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by Daniel de Munnik

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## Abstract

While a number of central banks publish their own business conditions indicators that rely on non-random sampling, knowledge about their statistical accuracy has been limited. Recently, de Munnik, Dupuis, and Illing (2009) made some progress in this area for the Bank of Canada's Business Outlook Survey (BOS) by estimating the impact of the Bank's non-random sampling on the accuracy of the survey results. They found no evidence that the Bank's firm-selection process results in significantly biased estimates and/or wider confidence intervals than in the random-selection case. The author deepens and extends this work by (i) outlining the statistical properties of population-proportion and balance-of-opinion questions, and demonstrating how their design affects the calculation of the confidence intervals; (ii) examining the variation in statistical confidence associated with changes in the underlying response distribution using actual quarterly BOS results; (iii) considering the possibility that statistical accuracy varies across questions; and (iv) investigating whether the statistical accuracy of the survey results changes with variations in the business cycle. The main findings are that confidence intervals around the population-proportion questions are about half of those for the balance-of-opinion questions, and that the confidence bands around both types of question can change from survey to survey when the underlying response distribution becomes more or less concentrated in particular response categories (such as "higher," "the same," or "lower"). The author finds that confidence intervals around the BOS population-proportion questions become somewhat narrower during periods of recession, while those for the balance-of-opinion questions vary within a similar range across the cycle.

*JEL classification: C46, C81*

*Bank classification: Business fluctuations and cycles; Central bank research; Regional economic developments*

## Résumé

Bien que de nombreuses banques centrales publient leurs propres indicateurs de conjoncture – qu'elles construisent à partir d'échantillons non aléatoires d'entreprises –, on sait très peu de choses sur la précision statistique de ces indicateurs. Récemment, de Munnik, Dupuis et Illing (2009) ont accompli des progrès sur le sujet en évaluant l'incidence du choix de cette méthode d'échantillonnage sur la précision des résultats de l'enquête trimestrielle sur les perspectives des entreprises que mène la Banque du Canada. Ils ont constaté que le mode de sélection des entreprises retenu par la Banque n'entraîne ni biais significatif des estimations ni élargissement significatif des intervalles

de confiance par rapport à l'échantillonnage aléatoire. De Munnik approfondit et élargit cette recherche : a) en décrivant les propriétés statistiques des deux types de questions de l'enquête (« proportion des répondants » et « solde des opinions ») et en expliquant l'incidence de leur formulation sur le calcul des intervalles de confiance; b) en analysant la variation du niveau de confiance statistique par suite de changements dans la distribution des réponses sous-jacente à partir des résultats réels de l'enquête; c) en envisageant que la précision statistique des résultats puisse varier d'une question à l'autre; d) en cherchant à savoir si la précision statistique varie suivant l'évolution du cycle économique. Ses principales conclusions sont les suivantes : a) les intervalles de confiance sont environ deux fois moins larges pour les questions du type « proportion des répondants » que pour celles du type « solde des opinions »; b) les intervalles de confiance entourant les deux types de questions peuvent varier d'une enquête à l'autre selon que la distribution des réponses sous-jacente est plus ou moins concentrée dans certaines catégories de réponses (telles que « supérieur », « égal » ou « inférieur »). L'auteur constate également que les intervalles de confiance autour des questions du type « proportion des répondants » se rétrécissent quelque peu en période de récession alors que, pour les questions du type « solde des opinions », ils restent à l'intérieur d'une fourchette qui ne varie guère tout au long du cycle.

*Classification JEL : C46, C81*

*Classification de la Banque : Cycles et fluctuations économiques; Recherches menées par les banques centrales; Évolution économique régionale*

# 1 Introduction

The Bank of Canada has been conducting its Business Outlook Survey (BOS) since 1997. Each quarter, Bank representatives interview 100 firms for their outlook on business activity, prices, inflation, and credit, and to gauge the extent to which they face pressures on production capacity. Balances of opinion are constructed to communicate firms' views on their outlook for sales growth, investment, employment, prices, and inflation, while population proportions provide the percentage of firms facing pressures on production capacity and labour shortages. The results are published on a quarterly basis and feed into the monetary policy decision-making process.<sup>1</sup> Accordingly, the accuracy of the survey results is of particular interest to policy-makers and financial market specialists. Although the information content of the BOS and other business surveys has been analyzed (see, for example, Martin and Papile 2004; Trebing 1998), very little work has been done to assess the statistical accuracy of the results.

As with any survey, there are confidence bands around the results. When the Bank started publishing its *Business Outlook Survey* in 2004, it noted that the survey's statistical reliability was limited by its small sample size, and that calculating the confidence bands was a non-trivial task, given that the BOS uses a quota-sampling methodology to select firms (Martin and Papile 2004). Moreover, since the survey reports balance-of-opinion and population-proportion questions, the confidence bands are dependent on the design of the question, and can vary from survey to survey based on the concentration of firms in particular response categories (such as "higher," "the same," or "lower").

Recently, de Munnik, Dupuis, and Illing (2009) made some progress in this area using a Monte Carlo simulation framework to estimate the impact of non-random sampling on the accuracy of the BOS. They found that the confidence intervals were close to the random normal case, even though the BOS sampling methodology imposes sampling constraints and a percentage of firms contacted do not respond. They presented estimated confidence intervals for the two types of BOS questions based on simulations from an artificial dataset. We deepen and extend this work by (i) outlining the statistical properties of population-proportion and balance-of-opinion questions, and demonstrating how their design affects the calculation of the confidence intervals; (ii) examining the variation in statistical confidence associated with changes in the underlying response distribution using actual quarterly BOS results; (iii) considering the possibility that statistical accuracy varies across questions; and (iv) investigating whether the statistical accuracy of the survey results changes with variations in the business cycle.

The rest of the paper is organized as follows. Section 2 considers the statistical properties of the population-proportion questions, the possible range of their theoretical variation, and their

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1. See Martin and Papile (2004) for more on the survey, and Macklem (2002) for a discussion of the monetary policy decision-making process in Canada.

historical response distribution. Section 3 does the same for balance-of-opinion questions. Some concluding remarks follow in section 4.

## 2 Population-Proportion Questions

Population-proportion questions (i.e., “yes” or “no” questions) are appropriate for measuring incidences of capacity constraints and labour shortages, since they report the proportions of respondents experiencing constraints. Hence, the sample proportions for these two questions are bounded between 0 and 100. Under a simple random-sample survey environment,<sup>2</sup> we can show how the accuracy of the population proportion, as estimated by the sample proportion, can vary over time.

The estimate of the standard error ( $\sigma_p$ ) for a population proportion ( $\rho$ ) is:

$$\sigma_p = \sqrt{\rho(1-\rho)/n},$$

where  $n$  is the number of observations. The confidence interval can therefore be represented by<sup>3</sup>:

$$\rho \pm \sigma_p * Z,$$

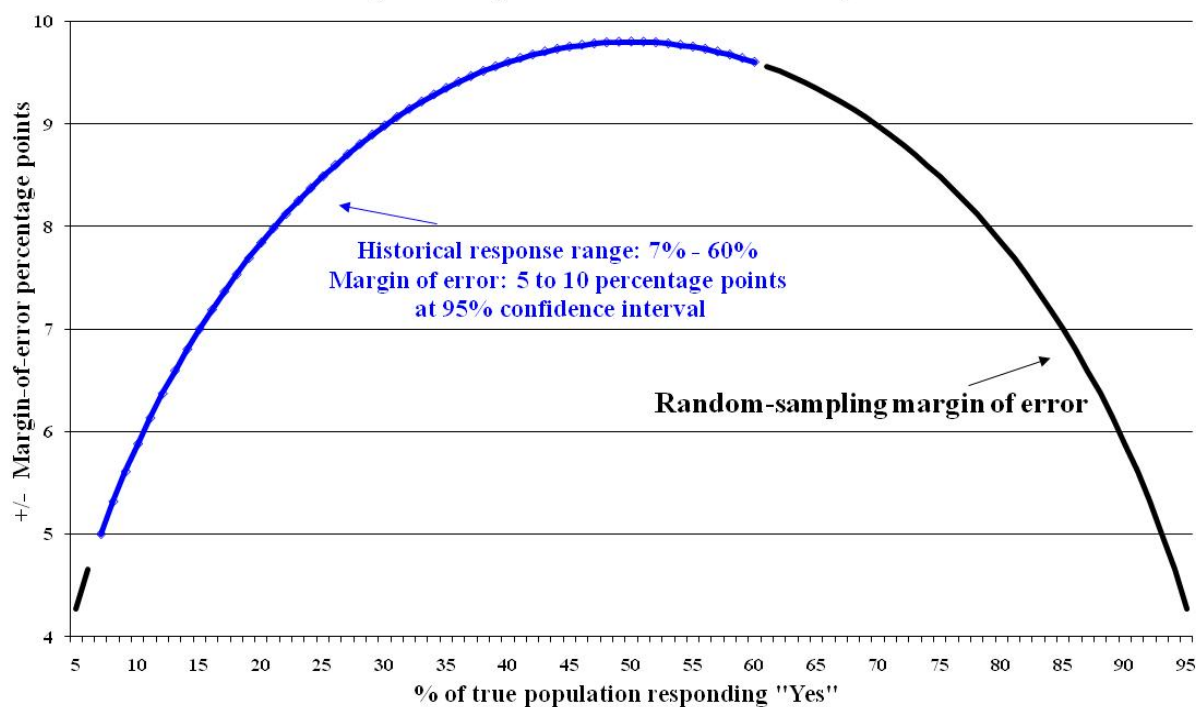
where the  $Z$ -value is selected according to the desired level of confidence.

As the above equations suggest, the confidence interval will be a function of a given population proportion.

Figure 1 reports both the theoretical confidence interval for the population-proportion questions and the historical range of BOS results for the capacity-constraints and labour-shortage questions. The y-axis represents the estimated confidence level (plus or minus), while the x-axis covers the range of possible responses (0 per cent to 100 per cent of firms answering “yes”). Theoretically, when the population proportion moves closer to 0 per cent or 100 per cent, the margin of error approaches very low levels, since there is more certainty in the true population-proportion status. The confidence interval will peak when 50 per cent of the firms sampled respond “yes,” since the standard deviation will be at its highest point.

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2. To isolate the effect of the question’s design on the confidence intervals over the business cycle, we assume a simple random sampling. We can feel somewhat comfortable doing so, because de Munnik, Dupuis, and Illing (2009) conclude that the BOS sampling methodology does not yield significantly different confidence intervals for the simple random-sample case.
  3. This is a simplification, since the confidence intervals are asymmetric and non-linear when the population proportion is at extreme values (<5 per cent or >95 per cent). Away from these extremes, the distribution is well approximated by the Gaussian distribution (i.e., the confidence intervals are symmetric). This is not an overwhelmingly important issue for us, since the survey results rarely lie in the extreme value territory.

**Figure 1: Mapping the Population-Proportion Margin of Error  
(Assuming Random-Selection Process)**



a. The non-linear portion of the chart (at both extremes) has been removed for simplicity.

Although the confidence intervals for population-proportion questions can theoretically vary from near 0 to  $\pm 10$  percentage points, confidence intervals for the actual BOS results have varied in a smaller range (as shown by the dashed line in Figure 1). The BOS responses to population-proportion questions have ranged from 7 per cent to 60 per cent, which implies a range of confidence intervals between  $\pm 5$  and  $\pm 10$  percentage points at the 95 per cent confidence level. In the winter 2009 survey, for example, the labour-shortages population proportion was 13 per cent, which has an associated confidence interval of  $\pm 7$  percentage points, while the capacity-constraints proportion was 36 per cent, which has an associated confidence interval of about  $\pm 9$  percentage points. The associated 68 per cent confidence level – corresponding to one standard error – reduces the confidence interval by approximately half.

Because both the labour-shortage and capacity-constraints questions measure the percentage of firms that face constraints in meeting demand, the historical highs and lows of these measures have been associated with the peaks and troughs in economic activity. For example, the percentage of firms reporting labour shortages reached its peak (59 per cent) in the winter 2001 survey, near the height of the dot-com boom, and it reached its trough (7 per cent) in the winter 2010 survey as the economy exited from recession. In general, these historical results suggest that the population-proportion questions will have a lower confidence interval during periods of



recession. Over the course of the survey to date, the range of difference in the confidence intervals (5 percentage points) is half of the theoretically possible 0 to 10 percentage points, and observations at the extremes have been modest.

### 3 Balance-of-Opinion Questions

A balance of opinion is used to summarize the results of the majority of BOS questions (such as those dealing with sales, investment, and hiring activity, as well as prices and credit). The balance-of-opinion question uses a 3-part scale for measuring qualitative responses: positive/higher, no change/the same, and negative/lower.<sup>4</sup> Balances of opinion are constructed by subtracting the proportion of negative responses from the proportion of positive responses. As such, balance-of-opinion values can range from -100 to +100.<sup>5</sup> The construction of a balance of opinion leads to confidence intervals that are a function of the underlying proportions. As outlined below, this means that the same balance of opinion can theoretically have up to fifty different confidence intervals – one for each possible combination of positive, negative, or neutral population proportions (proxied here by the sample proportions).

For the balance of opinion, the standard deviation ( $\sigma_{BOO}$ ) is calculated as follows:

$$\sigma_{BOO} = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2},$$

where  $x_i$  is the firms' specific responses and  $\bar{x}$  is the sample mean (the latter can also be viewed as the balance of opinion). Alternatively, we can write this standard equation to explicitly consider how the sample proportions of positive and negative firms' responses affect the standard deviation:

$$\sigma_{BOO} = \sqrt{\frac{1}{n-1} [(\rho_{POS} + \rho_{NEG}) - n(\bar{x})^2]},$$

where  $\rho_{POS}$  and  $\rho_{NEG}$  denote the positive and negative sample proportions, respectively.

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4. There is one exception to this rule. The inflation expectations question is somewhat different than other balance-of-opinion questions considered here, since it has four possible responses (Martin and Papile 2004). However, since two response proportions are aggregated subtracted from the remaining two to generate a balance of opinion, the confidence intervals are largely the same as the other balance-of-opinion questions.
  5. Some surveys report diffusion indexes, calculated by adding those reporting increases to half of those reporting decreases. For example, the Institute for Supply Management's diffusion indexes are calculated differently, as the percentage of respondents that report that the activity has increased is added to one-half of the percentage of those that report the activity has not changed. Both the balance of opinion and the diffusion index offer the same information, since they are monotonic transformations of one another.

The confidence interval is given by:

$$\lambda_{BOO} \pm \frac{\sigma_{BOO}}{\sqrt{n}} * Z,$$

where  $\lambda_{BOO}$  is the balance of opinion and the  $Z$ -value is selected according to the desired level of confidence.

Hence, the combination of positive and negative proportions will partially determine the confidence level of a given balance-of-opinion question. To further understand these equations, we examine the historical BOS results (Figure 2) and the implications for the confidence intervals (Figure 3).

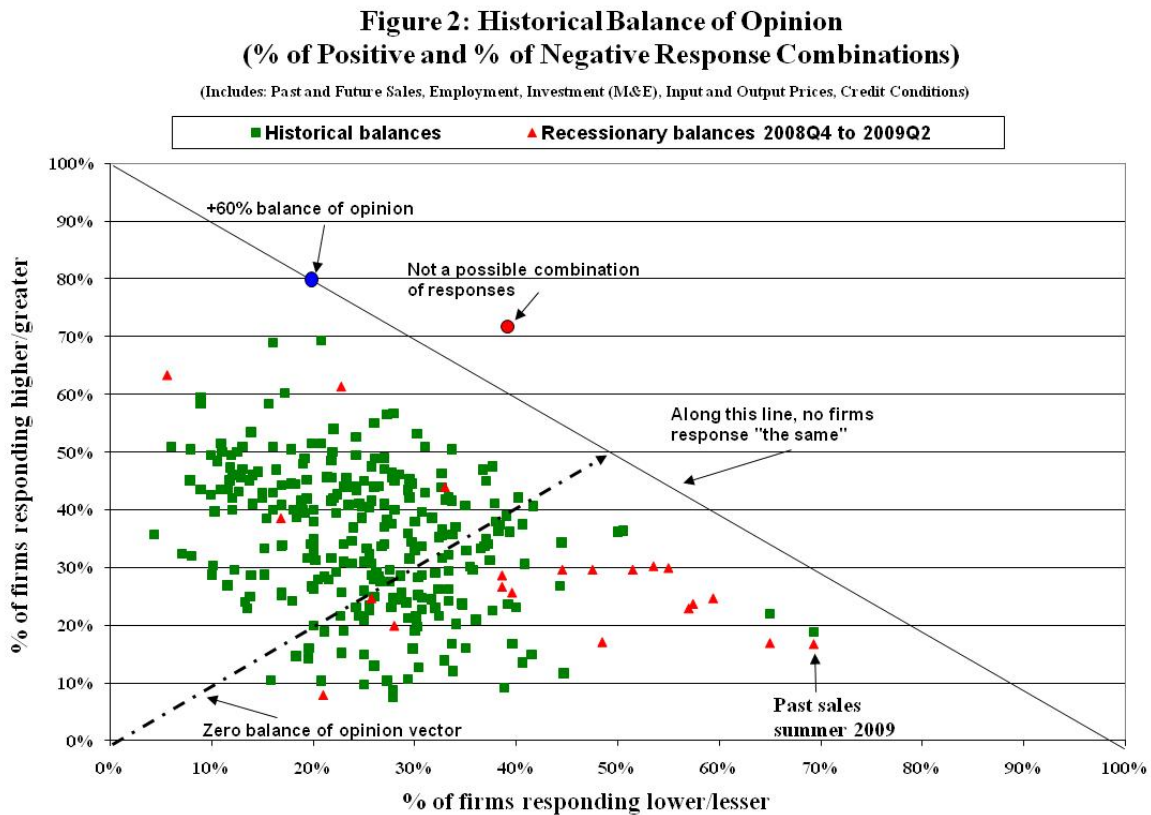


Figure 2 shows the complete universe of possible balances of opinion, plotted by the underlying response proportions. On the x-axis is the proportion of firms that reported negatively to a balance-of-opinion question, and on the y-axis is the proportion of firms that reported positively. For example, in the summer 2009 survey, 69 per cent of firms responded that their sales grew at

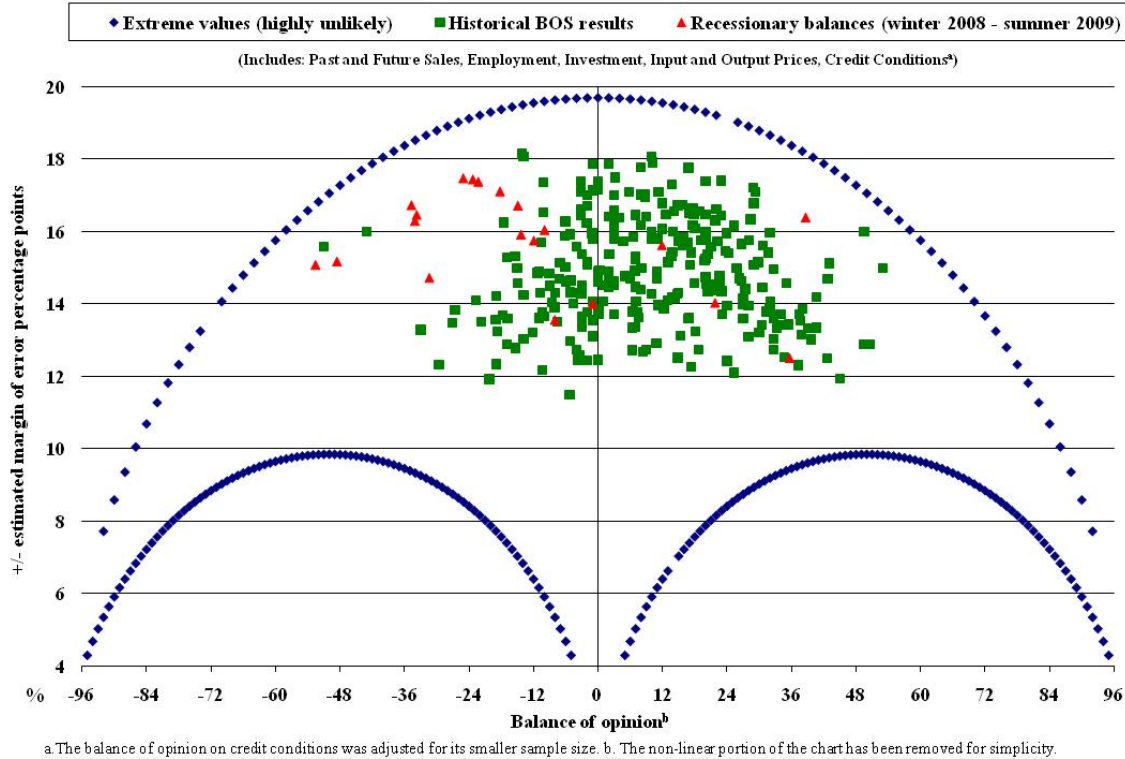
a lesser rate than over the previous 12 months, while 17 per cent of firms responded that their sales grew at a greater rate. Each square on the graph represents an observed combination from one of the balance-of-opinion questions. The triangles in Figure 2 show the quarters when the economy was in recession (from winter 2008 to summer 2009); these highlight the fact that the concentration of responses in the “lower/lesser” category was largely unobserved prior to this period.

Given that confidence intervals for the balance-of-opinion questions depend on the underlying response proportions, and that there has been variation in the concentration of firm responses over time, a few questions can be considered. Specifically, (i) how have changes in the concentration of firm responses affected the balance-of-opinion confidence intervals? (ii) Does the statistical accuracy of the survey results change with variations in the business cycle? And, (iii) are the confidence intervals the same for each question?

To address these questions, Figure 3 plots the range of possible balances of opinion from -100 to +100 along the x-axis, and the associated margin of error for a given balance of opinion on the y-axis. The outer dots represent the extreme cases, for which the underlying response proportions would be concentrated in two of the three possible response categories. There are more than 5,100 theoretically possible discrete balances of opinion within the area outlined by the extreme values. Within this area, the margin of error can vary from 0 to 20 percentage points. The associated 68 per cent confidence interval is approximately half that range. As Figure 3 shows, the margins of error for the BOS data have varied between about  $\pm 11$  and  $\pm 18$  percentage points at the 95 per cent confidence level – which is about a third of the possible range. This demonstrates that there has been some variation in the confidence intervals over time due to changes in the concentration of firm responses.

While the recessionary balances indicated by the triangles were particularly low during this period, the underlying response concentrations were similar to those observed in other periods, and thus the confidence bands are well within the historical range. In other words, confidence intervals for balance-of-opinion questions do not seem to follow a cyclical pattern.

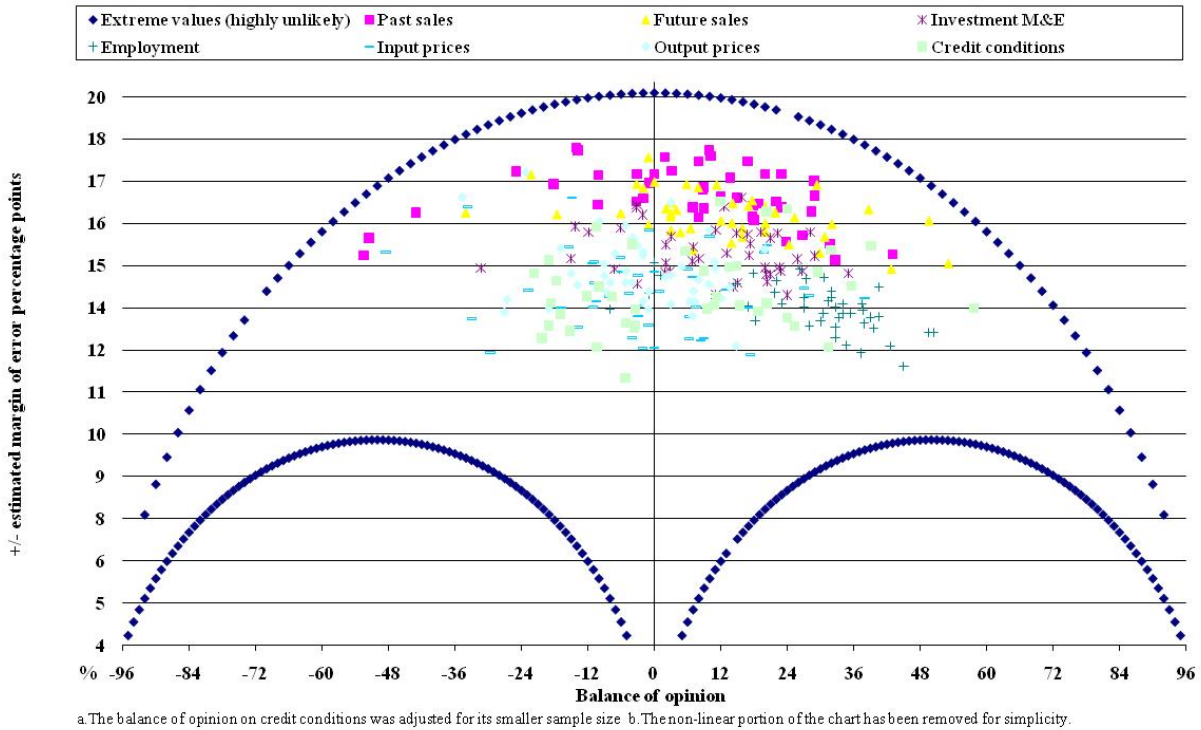
**Figure 3: BOS Balance-of-Opinion Margins of Error (95% Confidence Intervals)**



What about the variation in the confidence levels over time for individual balance-of-opinion questions? Figure 4 shows the same information as Figure 3, but indicates the balance represented by each point (for example, the squares represent the balances on past sales growth). While Figure 2 showed that, overall, the survey response proportions have varied considerably over time across questions, the response proportions have been more stable *within* questions. As a result, Figure 4 shows that the confidence intervals for a given question have been fairly stable over time, with an average spread in the margin of error of about 3 percentage points. Only in the case of input and output prices, as well as credit conditions, is the average spread slightly higher, at 5 percentage points. The responses have been more evenly spread across the response categories for the future sales and past sales questions, resulting in slightly wider confidence intervals.<sup>6</sup>

6. Understanding these differences, however, is left to future research.

**Figure 4: BOS Balance-of-Opinion Margins of Error (at 95% Confidence Intervals)**



## 4 Conclusion

While a number of central banks publish their own business conditions indicators that rely on non-random sampling, knowledge about their statistical accuracy has been limited. Recently, de Munnik, Dupuis, and Illing (2009) made some progress in this area for the Bank of Canada’s BOS by estimating the impact of the Bank’s non-random sampling on the accuracy of the survey results. They found no evidence that the Bank’s firm-selection process results in significantly biased estimates and/or wider confidence intervals than in the random-selection case. We have deepened and extended this work by (i) outlining the statistical properties of population-proportion and balance-of-opinion questions, and demonstrating how their design affects the calculation of the confidence intervals; (ii) examining the variation in statistical confidence associated with changes in the underlying response distribution using actual quarterly BOS results; (iii) considering the possibility that statistical accuracy varies across questions; and (iv) investigating whether the statistical accuracy of the survey results changes with variations in the business cycle.

Our main findings are that confidence intervals around the population-proportion questions are about half of those for the balance-of-opinion questions, and that the confidence bands around both types of question can change from survey to survey when the underlying response

distribution becomes more or less concentrated in particular response categories. We find that confidence intervals around the BOS population-proportion questions become somewhat narrower during periods of recession because the responses become more concentrated when there is little pressure on production capacity. The balance-of-opinion questions vary within a similar range across the cycle.

## References

- de Munnik, D., D. Dupuis, and M. Illing. 2009. “Computing the Accuracy of Complex Non-Random Sampling Methods: The Case of the Bank of Canada’s Business Outlook Survey.” Bank of Canada Working Paper No. 2009-10.
- Macklem, T. 2002. “Information and Analysis for Monetary Policy: Coming to a Decision.” *Bank of Canada Review* (Summer): 11–18.
- Martin, M. and C. Papile. 2004. “The Bank of Canada’s Business Outlook Survey: An Assessment.” Bank of Canada Working Paper No. 2004-15.
- Trebing, M. 1998. “What’s Happening in Manufacturing: ‘Survey Says...’” Federal Reserve Bank of Philadelphia *Business Review* (September/October): 15–29.