45	1.61	10.1

The Effective Half Spread is quoted in cents calculated as the average of daily averages. Standard errors are given in the second row for each measure. The figures in square brackets in each column represent the percentage number of trades with the indicated number of contracts. The total number of trades for a given contract can be found in Table 3a.

Table 4

CGB Market Depth
November 30, 2001 – February 25, 2003

Contract Maturity	8:20 am - 11:00 am				11:01 am - 1:59 pm				2:00 pm - 3:00 pm				All Day			
	Bid		Ask		Bid		Ask		Bid		Ask		Bid		Ask	
	Size	Price*	Price*	Size	Size	Price*	Price*	Size	Size	Price*	Price*	Size	Size	Price*	Price*	Size
March 2002	94.2	0.121	0.137	91.8	94.4	0.144	0.151	97.6	109.4	0.166	0.158	122.6	98.3	0.135	0.146	100.1
June 2002	92.9	0.096	0.104	80.8	95.4	0.108	0.112	89.8	132.7	0.113	0.119	109.1	101.0	0.103	0.110	89.9
Sept. 2002	81.3	0.091	0.098	83.8	81.3	0.111	0.105	80.8	100.0	0.132	0.136	105.4	85.3	0.104	0.108	87.5
Dec. 2002	77.8	0.092	0.094	76.4	79.5	0.097	0.102	74.0	95.7	0.121	0.114	92.4	81.6	0.098	0.102	79.8
March 2003	78.0	0.085	0.080	70.0	74.2	0.073	0.075	67.4	105.0	0.093	0.091	83.6	81.8	0.086	0.082	72.8

Note: 1 tick equals $0.01.
(*) Difference between the highest and lowest of the five best bid/ask prices.
Entries represent averages over the indicated contract and daily period. The size entries on the Bid side represent the total number of contracts available for a price within the indicated number of ticks of the best bid. The size entries on the Ask side represent the total number of contracts available for a price within the indicated number of ticks of the best offer.

Table 5

Duration-Based Hedging 2000 – 2002
Variance Reduction [Exposed = 1]

Overall Index

	Naïve	Daily	"Weekly"
CGB	0.310	0.170	0.170
Swaps	0.301	0.170	0.170
US Future-no FX risk	0.887	0.552	0.553
US Future- FX exposure*	2.340	0.704	0.704

Government Bonds

Canadas	Naïve	Daily	"Weekly"
CGB	0.293	0.169	0.169
Swaps	0.287	0.170	0.170
US Future-no FX risk	0.851	0.544	0.545
US Future- FX exposure*	2.235	0.691	0.692

All Government	Naïve	Daily	"Weekly"
CGB	0.295	0.168	0.168
Swaps	0.289	0.169	0.170
US Future-no FX risk	0.860	0.550	0.551
US Future- FX exposure*	2.258	0.692	0.693

Corporate

A	Naïve	Daily	"Weekly"
CGB	0.364	0.193	0.193
Swaps	0.348	0.188	0.188
US Future-no FX risk	0.969	0.604	0.604
US Future- FX exposure*	2.486	0.741	0.741

All Corporate	Naïve	Daily	"Weekly"
CGB	0.366	0.191	0.191
Swaps	0.349	0.185	0.185
US Future-no FX risk	0.978	0.576	0.576
US Future- FX exposure*	2.540	0.747	0.748

*Results from regression-based approach are quoted, as they outperform duration methods by a wide margin.

Table 6

Duration-Based Hedging 2000-2002
Value at Risk [99%]
100M Portfolio

Overall

	Naïve	Daily	"Weekly"
CGB	0.352	0.267	0.267
Swaps	0.422	0.338	0.339
US Future-no FX risk	0.787	0.633	0.633
US Future- FX exposure*	1.047	0.661	0.661

Government Bonds

Canadas	Naïve	Daily	"Weekly"
CGB	0.355	0.270	0.271
Swaps	0.424	0.343	0.344
US Future-no FX risk	0.753	0.648	0.646
US Future- FX exposure*	1.046	0.676	0.676

All Government	Naïve	Daily	"Weekly"
CGB	0.359	0.263	0.263
Swaps	0.422	0.348	0.348
US Future-no FX risk	0.748	0.645	0.645
US Future- FX exposure*	1.047	0.661	0.662

Corporate

A	Naïve	Daily	"Weekly"
CGB	0.424	0.304	0.303
Swaps	0.434	0.378	0.378
US Future-no FX risk	0.787	0.648	0.649
US Future- FX exposure*	1.053	0.679	0.679

All Corporate	Naïve	Daily	"Weekly"
CGB	0.444	0.299	0.299
Swaps	0.439	0.372	0.372
US Future-no FX risk	0.789	0.639	0.639
US Future- FX exposure*	1.052	0.669	0.669

Entries are in $100,000 units.
*Results from regression-based approach are quoted, as they outperform duration methods by a wide margin.