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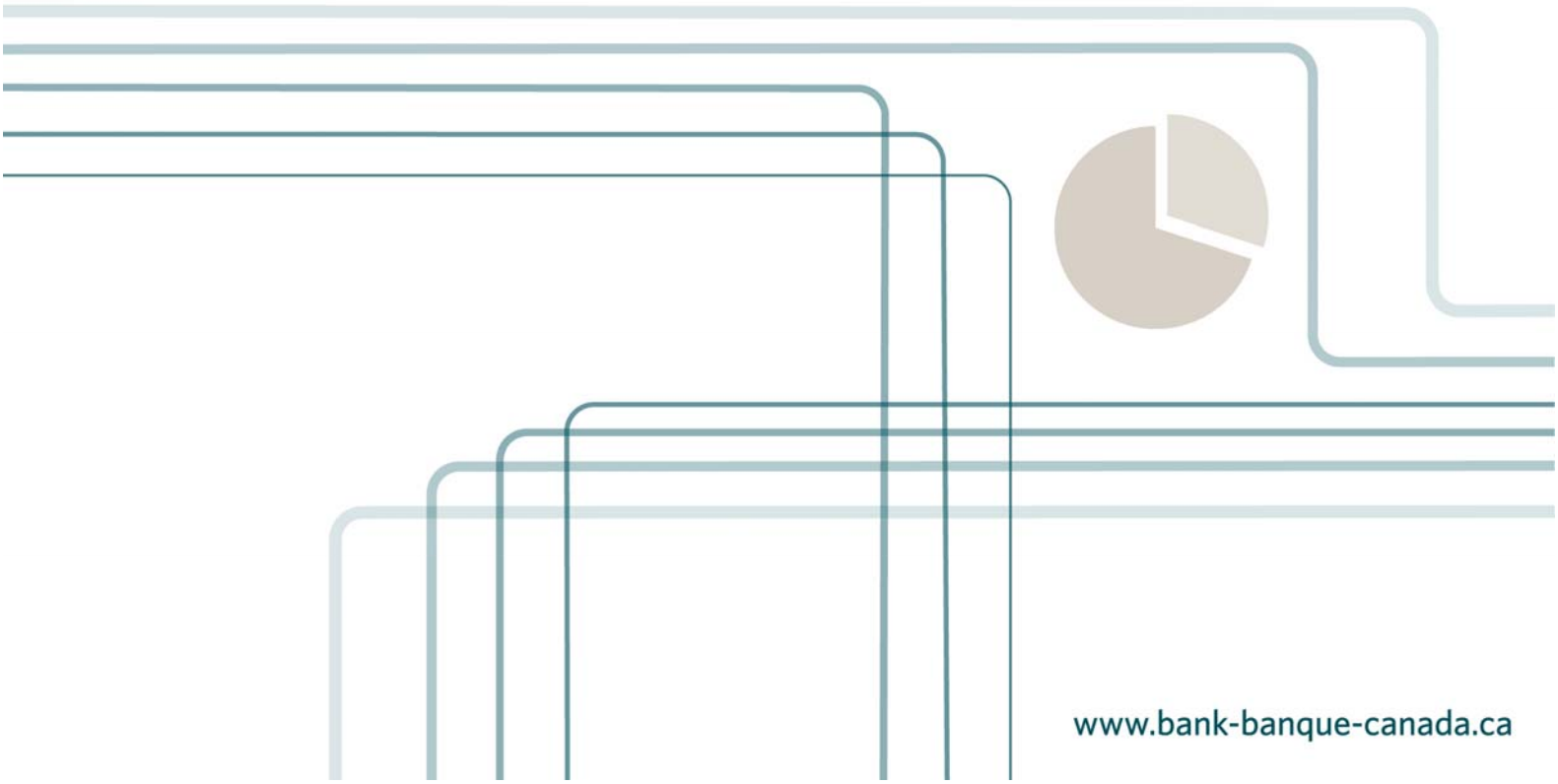
by Angelika Welte



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Abstract

In 2015, the Bank of Canada undertook the large-scale Retailer Survey on the Cost of Payment Methods. This paper describes and discusses the sampling methodology used in this survey, with a focus on the challenges of voluntary business surveys. Recommendations for sampling strategies in future retailer surveys are offered.

Bank topics: Central bank research; Econometric and statistical methods
JEL codes: C, C8, C81, C83

Résumé

En 2015, la Banque du Canada a mené une enquête de grande ampleur sur les coûts des différents modes de paiement pour les détaillants. Dans ce document, nous décrivons et examinons les méthodes d'échantillonnage alors utilisées, particulièrement les difficultés que posent les enquêtes à participation volontaire réalisées auprès d'entreprises. Nous recommandons également des stratégies d'échantillonnage pour les futures enquêtes auprès des détaillants.

Sujets : Recherches menées par des banques centrales; Méthodes économétriques et statistiques
Codes JEL : C, C8, C81, C83

1 Survey Context

The Bank of Canada as the sole issuer of bank notes in Canada has a policy and research interest in the use of payment methods by Canadian retailers, consumers and other stakeholders in the retail payment system. Smooth and efficient retail payments depend, to a large part, on the costs borne by each stakeholder and on the fees paid from one stakeholder to the other. Therefore, in 2014, the Bank of Canada's Currency Department initiated a large-scale research project, the Cost of Payments Study, to collect cost data on point-of-sale (POS) transactions from retailers, financial institutions, cash-in-transit companies and consumers. With this study, the Bank of Canada followed the example of other central banks, such as 13 countries in the European Union (Schmiedel et al. 2013) and the Reserve Bank of Australia (Stewart et al. 2014), and public authorities such as the European Commission (European Commission Directorate-General for Competition 2015). The Bank of Canada Cost of Payments Study, like many of the other studies, focused on cash and payment card transactions at a physical POS where a consumer purchases a good or service from a business. It also collected some data on cheques, but not on online transactions, credit transfers and direct debits. Business-to-business transactions were likewise out of its scope.

This report focuses on the survey methodology used for the data collection among Canadian retailers, termed the Retailer Survey on the Cost of Payment Methods (RCPM survey). It first summarizes challenges encountered in an earlier payment-focused Bank of Canada Retailer Study conducted in 2006 and then highlights the methodological changes implemented for the RCPM survey, followed by two technical sections on the RCPM survey sample frame and sampling procedure. Key issues with the RCPM survey sampling methodology are discussed before a brief conclusion is reached.

2 Methodological Revision of 2006 Retailer Study for RCPM Survey

For the 2006 (Bank of Canada) Retailer Study, the precursor of the RCPM survey, a marketing research firm had been commissioned to collect data from retailers through computer-assisted telephone interviewing (CATI). The development of the survey methodology, including the choice of a sample frame and the weighting of the final responses, were carried out by the same firm. To reach a representative sample, the marketing research firm made phone calls until the quotas in the contract were reached. Quotas were set for region, industry and business size. The survey had a response rate of 5 per cent among dialled numbers and a respondent sample size of 500. Some quotas were not reached, and Arango and Taylor (2008a) caution against a generalization of the survey's findings owing to a high margin of error. In Arango and Taylor (2008b), they based cost calculations on an even smaller sample of 35 respondents from a follow-up paper survey. The follow-up survey was necessary since key questions on the cost of payments had suffered from high item nonresponse in the CATI survey. The 500 responses also came from a mix of chain and independent stores, but were not adjusted for repetition of the same chain within the sample.

Three main concerns for the RCPM survey emerged from the 2006 Retailer Survey: First that, owing to a high response burden and the voluntary nature of the study, overall response rates in 2015 would be low and that the completed questionnaires would suffer from item nonresponse. Second, that the collected responses would not constitute a representative sample of Canadian retailers. And, third, the Bank of Canada team sought greater control of the sampling procedure and the inclusion probability of each business. The methodological choices for the RCPM survey aimed at addressing these three issues.

To boost response rates and reduce respondent burden, the survey team relied on the Tailored Design Method (Dillman et al. 2008) and feedback collected from business owners during the testing of the questionnaires (Sections 2.1 to 2.3). For the second concern, stratification was employed

in combination with responsive sampling design (Sections 2.4 and 4) so that survey effort, such as time allocation and financial resources, would increase where low response rates or large margins of error were encountered. To gain control over sampling, the Bank of Canada constructed a survey frame, sampled all businesses in-house and then provided the inclusion probabilities where possible (Sections 2.3, 3 and 4). The majority of the data collection and processing was still carried out by a marketing research firm as the Bank of Canada did not have the resources for those tasks.

2.1 Survey mode

The RCPM survey was planned as a mixed-mode data collection survey, meaning that survey responses would be submitted through several channels: paper questionnaires, online questionnaires and telephone interviews (CATI). While Dillman (2006) identified survey mode as a source of instability in household surveys, flexible survey modes can also reduce respondent burden and increase response rates. Cognitive testing of the questionnaire with a small number of businesses in early 2015 confirmed that completion by phone would take too much time during a typical work day since the questionnaire consisted of eight pages and required respondents to look up details in their financial records. The majority of the RCPM sample therefore received paper questionnaires by mail.

The personalized online questionnaire was made available to every other sampled business (selected at random), and all sampled businesses were given online access on reminder postcards several weeks later. Unpersonalized online access was also available on the Bank of Canada's website. Lastly, phone calls were used for nonresponse follow-up and to boost sample size in certain strata.

2.2 Incentives

Incentives offered to respondents in the 2006 Retailer Study were charitable donations in the name of the responding business and a special copy of the study report. Similarly, the RCPM survey

also offered incentives to respondents, since the Bank of Canada felt that incentives not tied to responding may be viewed as an inappropriate use of funds. Dillman et al. (2008) demonstrate that advance cash incentives effectively increase response rates, however. Advance letters signed by the Governor of the Bank of Canada and letters accompanying the survey package signed by the Chief of the Currency Department explained that the data collected in the study would help the Bank gain insight into the cost of payments and emphasized that the data would only be used for Bank of Canada research. Chen et al. (2016) report that a similar letter had improved participation in a Bank of Canada consumer survey. Besides the letter, the questionnaire allowed the business to select any number of the following incentives: (i) the final study report; (ii) a detailed study report by industry, region and size; (iii) a webinar presentation of the study report; (iv) a certificate of appreciation; and (v) the business's name entered into a draw for a tablet computer. The draw for the tablet computer turned out to be the most popular incentive, but many respondents also requested a study report.

2.3 Sampling frame and survey instruments

The survey frame was mainly based on over 400,000 downloaded business units from the Dun & Bradstreet (D&B) database, which were combined with information on the largest retail and restaurant chains in Canada. D&B has been used extensively by the Bank of Canada for other business surveys (de Munnik et al. 2013) and also by the Federal Reserve Bank of San Francisco for the pilots of its Cash Payments Survey. The database lists addresses, employee counts and industry information in the form of the North American Industry Classification System code (NAICS) for the majority of units, thus facilitating stratified sampling. In business surveys, the most economically significant firms are usually included in the sample with probability one, forming a take-all (TA) or certainty stratum. Bank of Canada researchers combined information from D&B, Restaurants Canada,[1] the Monthly Retail Trade Survey (Statistics Canada 2014) and the Retail Council

[1] http://foodserviceandhospitality.com/june-2014-digital-issue/

of Canada for the definition of the TA stratum.

Choosing the correct survey unit is an important part of business survey methodology (Rivière 2002). In the RCPM survey, the contacted survey unit had to be capable of providing data on payments while also being authorized to release this information. To avoid duplication, the unit also had to be at the highest level in its organizational hierarchy where data on payments were available. Most businesses in Canada are simple and consist of just one unit, while a small fraction of businesses are organized into a complex hierarchy of multiple units. Complex businesses, however, contribute a significant portion of economic activity (Statistics Canada 2010). Stratification by firm structure was therefore recommended. Businesses in the Single-Location stratum (SL) were independently owned and operated, were mainly small and medium-sized and did not operate under a brand name or banner of a large chain. The HQ stratum consisted of clusters representing large chains, multi-unit businesses with a complex structure and potentially several locations, businesses falling under the same brand and other businesses with large assets or revenue. Since an HQ may represent several units in the original database, we also refer to the units in the HQ stratum as "chains" or "complex businesses." The aforementioned TA stratum was included in the HQ stratum as the HQ TA stratum. Section 3.1 gives a detailed technical description of the strata and cluster construction.

For SLs on the frame, the survey and the responding unit were identical. For clusters, the survey unit was the cluster. Since the head office may not be able to report all payment activities, such as the time spent every day on counting coins and bank notes, responses were also required from individual locations. As suggested by Dillman et al. (2008), the survey instruments were tailored to the business's structure:

(i) Single-Location (SL) questionnaire for businesses that are independently owned and operated, do not operate as part of a chain or banner, and are not classified as headquarters.

(ii) The questionnaire for HQ clusters is divided into two sections:

(a) The Headquarter questionnaire (HQ) for the head offices,

(b) Branch or location questionnaire for locations, branches or franchises.

The head office needed to coordinate and authorize the completion of all questionnaire sections.

2.4 Stratification

The units on the sampling frame were first stratified according to their *structure* and then according to *region*, *industry* and *size*, as is routinely done in business surveys (Table 1). The HQ TA stratum contains the largest retail chains in Canada, the HQ Take-Some (TS) stratum covers other large and complex businesses, and finally the Single-Location (SL) stratum contains the remaining independently owned and operated businesses. SL has the largest number of units, but each contributes a small fraction of POS transactions, while HQ TA has a small number of units with many more POS transactions.

Results from the 2013 Methods-of-Payment Survey (Henry et al. 2015) indicate that region, industry and size may be correlated with acceptance of payment methods. Stratification by all three dimensions—region, size and industry—was used for the SL sample, while the HQ TS sample was stratified by region and industry, and the HQ TA stratum by industry. The separation of HQ TA and TS already takes care of size differences between HQs. The regional strata were Atlantic (AT), Quebec (QC), Ontario (ON), Prairies (PR) and British Columbia (BC). For the size of the businesses: Stratum A were single locations with fewer than 5 employees or a missing number of employees; Stratum B, those with at least 5, but fewer than 50 employees; and Stratum C, those with at least 50 employees. Industry strata were given by the 2-digit NAICS (44-45[retail trade], 72 [food services and drinking places], and 81 [repair and maintenance, personal and laundry services]).

	SL	HQ TS	HQ TA
Revenue per unit	Low	$\rightarrow$	High
Number of businesses	High	$\rightarrow$	Few
Stratification	R, N, S	R, N	N

Table 1: Stratification levels—region (R), size (S) and industry (N).

3 Sampling Frame Construction

A customized sample frame was constructed for the RCPM survey to accommodate the desired stratification by firm structure (see Figure 1 in the Appendix).

3.1 Construction of clusters for HQ frames

The construction of the clusters for the HQ TA frames was based on a fixed list of national chains that the HQ TA frame had to cover, while there was no such list for the HQ TS frame. For the HQ TS frame, the clusters were formed using relationships between units derived from D&B.

3.1.1 HQ TA

The HQ TA frame consists of approximately 100 restaurant chains (NAICS 72) and 80 retailers (NAICS 44-45) in Canada. Services (NAICS 81) are not included in the HQ TA, owing to lack of access to a reliable list of the largest providers of consumer services in Canada at the time. The technical implementation of the clustering procedures takes the following steps:

(i) Split the D&B database into three databases: retail (NAICS 44-45), restaurants (NAICS 72), and services (NAICS 81).

(ii) For NAICS 44-45 and NAICS 72:

  (a) Standardize the spelling of the following D&B variables: companyname, doingbusinessas, immediateparent, ultimateparent.

(b) Form clusters by matching company names, parent names and operating names to the list of the largest businesses in the NAICS stratum.

(c) Eliminate all units within a cluster from the database and proceed to the HQ TS.

3.1.2 HQ TS

In the HQ TA step, units associated with the largest Canadian retail and restaurant chains are filtered out of the database. The HQ TS step accounts for other large and complex enterprises. Clusters are formed based on:

(i) Classification as a "headquarters" in D&B,

(ii) Revenue exceeding US$15 million,

(iii) Total assets exceeding US$10 million dollars,

(iv) Same immediate or ultimate parent within a NAICS,

(v) Repeated names within a NAICS.

3.1.3 SL

In the construction of the HQ cluster, many units that are "single locations" in D&B were sorted into clusters. To avoid duplication, the SL frame consists of all "single-location" units in D&B that are not contained in any HQ cluster. The SL CATI frame further consists of the SL frame units listing a telephone number in D&B.

4 Sampling Procedures and Design Weights

Sampling and data collection proceeded in two phases, where the first phase was divided into three waves. The survey process is schematically represented in Figure 2. The activities on the left

side were performed internally, while those on the right were outsourced to the marketing research firm. Bank of Canada researchers were involved at every stage of the sample selection and kept in continuous contact with the data collection firm that performed address verification, mail-outs and phone calls. The Bank of Canada monitored the margin of error for two benchmark variables from the SL responses, namely, amount of cash held on the premises and the value of cash transactions. If the margin of error was too high, additional responses had to be obtained.

In parallel to the description of the sampling procedure, this section also explains the approximation of inclusion probabilities π_i for the units i on the SL frame.

4.1 Cluster sampling of HQs

The sampling of HQs was a three-step process. In the first step, a cluster of businesses was selected. In the second step, a contact unit was selected within the cluster. In cases where the Bank of Canada had a personal contact with the head office of the chain, that person was contacted. In other cases, the contact unit was chosen from the D&B units in the cluster: If the cluster contained units of location type "headquarters" in D&B, the "headquarters" with the largest revenue was the contact unit. Otherwise, the unit with largest revenue was the contact unit. In the case of a tie, one of the top revenue units was sampled at random. For large chains, the Bank of Canada's contacts yielded better response rates than mailing a package to the largest revenue unit in D&B.

In the third step, the contact unit selected, at its convenience, up to three branches or locations. Responses were then obtained from the contact units and from the branches (locations). The inclusion probabilities for the HQ sample could not be calculated since convenience (or familiarity) sampling through personal contacts was the main recruitment method for HQs (see also Jiongo 2017).

4.2 Phase 1

Phase 1 for SLs consisted of three waves for which samples were drawn at random within cells h defined by three stratification variables, namely region, size and industry.

Waves 1 and 2 initial draw The 2006 Retailer Survey served as the basis for sample size calculations. The targeted number of responses from SLs in each cell for Phase 1 was based on a set level of precision when survey weights were obtained from the raking procedures described in Deming and Stephan (1940). Furthermore, the minimum number of invitations for each stratum was 2,400 and additional invitations were allocated proportionally to the size of stratum on the SL frame.

Waves 1 and 2 replacement draw The sample size for the addresses replacing invalid addresses from the initial draw was calculated from the number of required replacements and the ratio of valid to invalid addresses so that Bank of Canada staff could assume with 95 per cent confidence that screening of the replacement addresses would leave enough addresses to replace the invalid addresses in each cell h.

Wave 3 CATI booster sample draw Analysis of the responses collected in Waves 1 and 2 determined the need for additional responses since the margins of error were too high for the benchmark variables in certain cells. In these cells, the Wave 3 sample was drawn from among units with a phone number.

4.2.1 Phase 1 inclusion probabilities

Inclusion probabilities for each wave and draw W were obtained by dividing the number of sampled entries n_h^W in a cell h by the frame size N_h^W, $\pi_i^W = \frac{n_h^W}{N_h^W}$ for all i in h. If a unit i was not on the frame for a wave W, then $\pi_i^W = 0$. In particular, for Wave 3, the frame consisted of units with a

phone number in the contact information and, hence, $\pi_i^{W3} = 0$ if i does not have a phone number. The obtained inclusion probabilities are $\pi_i^{W1}, \pi_i^{W2}, \pi_i^{W2r}$ and π_i^{W3}.

Recall that, owing to frame revisions, the frame sizes vary across waves (see the discussion in Section 5.1). Since a unit on the frame is included in at most one sample, an approximation of the Phase 1 inclusion probabilities is given by the sum of the four inclusion probabilities calculated so far

$$\pi_i^{P_1} = \pi_i^{W_1} + \pi_i^{W_2} + \pi_i^{W_{2r}} + \pi_i^{W_3}.$$

Finally, the Wave 2 sample also contains businesses recruited through personal contacts. No attempt has been made to calculate the inclusion probabilities.

4.3 Phase 2

Phase 2 aimed at filling the quotas in cells that were still considered underfilled after the booster sampling. The desired number of responses for Phase 2 in a cell h was determined as for the CATI booster sample, based on the same benchmark variables and all responses from Phase 1. Since the Bank of Canada researchers had access to cell response rates from Phase 1, they were confident about the required sample sizes $n_h^{P_2}$ and drew the entire Phase 2 sample at the beginning. To avoid returned survey packages in Phase 2, the marketing research firm made screening phone calls before mailing out the survey packages to validate the addresses and NAICS on the frame, as well as to determine whether the business accepted cash, debit cards or credit cards for POS transactions.

4.3.1 Phase 2 inclusion probabilities

The sampling proceeded in two steps. In the first step, the address frame was partitioned by phone number. Since phone numbers do not uniquely identify businesses, one unit was sampled at random for each phone number. In the second step, the phone numbers sampled in the first step

were stratified by region, NAICS and size. In each cell h, $n_h^{P_2}$ phone numbers were then sampled at random. Phone numbers belonging to businesses sampled in Phase 1 were not eligible for the draw. Instead of the exact calculation of the inclusion probabilities, the following approximation was used: Denote by r_t the number of repetitions of the phone number t on the address frame. The probability of including a business with phone number t on the phone frame is $1/r_t$, since one business with that phone number is picked at random. The cell weight $w_{t,h}$ of the phone number t is the fraction of businesses with phone number t in cell h. The frame size for cell h in the second stage, $N_h^{P_2}$, is a random variable with the expected value

$$E(N_h^{P_2}) = \sum_t w_{t,h}, \tag{1}$$

where the sum is over all phone numbers t. The probability for including a business i with phone number t from cell h in Phase 2 is approximated as

$$\pi_i^{P2} = \frac{n_h^{P_2}}{E(N_h^{P_2})}.$$

Businesses without a phone contact on the frame have an inclusion probability of zero for Phase 2. Table 2 compares the approximated inclusion probabilities with the sampled fractions (for the cells targeted in Phase 2).

Repetitions	Share of pairwise different phone numbers	Observed Inclusion in %	Approximated Inclusion in %
1	92.57	4.47	4.46
2	6.92	2.58	2.62
3	0.45	1.81	1.77
≥ 4	0.06	1.20	2.07

Table 2: Observed vs. approximated inclusion probabilities in per cent. Calculated on the set of businesses having a phone number and falling into the targeted cells for Phase 2.

The calculation of the exact Phase 2 inclusion probabilities would be computationally intensive

and would require enumeration of all possible samples.

For illustration, let the frame for Phase 1 be $\{1, \bar{1}, 2, \bar{2}, \bar{\bar{2}}, 3\}$. Elements $i, \bar{i}$ and $\bar{\bar{i}}$ have the same phone number. Assume that $n^{P_1} = 2$ and $n^{P_2} = 1$. It can then be shown by enumerating all possible samples that the probability to include the element 3 in either the Phase 1 or Phase 2 sample is $\pi_3 = 13/15$. With the approximation, $\pi_3^{P_1} = 1/3$ and $\pi_3^{P_2} = 1/3$, so that $\pi_3^{P_1} + \pi_3^{P_2} = 2/3 \neq 13/15$.

4.4 Design weight for SL

The overall inclusion probabilities are approximated as the inclusion probabilities for Phase 1 and Phase 2, truncated at 1:

$$\pi_i = \min(\pi_i^{P1} + \pi_i^{P2}, 1). \tag{2}$$

Note that a unit was included in at most one wave, so that, in the special case where the frames are identical for each draw and random sampling is used in each wave, this formula is actually exact. The sampling and calculation of inclusion probabilities have now been completely described. The remaining challenges, both technical and non-technical, will be discussed in Section 5.

5 Lessons from the RCPM Survey

Compared with the 2006 Retailer Study, the RCPM survey saw a much greater involvement of Bank of Canada staff. Staff constructed the sampling frame and devised a complex sample design to collect a nationally representative sample and reduce the margin of error. Owing to their hands-on experience and access to the sample frame, they were also able to identify further areas for improvement. Sections 5.1 and 5.2 are directly related to the sampling process for SLs, Sections 5.3 and 5.4 concern the quality of information on the frame and in the D&B database, Section 5.5 discusses the construction of clusters for the HQ frame and, finally, Section 5.6 touches on calibration.

5.1 Sampling design

The RCPM survey was designed to consist of two phases and each could have several waves. Sampling and data collection in later stages were to be guided by paradata from earlier stages, such as call records from phone calls, returned-to-sender (RTS) survey packages and observations from data processing and coding. The sample design performed well in terms of flexibility since the survey team was able to adjust the sample frame and data collection protocol during the data collection. The survey team could also allocate greater survey effort to cells where they observed low response rates or high variability of the outcome variables. Additionally, waves randomized the time when the business received the questionnaires and protected against weekday and holiday effects. The design is complex and exact inclusion probabilities cannot be calculated, however.

If frame revisions can be avoided, a future survey could follow a simplified survey design. The following proposed adaptive collection design has one phase of sampling and can accommodate several waves of data collection. Response rate estimates need not be known and only the required number of responses is collected. First, the businesses are ordered randomly within each cell. Businesses are then selected according to the random order until the desired number of responses is reached. Because the order is random, the selection probability is simply the index of the last selected business divided by the total number of units in the stratum. In practice, the sampling would be done in batches, still following the indices. Follow-up also proceeds according to the indices, skipping those that have submitted satisfactory questionnaires. In such a design, data collection efforts, such as the call attempts or the value of the incentives, can be adapted based on paradata acquired during the survey (e.g., subgroup response rates). For example, Beaumont et al. (2014) show how to increase survey quality given a fixed survey budget using adaptive data collection for a CATI survey. Alternatively, when response rates are well understood for each stratum and frame revisions are unlikely, stratified simple random sampling with just one draw (wave) is the simplest option. While this option offers less control over the exact number of

responses, the inclusion probabilities, as well as estimation and inference procedures, are well understood.

5.2 Distribution of design weights

The design weight d_i of unit i is the inverse of the inclusion probability $\frac{1}{\pi_i}$. If S is a probability sample from a finite population P of size N, then unbiased estimators of the population size and the sample size (Levy and Lemeshow 2008) are given by

$$\widehat{N} = \sum_{s \in S} d_s, \qquad (3) \qquad\qquad \hat{n} = \sum_{j \in P} \pi_j. \qquad (4)$$

In particular, if the population is divided in strata and the design is stratified random sampling, then we obtain unbiased estimators for the stratum size N_h and sample size n_h in a similar fashion. The variability of the design weights within a cell h, as seen in Table 3, is mostly due to the sampling from multiple overlapping frames: after the initial Phase 1 draw, improvements to the clustering procedures resulted in a new frame for the replacement draws. Next, all units without a phone number were dropped from the frame, starting with Phase 1 Wave 3. Sampling from the phone frame is further modified for Phase 2 by switching to a two-step sampling procedure to deal with phone number duplication. Lohr (2011) introduced the single-frame adjustment for design weights in multiframe sampling and this adjustment was used in the RCPM survey as described in Section 4. This adjustment preserves relationships between survey variables and, hence, is *internally consistent*. If identity (4) holds in each cell, the design weights are said to be *externally consistent* with the population size in each cell on the frame. The ratios $\hat{N}$ and $\hat{n}$ to actual population and sample size, respectively, are displayed in Figure 3. The figure confirms Lohr's 2011 statement that the single frame adjusted weight may be externally inconsistent, even if the weights are consistent for each frame. While calibration is usually used to ensure external consistency of the combined weights, future surveys should avoid the frame revisions that increased the number of frames in the RCPM survey.

Stratum	mean	SD	min	p5	p50	p95	max
A	28.05	44.64	1.00	3.70	21.45	51.45	1114.06
B	44.84	101.29	1.40	3.28	16.27	314.67	515.75
AT	9.92	17.90	1.00	1.02	4.09	43.26	129.77
BC	24.00	54.18	2.36	2.67	15.47	106.38	332.64
ON	47.38	83.10	5.01	5.69	24.60	278.51	1114.06
PR	23.29	46.08	3.16	3.28	15.65	72.10	1037.73
QC	30.09	69.35	3.33	4.54	21.45	46.24	515.75
44	33.36	54.00	3.38	7.19	23.99	43.26	1114.06
45	14.79	16.30	1.40	3.54	9.08	22.54	220.37
72	53.95	122.68	1.00	2.67	7.38	463.46	515.75
81	26.44	33.73	3.75	4.15	21.45	51.45	1037.73

Table 3: Distribution of design weights by stratum: Columns show the means, standard deviations, 5, 50, 95 percentiles, and minimum and maximum design weights for the population.

5.3 Coverage error and unit nonresponse

In the RCPM survey, it is difficult to distinguish between (frame) coverage error and nonresponse error.[2] In particular, businesses with invalid addresses or returned survey packages (RTS) are treated as nonresponders, since it is not known whether they are still operating (eligible or "alive") or not (ineligible or "dead"), although the ineligible businesses should be excluded from response rate calculations and the estimation of the nonresponse bias. Invalid addresses and RTS are both indicators that the information in D&B and, hence, on the survey frame, is outdated. An added concern involves the response rates of 3 per cent for all sampled businesses and of about 4 per cent for all contacted businesses. Bank of Canada staff identified a need for nonresponse analysis, even if response rates are at best an incomplete measure of nonresponse bias, and the actual response rate among eligible units may be higher. Bank of Canada staff efforts to study nonresponse broadly followed the guidelines in Lineback and Thompson (2010). As pointed out there, a full nonresponse follow-up study can be costly and time-consuming, since units must be pursued until their reason for nonresponse is discovered and data are collected from eligible nonresponders.

[2]Unit nonresponse is the failure to obtain survey data from a sampled business and occurs after the sampling step. For the remainder of the section, "nonresponse" means unit nonresponse.

In the RCPM survey, follow-up efforts were greatest for units in the HQ TA population since these units contribute a large portion of POS transactions and, hence, are considered influential in the estimation of total payment-related costs for the surveyed population. Hatko (2017) uses auxiliary information from D&B to compare respondents and nonrespondents and develops a non-response model based on the frame variables. Bank of Canada research staff have been undertaking several initiatives to determine the eligibility of SL units in the D&B database. According to their probabilistic models, SL units with missing fields in the database had a higher-than-average propensity for RTS. After units at high risk for RTS were called to verify their status, about 25 to 30 per cent of them were deemed ineligible. Based on these findings, in Phase 2, the Bank of Canada added a screening phone call to verify the address and status of the sampled SL units. Again, a number of units were found to be ineligible. Since RTS appears to be linked to frame quality, a follow-up with the database provider for D&B is recommended to gather information on the current status of the sampled units and the last time they were updated.

5.4 Stratum jumpers

Stratum jumpers are units that turn out to belong to a different stratum than assumed during sampling. Stratum jumping with regards to measures of size can lead to influential units when the variable of interest is correlated with firm size, such as the number and total value of transactions in the RCPM survey. Owing to the asymmetric firm size distribution, the strata of small firms (sizes A and B) are larger than the strata of large firms (size C, HQ TA and TS), so that the former have larger design weights than the latter. Businesses are also more likely to increase in size than to decrease. Therefore, stratum jumpers will often have large design weights and report high transaction numbers or values.

Bank of Canada staff found that approximately 25 per cent of the reported employee counts do not fall into the categories defined by the employee counts in D&B. For the vast majority of the stratum jumpers, the reported category is either one size up or down from the category on the frame

(i.e., jumping between A and B or B and C) and these were deemed unlikely to cause problems. Among the small number of potentially problematic stratum jumpers from size A (small size, large design weights) to C (large size, small design weights), two main types of stratum jumpers emerged. For the first type, the reporting unit appears different from the unit on the frame and is not a true stratum jumper. For the second type, the "true stratum jumpers," the revenue on the frame is large and consistent with the reported employee count (but not the employee count on the frame). Future surveys may want to use revenue in addition to employee counts for the definition of strata.

5.5 Cluster sampling

Cluster sampling is usually used in the presence of large within-cluster heterogeneity when a few clusters contain enough units to represent the population of interest. In the RCPM survey, intra-cluster (intra-chain) heterogeneity is assumed to be small, because the cost of payments varies less between locations of the same chain than between chains. Therefore, as many clusters as possible must be sampled, but only a few units within each cluster. Franchises that are financially independent businesses are included in the clusters of their brand, as are company-owned stores. The assumption of intra-cluster homogeneity in the RCPM survey implies that franchises and company stores should incur similar costs for accepting payments. This assumption has merit since franchises and company stores are usually expected to offer a uniform customer experience and thus accept the same payment methods. The franchisor may also offer a pre-negotiated agreement with a payment service provider to the franchisee, and fees paid for card payments will be similar within the chain.

After a lower-than-expected response from the Phase 1 mail-out sample, the HQ sampling relied mostly on contacts between Bank of Canada staff and the firms and, consequently, inclusion probabilities for the HQ sample could not be obtained. Future research may employ simulation methods as in de Munnik et al. (2013).

5.6 Sampling frame and population frame

While design weights are always based on the sampling frame, calibration adjustment can also use auxiliary information from another frame, the *population frame*. If the sampling frame is not representative of the population, calibration to auxiliary information may ensure that the final estimates are representative of the whole population. The Statistics Canada Business Register (BR) suggests itself as a population frame for the RCPM survey. The BR is the basis of official business statistics in Canada, so that the calibrated sample characteristics of the RCPM survey would be in agreement with these official statistics. Statistics from the BR are generally considered to be reliable and up-to-date, owing to monthly quality assurance and mandatory participation (Statistics Canada 2010). A drawback is that the units on the RCPM survey frame may not coincide with the units on the BR; SLs on the survey frame are not defined in the same way as the "statistical locations" in the BR. The difference is partially explained by D&B's definition of a single location and partially by the clustering of certain single locations into chains (see Sections 3.1 and 5.5). The BR also defines stratification variables in a different manner. For example, almost all headquarters and single locations in D&B have a positive number of employees, while a large number of the locations on the BR have an "undetermined" number of employees. The technical report by Chen and Shen (2017) proposes a calibration of the RCPM survey to the BR where the BR counts for "undetermined" are combined with those for businesses with fewer than five employees (Stratum A).

6 Conclusion

For the RCPM survey, Bank of Canada staff developed a flexible survey design, taking advantage of auxiliary information in the D&B database and paradata obtained during the fieldwork. As a result of the revised survey design, the SL sample fulfilled all cell targets, and cost-of-payment estimates from the RCPM survey will be more robust than the estimates in Arango and Taylor

(2008b). Since the RCPM survey was voluntary, low response rates were identified as the greatest challenge. A nonresponse analysis is recommended to address biases arising from nonresponse and frame imperfections, including follow-up with the provider of the D&B database from which the frame was built. More effort could be made to convert sample units from the initial draw into respondents or to verify their status through screening instead of sampling additional units to reach the desired response counts. In the case of large chains, their economic and statistical significance justifies additional survey effort. Bank of Canada staff found that direct outreach and networking, while labour-intensive, were more effective in obtaining their responses than using the information in the D&B database. Since they had access to the sampling frame, Bank of Canada staff also improved the weighting and nonresponse adjustment in the RCPM survey compared with the 2006 Retailer Study. The weighting (Chen and Shen 2017) and nonresponse reports (Hatko 2017) are available under a separate cover.

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Appendix: Figures

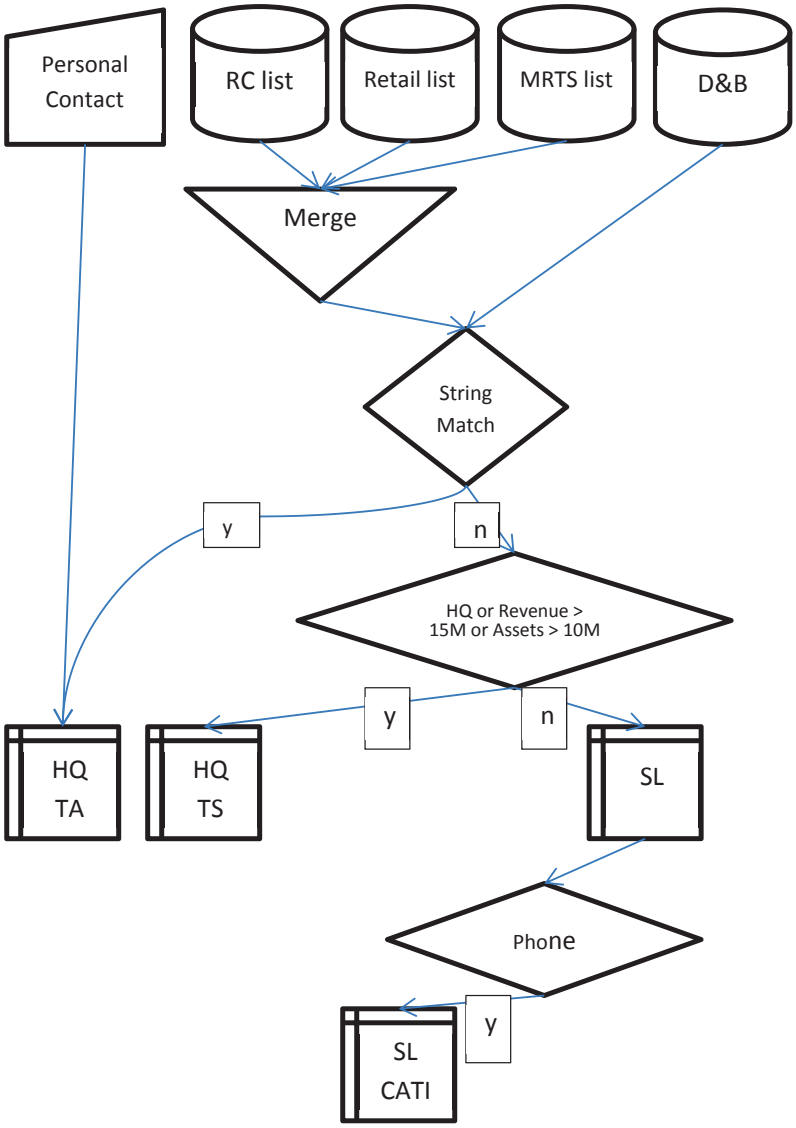

Figure 1: Construction of the sampling frame.

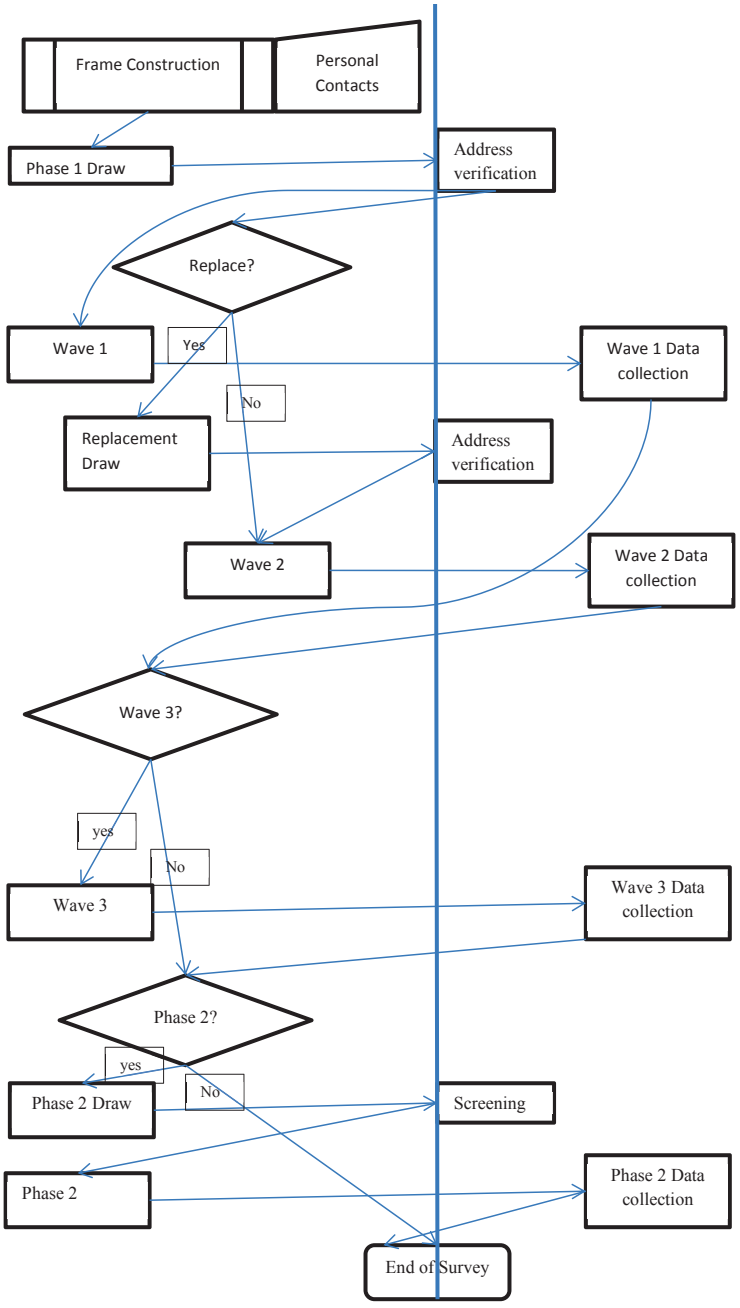

Figure 2: Sampling for the single locations.

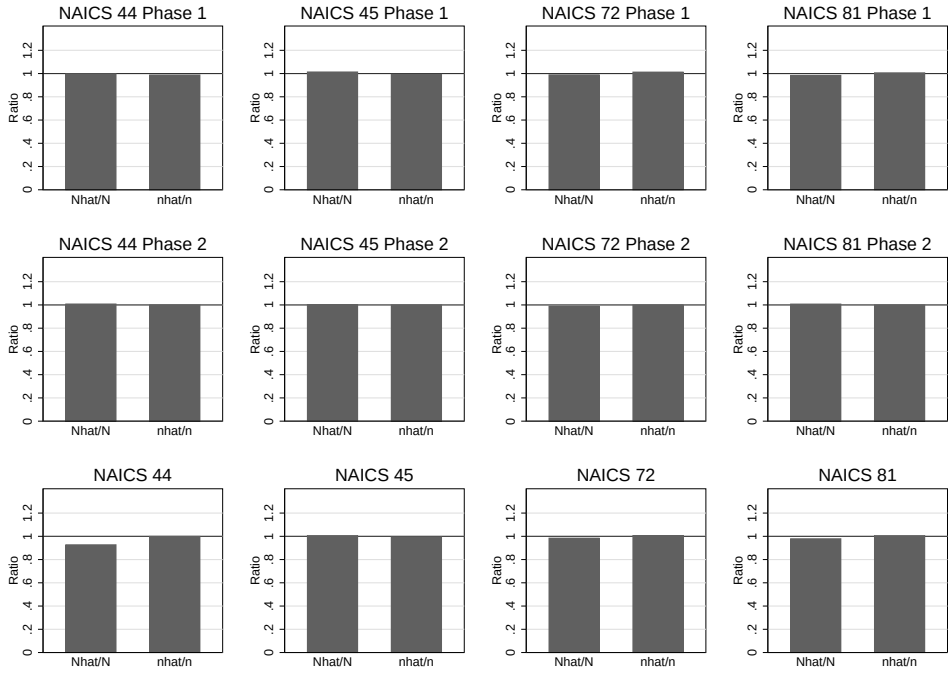

Figure 3: Sample size and population size identities-fit by NAICS stratum.