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BUREAU OF THE CENSUS

I. Introduction

An area sample is used as a supplementary sample in the Census Bureau's Monthly Retail Trade Survey and Monthly Selected Services Survey. The main list sample for these surveys is selected from a universe list of business firms developed from the Censuses of Retail Trade and Selected Services and from the administrative records of the Federal Government. The primary identifier of the business firms on this list is the Federal Employer Identification (EI) number.

The area sample is used to cover businesses not represented by the list sample. These businesses are of two types: new employer businesses ("birth" employers) and nonemployer businesses. For the retail and service surveys, the universe list from which the list sample is selected does not contain nonemployer businesses. One reason for this is to avoid the expense of maintaining a list of a large number of very small businesses, many of which are in operation for only a short time. Even though the universe list is continuously augmented for birth employers, there is a lag in representing new or birth employer businesses by the list sample for the following reasons: first, new employers may open for business before filing forms that would enter the businesses into the administrative or tax system; secondly, the time it takes for the business record to be processed and sent to the Census Bureau; and finally, the time it takes for the Bureau to conduct its own double sampling procedure that leads to the representation of the birth employers in the list samples.

In recent years the area sample has accounted for 5 % to 10% of the monthly retail sales estimate for the United States as produced by the Retail Trade Survey. The estimated sales for nonemployers are about 3% of the total sales estimate varying between 2 1/2% and 4%. The birth employers in the area sample account for 3% to 7% of the total sales estimate depending on the length of the delay in representing the births in the list universe. The longer the delay, the larger the percentage of sales represented by the births in the area sample. Percentages are similar for the service receipts estimates produced by the Selected Services Survey except that nonemployers account for a larger percentage and birth employers account for a smaller percentage.

The area sample has several problems. One is that it adds an extra expense to the cost of the two surveys. This cost is about 15% of the total budget allocated to these two surveys or approximately three quarters of a million dollars. Having its most recently selected sampling units dating from 1964, the area sample

was overdue for reselection. This outdatedness is manifest in the increasing variances of the area sample estimates. For these reasons a task force was set up in late 1977 to investigate alternatives to the area sample or, failing that, to reselect a new area sample for use in the retail and service trade surveys. Any alternative to the area sample was mandated to cost less than the present area sample but to produce estimates with at least the same or smaller mean square error.

The rest of this paper describes the present area sample, some of the alternatives considered and their unsuitability as replacements for the area sample, and finally a description of the methodology for reselecting an area sample.

II. Description of the Present Area Sample

The present area sample is a 20% subsample of a previous area sample that was used for the Monthly Retail Trade Survey and the Monthly Selected Services Survey until 1968. At that time the surveys were completely redesigned so that the primary sample was a list sample selected from files of employer businesses developed from previous Censuses and administrative records. The area sample then became a supplementary sample to ensure coverage of all businesses since the files from which the list samples are developed and updated contain neither recent births of employer businesses nor nonemployer businesses.

The original area sample underwent several reselections and expansions. The first area sample, drawn in 1948 and used until 1953, consisted of 68 selected Primary Sampling Units (PSU's) that were used in the Current Population Survey (CPS). As the CPS sample expanded through the years, the Business area sample followed along using the same PSU's as the CPS or collapsing some strata and then using fewer PSU's. The Business area sample from 1964 to 1968 contained 245 PSU's obtained by collapsing and redefining some of the 367 strata then used for the CPS. Most of the 245 PSU's in the Business sample were also used in the CPS. One reason for this was probably the efficiency of using the same field personnel for both surveys.

The manner of selection of the Business area sample within each selected PSU remained relatively the same throughout its history. Within each PSU secondary sampling units (SSU's) consisting of cities and minor civil divisions were given a probability of selection proportional to their population. The selected SSU's were then divided into land segments containing usually less than 9 retail establishments. This was accomplished either by using maps which had retail establishments spotted on them by an enumerator or by using Sanborn maps which already had retail establishments marked

on them. These Sanborn maps were available for certain large cities. Segments were then selected and divided into 12 panels, one of which would be enumerated each month on a rotating basis. The sample was designed to be for the most part self weighting, i.e., all segments had the same weight. This weight was 200 for almost all PSU's in the 245 PSU design.

It should be pointed out that the area sample from its inception was used with a list sample. This was necessary because the distribution of the retail establishments (in terms of sales - the variable to be estimated) is skewed. The list sample consisted at various times of establishments in the United States above certain size cutoffs and establishments in the selected PSU's above other smaller size cutoffs. Also unusually large establishments found in the selected segments could be enumerated each month by list; consequently, their weight could be divided by 12 because of the 12 panels used.

The present supplementary area sample is a subsample selected from the 245 PSU's used until 1968. The 10 largest PSU's, all of which were selected with certainty, were kept; but a 1 in 5 sample of each panel of their monthly segments was selected. The other 235 PSU's were grouped into 48 sets of 5 or fewer PSU's and a 1 in 5 sample was selected from each group. This yielded the present 58 PSU's in the area sample. The weights are 1000 for the selected segments in all PSU's except two which have weights of 2000 and 3000.

The procedures used to tabulate the area sample data are relatively involved since any establishment belonging to a business given a chance of selection in the list sample is not to be tabulated in the area sample. Further, if these establishments can be identified ahead of time, then the area sample enumerator will not collect data for them. This identification is made easier since the information for establishments in business the previous time the sample was enumerated (usually 12 months ago) can be used to decide whether the establishment is now a candidate for enumeration. The process of deciding whether an individual establishment should be tabulated or not involves matching the area sample establishment's EI to the list or universe file from which the list sample was selected, searching various files of employers, and finally utilizing a special decision procedure when there is conflicting information on the establishment's coverage by the list sample. This process uses a combination of both computer and clerical work. It should also be pointed out that the procedures for enumeration of the area sample segment are for a canvass of certain business establishments. Households, without any sign of business activity, are not canvassed.

A more complete description of the area sample by Max Bershady is found in Hansen, Hurwitz and Madow [1, Vol. I, P.515-558] and is basically repeated in [6]. Descriptions of the estimation techniques used in the Retail Trade Survey for the area sample are given by Woodruff in [7] and [8]. Similar techniques apply to the list sample and to the Selected Services Survey.

III. Alternatives to the Area Sample

This section describes some of the alternatives considered as replacements for the area sample in the retail and service surveys. As many alternatives as possible were investigated, but unfortunately each had serious drawbacks.

One of the first alternatives studied was the use of other lists to cover birth employers and nonemployers. Research into the use of several commercial list files was undertaken. These files contain retail and service employers as well as nonemployers; however, there was some question about their completeness. This completeness was lacking particularly in the small businesses that had no credit and in new businesses. These are precisely the businesses the area sample must cover. Also these files are effectively incompatible with the Census Bureau's lists because of different identifiers. These drawbacks of the lists studied would apply to all commercially available lists.

Another alternative is to sample from the list of nonemployers identified every five years in the Censuses of Retail Trade and Selected Services. (This list of nonemployers could not be produced more often because of prohibitive expense.) This list sample of nonemployers could then be used in conjunction with the usual list sample of employers. To account for birth employers and birth nonemployers, all establishments, belonging to the selected businesses in the two samples, would be checked if they were sold or closed. If this check found a new retail or service business, then this business would be added to the appropriate list sample. The procedure of checking on closed or sold establishments is now used for only the very largest businesses in the retail and service surveys, and then only in certain situations. To complete this check for these large businesses is now hard to control. To do it for any business especially small ones, would be difficult, expensive and would at times require an enumerator to visit the establishment. Furthermore, this procedure can not account for birth businesses in new buildings or in locations not previously occupied by a business given a chance of selection in the original list samples. These types of births account for a large proportion of new businesses, especially in growth areas; moreover, the bias due to missing them would increase arithmetically with time.

A third alternative to the present area sample is simply a change in canvassing. Instead of canvassing businesses in each selected segment by personal enumeration, all telephone listings of these businesses would be obtained and then be used for a mail or telephone canvass. The costs of this procedure except for the cost of obtaining the listings from the telephone companies were estimated. In order for the telephone procedure to be less than the current area sample canvassing, the cost to obtain annually cumulative updated telephone listings from telephone companies would have to average less than \$25.00 per

segment. Meeting this cost seems unlikely. This alternative is procedurally questionable since we do not know if we could get telephone listings for given land segments from any telephone company much less the 50 or so telephone companies servicing the regions where the area sample segments are located. Also, separate contractual arrangements with so many companies would present problems. Other drawbacks to this telephone alternative are the following: first, the listings themselves are likely to be one to three months out of date and not necessarily complete; and secondly, essential information for nonrespondents such as industrial coding can be obtained only through a personal canvass of the segment.

A fourth alternative to the area sample is the use of the Current Population Survey (CPS). Several additional questions would be added to the CPS questionnaire each month, e.g., asking if any member of the household was a sole proprietor or partner in a business, asking the industry description of the business, and asking the sales or receipts of the business. The CPS should be roughly the same size as the present area sample in terms of number of businesses. The CPS should be less biased than the present area sample in the coverage of nonemployer businesses operating from a house instead of a store. This is especially a problem in the selected services area. Also, the CPS rotates respondents out of the sample thus reducing respondent burden, whereas the area sample consists of fixed segments.

The drawbacks of using the CPS are many. There are the political and practical disadvantages of using a survey designed and implemented for an entirely different purpose. These disadvantages include the following: first, the added business questions would not be stressed over labor force items; secondly, an acceptable CPS respondent in a household may know little detail about the business of another individual in the household; and finally, the timing of the CPS is later in the month than the present area sample. Some other disadvantages include the following: the CPS rotation pattern does not allow certain unbiased variance reducing procedures, there would probably be no way of correctly covering birth businesses that were incorporated, and there is no reason to believe the CPS would be any less expensive than the present area sample.

Among other alternatives considered was the use of factors applied to the list sample estimates to account for nonemployers and birth employers. This method is essentially the cheapest, but it has unknown biases. We do in fact use factors to account for the nonemployer receipts estimates in some kinds of businesses in the Monthly Selected Services Survey. These factors are developed from the previous Census and make the assumption that percentage of total receipts due to nonemployers is a constant. This technique is used for estimates in kinds of business where many nonemployers operate out of their own home and can not be adequately identified by an area sample canvass of businesses. For these kinds of business

the factors developed are much better than the area sample estimates would be.

In summary, all the alternatives to the area sample were rejected because of their individual drawbacks. It was further decided to not only keep an area sample but to reselect a new one. This new area sample would be approximately the same size and same type as the present one. It would, therefore, still have the problems of relatively small size and of inability to identify certain types of businesses. However, a reselection, which would reduce variances, seemed to be the best alternative. The methodology of this reselection is described in the next section.

IV. Methodology for the Area Sample Reselection

A. Overall Sample Design

Investigations into possible area sample designs showed that most workable designs would be similar to the present design. For this reason the overall plan was to first select Primary Sampling Units (PSU's) using sales or population as a measure, then at a second stage of sampling, to select Secondary Sampling Units (SSU's) within the selected PSU's. In the third stage, a sample of segments is drawn from the selected SSU's.

In line with this general design, the first question addressed was that of whether to re-define, restratify and reselect the present PSU's, using a more recent population than the 1960 Census counts as measures. Based on a study of this question by Isaki [2] it was concluded that, while a restratification and reselection of the PSU's using an updated measure would result in some reduction in the between PSU variance for some KB's, the overall reduction in variance would be small due to the large effect of the within PSU variance. In addition, tables were prepared which compared the 1977 Census retail sales with the weighted up 1977 Census retail sales from the selected 58 PSU's in the present area sample. The comparison was done for all Census establishments with payroll. At the U.S. level for total retail sales, the difference between the 1977 Census and the weighted up PSU total was only .9 percent. While the correlation between retail sales for establishments with payroll and the types of establishments tabulated in the area sample (nonemployers and birth employers) may not be necessarily high, nonetheless the tables point to the adequacy of the existing PSU sample.

Because of these findings, it was decided to retain the current sample of 58 PSU's and direct our efforts toward reducing the within PSU variance by resegmenting within the currently selected PSU's. The overall plan is to reselect the segments over a 7 year period by first working on the 10 certainty PSU's, then on the 48 noncertainty PSU's. The Washington, D.C. PSU is to be reselected first, during 1981, and the methods and procedures developed in this first test will be used for the remaining PSU's. As an additional part of this

effort, the definition of the certainty PSU's will be updated to coincide with their 1977 SMSA definitions. For the Washington, D.C. PSU, this means adding Charles County in Maryland and Loudoun and Prince William Counties in Virginia to the PSU. Therefore, in what follows, the Washington, D.C. PSU will be coincident with the Washington, D.C. SMSA.

The reason for the second stage of sampling can be seen from the following considerations. The procedure of drawing a sample of segments of appropriate size out of a selected PSU ideally requires forming the necessary segments then selecting the sample. Obviously, locating or "spotting" all retail and service establishments within the PSU on maps in order to form the segments, each with well-defined geographical boundaries, is prohibitively costly. For example, spotting costs are estimated at \$1.25 per case. Thus, just the cost of spotting in the Washington, D.C. PSU where there are about 40,000 retail and service establishments would be estimated at about \$50,000. Added to this would be the extended time period necessary to do the spotting, the extensive map procurement to cover the area, enlargement to the scale needed for spotting, and the work involved in setting up the many segments.

Computer generation of the segment maps was also considered. Conceptually, using addresses from the Retail and Service Censuses files, the Bureau's GBF DIME (Geographic Base File, Dual Independent Map Encoding) file, and the COMP-80 plotter, a map of the Washington, D.C. SMSA could be produced with the business establishments spotted on the map. However, the expected cost for doing this was high and there were sufficient technical and data problems anticipated which made us unwilling to form and select segments by this method. Also, the automated maps would not cover the entire SMSA area. In light of all of this, the decision to retain the scheme of selecting SSU's within the PSU's was thought to be the only practical alternative.

B. Selection of Secondary Sampling Units (SSU's) and Segments in the Washington, D.C. PSU

1. Basic Framework for the SSU and Segment Selection

The procedures to be used for selecting SSU's and segments which were developed and are now being applied in the Washington, D.C. segment reselection will be used, with some minor modifications, for other PSU's as well. Thus, we will here give a detailed description of the procedures being followed for the Washington, D.C. resegmentation effort as a way to describe the methodology chosen.

Currently there are four area sample segments canvassed each month in the Washington, D.C. PSU. Each segment has weight 1000. In the reselection it was decided that we would retain this segment weight. Given an estimated universe of 40,000 inscope retail and service establishments in the PSU and a desired average segment size of 8 inscope establishments, a sample of 5

segments of the desired weight in a monthly panel was indicated to represent the universe. Therefore, it was decided that 5 segments would be canvassed each month and allocated so that Maryland and Virginia each had 2 segments while D.C. had 1. This is an allocation which approximates each area's proportion of the total number of retail and service establishments in the SMSA. Moreover, this allocation is called for because the area sample contributes to published state estimates for Maryland and Virginia as well as for the SMSA and U.S.

In addition, it was determined to have 6 panels in the sample rather than the current 12, thereby reducing costs. Using 6 panels means that each establishment in the area sample would be canvassed twice a year, but this is thought to cause no undue respondent burden problems. Also no variance reducing procedures are now used which take advantage of having 12 panels.

The chosen framework for the segment reselection task then was to select 5 SSU's from the Washington, D.C. SMSA in such a way as to permit the selection of 6 segments from each SSU, with each segment having an overall probability of selection of 1/1000. In turn, each of the required 6 monthly panels would be made up of 5 segments, 1 segment from each of the selected SSU's.

Given the basic framework for the segment reselection, the next questions to be addressed were those of geographically defining the SSU's, assigning a measure of size for SSU sampling, and conducting the sampling.

2. Formation of the SSU's

Some field work in D.C. in the fall of 1980 using a sample of addresses obtained from establishments tabulated as nonemployers in the 1977 Retail and Services Censuses showed that the addresses from the censuses provide a good indication of the physical location of the establishments. Also, the ZIP code from the establishment's record on the census file agreed with the correct ZIP code associated with the establishment's actual location in a large percentage of cases checked. Our conclusion from these efforts was that using census addresses and ZIP codes to form SSU's within the selected PSU's was a reasonably accurate approach to be used in the resegmentation and reselection of segments in the existing PSU's.

Consequently, SSU's were defined in terms of ZIP code areas or combinations of contiguous ZIP code areas (also called ZIP clusters). The number and sales of all retail and service establishments coded to the Washington SMSA broken out by employers, nonemployers, and birth employers in the 1977 Retail and Services Censuses were obtained and tabulated to the ZIP code by State (MD., VA., or D.C.) level.

As for size limitations of an SSU, it was determined that an SSU should contain at least 100 retail and service establishments. Since a minimum of 6 segments would be needed in a selected SSU and the average segment size was expected to be 8 establishments, the figure of

100 was felt to provide a margin of safety.

Using commercial maps with delineated ZIP code areas and the economic census data tabulated to the ZIP code level, SSU's were formed to contain the required minimum number of retail and service establishments. However, some of the ZIP code areas were rather large, having hundreds of retail and service establishments. Fifty SSU's were set up in the Maryland portion of the SMSA, 48 in Virginia and 22 in Washington, D.C. To ensure exhaustive coverage, a check was made so that every area of the SMSA was represented within an SSU.

3. Assignment of a Measure of Size to the SSU's

It was initially felt that the best measure of size to assign to an SSU was the total number of retail and service establishments in the SSU as determined in the 1977 Censuses. An investigation into the estimated variances produced by this and other possible measures of size essentially led to the same conclusion. Specifically, the 5 possible measures of size developed from the 1977 Censuses were: (1) total sales of all retail and service establishments; (2) total number of all retail and service establishments; (3) total number of retail establishments; (4) total number of birth and nonemployer establishments; and (5) total number of retail nonemployer and birth employer establishments. Using measure (6), total retail and service sales of nonemployer and birth employer establishments, as the characteristic to be estimated, measure (2) was selected because no appreciable reduction in variance was exhibited by the other measures, and because measure (2) is most closely related with the measure to be used in forming segments. This latter measure is the number of all retail and service establishments found by actual spotting of the SSU.

Measure (2) was modified. A linear regression of the characteristic to be estimated, measure (6), on measure (2) was computed and a two standard deviation band applied, as a way to adjust for outliers. An adjustment was made to the measure (2) so that the adjusted outlier fell on the band. This assigns a smaller measure (2) to an SSU with atypically small measure (6) relative to measure (2) and assigns a larger measure (2) to an SSU with atypically large measure (6) relative to measure (2). Seven of the 120 SSU's had their measures modified in this manner. All 7 measures increased. Based on our Washington experience, in subsequent PSU's we also plan to regress measure (4), the total number of nonemployer and birth employer establishments, on measure (2). Then, measure (2) for an SSU would be modified only if the SSU is an outlier in the same direction for both regressions.

This analysis excluded department stores and new car sales establishments because of their atypically large sales per establishment and because it would be rare that such large stores would be subject to coverage by the area sample. Also, service nonemployers in KB's other than 72 (Personal Services) or 75 (Automotive Repair, Service, Garages) were excluded because the

area sample is not used to cover nonemployers in those service kinds of business due to their extensive "nonvisibility" and because of the problems of forming segments if these "nonvisible" service establishments could not be located in the spotting.

Another important conclusion of this study was that stratification by state yielded smaller variances than nonstratification. That is, rather than draw 5 SSU's from the 120 formed for the SMSA, it would be better to draw 2 SSU's from the Maryland SSU's, 2 from the Virginia SSU's, and 1 from D.C. A complete description of this investigation is given by Isaki [4].

4. Selection of SSU's and Segments

Calling M_i the adjusted measure (2) (described above) for SSU i , the probability of selection for SSU i was approximately

$$S_i = \frac{n M_i}{M}$$

where n is the number of SSU's to be selected in the stratum (e.g., the Virginia part of the Washington SMSA) and M is the sum of the M_i over all SSU's in the stratum. Since it had been decided that the probability of selection of any segment would be $1/1000$, S_i was adjusted so that it would be of the form

$$S_i = \frac{n_i}{1000}$$

where n_i was an integer such that the sum of n_i over all SSU's in the stratum was $1000n$. Then the selected SSU i would be divided into n_i segments each given a conditional probability of selection equal to $1/n_i$.

The procedure used to select the SSU's was PPS systematic sampling within strata. The SSU's in a stratum were first ordered by decreasing value of S_i , a random start was selected, and then n SSU's were selected in each stratum.

As suggested by Isaki [3], following the segment formation in the selected SSU's as described below, the segments are to be numbered on the spotting maps in a serpentine fashion and a systematic selection of 6 segments made. This will allow one segment from the SSU in each of 6 panels. This scheme should provide good geographic distribution for the selected segments within the SSU which, though it will not affect the monthly estimates, will help the annual estimates.

5. Formation of Segments within the Selected SSU's

Once the SSU's were selected, maps of appropriately large scale for field spotting of in-scope retail and service establishments were obtained. The most appropriate maps found to be available for this purpose are the Bureau of the Census Metropolitan Map Series maps. These maps give basic geographic details and street names and are of scale 1 inch = 1600 feet. Using copy enlargement capabilities of the Bureau, we are able to enlarge any portion

of the map to the scale needed. Thus, for a city block area, we can produce a very large scale, while for rural areas the same scale is not required.

Specifications for Field Division's spotting for inscope retail and service establishments were developed and are specified by Sturdevant [5]. These procedures call for marking the exact location of each retail and service establishment on the spotting maps so that segments containing from 4 to 8 establishments can be constructed. Special instructions are provided for spotting in multi-story structures where counts of establishments are to be given by floors. Also, the spotter is instructed to draw in on the map any physical boundaries such as alleys which may be of use in constructing segments. Trained area sample enumerators are to conduct the spotting effort because of their ability to recognize and spot inscope establishments and because of their experience in conducting a thorough canvass.

A field test of the specifications in a selected SSU in Silver Spring, MD showed that two problems need to be anticipated: (1) a good deal of time will be spent canvassing office buildings in order to locate and identify spottable service establishments; and (2) it may be difficult to break up some blocks or buildings into well-defined segments of appropriate size. The first problem mentioned above is essentially one of cost and no workable alternative has been found at this point. The second problem could be handled by first assigning a measure to each block or otherwise physically or geographically distinguishable area (for example, using for this measure an integral multiple of the desired average segment size). Then after selecting certain of these blocks in a selection process, there would be several options of how to split the selected block into the desired segments:

- (1) split up the block into segments through a return visit to the selected area;
- (2) use a skip pattern of establishments whereby every third establishment starting with the first, second or third are in the same logical segment, if, for example, we needed to split the area into 3 segments;
- (3) use the notion of a face block in constructing segments;
- (4) use a weight less than 1000 for the selected area.

In this last case, for example, if a block were selected with a measure of $4x$ (where x is based on the average segment size), and there were no way to split up the block, the entire block could be considered as a segment in the sample with weight 250. Obviously, this last procedure increases the sample size and therefore the cost of canvassing.

After considering these options, it was decided to use a variation of options (1) and

(2). Thus, as in the above example, after systematically selecting a block which has measure $4x$, a return visit to the block was made to divide the block into 4 recognizable segments. Then a random selection of 1 in 4 was done. In some areas where the block could be split into only 2 parts, for example, each with measure $2x$, a random selection of one of the two parts was done and the final selected segment had a 1 in 2 skip pattern. If the block with measure $4x$ could not be broken up any further, the block was accepted as a segment with a skip pattern of 1 in 4. For the Washington PSU, 14 of the 30 selected segments had a skip pattern ranging from 1 in 2 to 1 in 4.

6. Application to other PSU's

The work so far completed in the Washington, D.C. PSU indicates that the methodology used will be applicable to the other PSU's as well. The methods used are satisfactory both in forming segments of uniform size and in doing this for a fairly low cost. This methodology is already being applied to some other large PSU's.

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