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Topic I: New theories and emerging methods

ROUNDING AS A CONFIDENTIALITY MEASURE FOR FREQUENCY TABLES IN STATBANK NORWAY

Supporting paper

Submitted by Statistics Norway[1]

Abstract: Dissemination of statistics on the web raises opportunities as well as challenges to statistical confidentiality. Last year Statistics Norway (SN) opened its Statistics Bank (SBN) on the web giving users the opportunity to make their own tables by aggregating from detailed base tables at a disaggregated geographical level. The architecture of such web publication structures puts restrictions on which disclosure protection methods are relevant. In 2002, SN experimentally developed a rounding method to make it possible to disseminate frequency count tables from the Census 2001 in SBN in a safe manner and in accordance with the rules of the Norwegian Statistics Code. The experiment was successful enough to be applied to the census publication and the results inspire further development of the method. The paper describes the method and why existing methods and software was not used. Ideas for improvements are outlined.

Keywords: Frequency counts, additivity, linked tables, search methods, minimum distance.

I. INTRODUCTION

1. Since July 1st 2002 Statistics Norway (SN) has offered statistical tables on the Internet through StatBank Norway (SBN) and from March 1st 2003 virtually every official statistic published by SN is disseminated through SBN.

2. The idea of SBN is to publish a large number of high-dimensional table matrices on a detailed geographical level for public use, allowing users to aggregate numbers from them according to their own needs. However, such detail raises confidentiality problems. It is considered undesirable that frequency table matrices reveal combinations of discrete variables that are (almost) population unique or situations where knowledge of some variable values associated with a statistical unit in a table makes it possible for some to derive its values on other variables. More specifically this means that counts like 1 and 2 should be avoided in the tables and uncertainty about whether a zero is actually a zero should be introduced. This problem, which has been encountered by many National Statistical Institutes (NSIs), has been handled in different ways in different countries, rounding being one of them.

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3. In particular, the tables from the Norwegian 2001 Census of Population and Housing are being published in SBN. The Census tables are spanned by two to five variables consisting of up to 450 cells each. These tables have been published for 434 municipalities, 52 urban districts and 19 counties, ranging in size from a population of 250 to 500 000. Another set of tables has been published for the nearly 14000 basic units. These tables have at most two variables and less detail than the municipality tables. The customers at the web are free to order any aggregations of the released tables or look at them in full detail.

4. To meet its intention with the present technology (which is based on PC-Axis), the tables released in SBN must have the same variables for every geographical unit and the same level of detail for all categorical variables. All tables are accessible at their most detailed level. They are released without margins. The margins are calculated in the process of meeting the users orders. This has consequences for what kind of table protection methods that can be applied. The English lanuage version of SBN is found at http://www.ssb.no/english/.

5. The decision to go for rounding as the method of confidentiality protection in the Census was taken in June 2002, only two months before the Census should start publishing and programming work started immediately. The method involved uses a search algorithm to find a sufficiently good solution. Because of the tight time schedule, only a very primitive search algorithm was employed. Intensive use of computers had to do the rest. It was an experiment with uncertain outcome. Nevertheless, allowing sufficient computer time, the results of the experiment were good enough to be accepted for use in publication. The Census tables released in SBN have since been rounded with this method and the results have encouraged us to go ahead and with more efficient search methods. The programming so far has been in SAS and SAS macro. Ultimately, when a sufficiently efficient search method has been developed and tested, we hope to implemented it into SuperCross which is the standard tool for future table production chosen by SN.

6. The next chapter discusses the kinds of confidentiality problems that occur with frequency tables. Chapter III gives a short review of existing methods and why we chose to make something of our own rather than using methods and software already available. Chapter IV describes the goals we set for the performance of our procedure and what we chose to sacrifice. Chapter V explains the method through an example. Chapter VI tells about the application of the method to the census. Chapter VII explains our ideas for improvement.

II DISCLOSURE IN FREQUENCY TABLES

7. There are essentially two kinds of confidentiality problems associated with frequency tables.

a. When, for some variable(s), only one category has a positive count on some combination of characteristics on all the others.
b. When the counts for some combinations of characteristics are very small, say one or two.

Case **a** constitutes an *attribute disclosure.* (Willenborg and de Waal 1996, 2000). It makes it possible for an *intruder* to disclose the value of the some variable(s) if the values of the other variables are known. Case **b** reveals combinations that represent population uniques and prepares the ground for a *identification disclosure*. The case where **b** occurs but not **a,** does not automatically imply an attribute disclosure since all attribute values in the table must be known to disclose the identity. However, if the count in case **a** is one (or two), both **a** and **b** occur. Population uniqueness (**b**) on a given set of variables is never the less often seen as potential threat to privacy. Identification disclosure in combination with external information, for instance a sample survey, can be the key to attribute disclosure and potential harm. This has led NSIs to take action to remove uniques from population tables. The gravity with which this point is considered is stressed by the fact that numerous papers have been written in search for methods to estimate the probability that a unique in a survey sample (microdata) is also a population unique. The (expected) number of population uniques is used as a measure of the over all disclosure risk in survey microdata (Bethlehem et al. 1990, Fienberg and Makov, 1996, 1998, Chen and Keller McNulty 1998, Skinner and Holmes 1998, Carlsson 2002).

III METHODS FOR PROTECTION OF FREQUENCY TABLES

8. National Statistical Institutes (NSIs) attack the problem with small counts in different ways. Some contries restrict the detail of the tables by using crude categorisations and few variables in published cross classifications. This method often means that the users' demand cannot be adequately met and therefore counters the very idea of StatBank Norway. Another very simple solution in use is to round all ones to 0 and twos to 3. This method can lead to bias. As pointed out in several of the papers mentioned at the end of paragraph 6, the distribution of the number of cells with a given count has a decreasing shape so that in sparse tables typically $\#(0) > \#(1) > \#(2) > \cdots$. Thus, this simple rounding method may lead to a downward bias which can be serious when a large number of cells are being aggregated. A third method being used is Unbiased Uncontrolled Random Rounding. UURC is typically an option in tabulation programs like SuperCross and Beyond2020 and therefore easy to use. It rounds every count, regardless of size, stochastically to a nearest multiplum of a base value (ususally 3) in such a way that the expected value of the rounded count is equal to the original count. The table marginals are rounded independently of the internal cells so that the rounded tables seize to be additive. UURC is useful and often satisfactory for tables that are published in a final form on paper or web. But since marginals in SBN are calculated in the process of meeting the users orders, UURC of elementary internal cells would lead to too large random rounding errors in aggregations. Cell suppression is a much used method which is also not compatible with the architechture of SBN. Moreover, cell suppression is primarily a method for magnitude tables. It is not a suitable method for frequency tables although sometimes used (Willenborg and de Waal 1996). Swapping of information for similar units in neighbouring areas is used by the American Factfinder. More details about this can be found on the Factfinders website.

9. There are other methods, some of which are available in software. The well known ARGUS software offers Controlled Rounding for two and three way tables. Like UUCR, CR essentially rounds every cell. The method of CR could in principle be applied to two and three way tables in StatBank Norway, but falls short for the tables of higher dimension. Furhermore, ARGUS does not run on UNIX which is the production platform for SN. Fienberg, Makov and Steel (1998) propose an advanced method of count swapping within frequency tables keeping margins intact. This is one of the most advanced methods that exist, but to our knowledge software for the method is not generally accessible. A drawback with the method is that it does not remove a 1 from a marginal but only moves it along its row or column within the table. The PRAM method proposed by Gouweleeuw et al. (1998) is interesting. However, it requires a decision for some variables to be declared sensitive and that a Markov transition matrix for perturbation of the variable values for these variables is decided upon. There are several problems using this method that are also mentioned in the paper of Gouweleeuw et al. and which will not be repeated here. PRAM and many other methods require extra information to be communicated to the users to guide them in a correct understanding of how the tables should be interpreted. This is undesirable although not completely avoidable in the public use context of SBN.

IV DEMANDS AND SACRIFICES

10. To meet the needs of SBN and for the rounded tables to be suitable for publication they should meet some goals and standards.

a. *The rounded tables must be additive*. This is automatically satisfied in SBN since marginal tables are calculated from the base tables in the process of answering a request.
b. *No more cells should be rounded than are necessary to make the tables confidentially safe*. This means that only counts less than an integer base b (usually 3) should be rounded to 0 or b, not

all cells as is common for the rounding procedures mentioned in chapter III. The purpose of this requirement is to reduce the size of the problem and to facilitate goal c.

c. *Search for solutions minimising a distance between the rounded and the original tables.* This means that roundings should cancel each other as much as possible at aggregate levels. This is important in CR, but not in UUCR. A metric to measure the distance must be chosen. Our metric of choice is the maximum absolute difference between the rounded and original cell counts in a set of marginals specified to the program. This measure is rather crude. Therefore, among solutions with the same maximum absolute difference, the program will prefer solutions that minimise the number of occurences.
d. *Common marginals in linked tables should be rounded consistently*. The program can handle this, but often to the price of higly increased computing time and larger distances between rounded and original tables. For most of the census tables this goal had to be abandoned to manage running through them in time without unacceptably large deviations. The occurrence of diverging counts for the same marginals calls for an explanation to the users and inflicts somewhat reduced disclosure protection where visibly a count has been rounded to zero in one table but to three in another.
e. *No counts less than the rounding base b should occur in the rounded tables*. At aggregate levels, the rounding method affects other counts than those actually in need for rounding. We call this *secondary perturbations*. With base 3, this means that a cell count of 3 or 4 may well be perturbed to 1 or 2. However, 1 and 2 in the rounded table will never occur in cells that were 1 and 2 in the original table. Such 1's and 2's therefore do not compromise confidentiality if the user is aware that 1 and 2 actually means "at least 3". A user who is not aware of this can be mislead to believe that the counts are real and draw wrong conclusions concerning population uniqueness and the confidentiality measures used. It is to avoid such misconceptions that this goal is desirable. In the version of the program used for the census, this goal was not given priority. However, such secondary small counts can be removed either by running the rounded table through the rounding program once more or by altering some spesifications for the program.

11. Traditionally, disclosure control metods for tables have focused upon preserving the table marginals unless they themselves present a disclosure risk. To avoid backtracing of the original cell values, methods for cell suppression uses secondary suppression. Rounding methods cannot avoid affecting marginals. Therefore, to avoid excessive differences between rounded and original marginals, uncontrolled rounding rounds marginals independently of internal cells and abandons additivity. Controlled rounding, the method of ARGUS, is not guaranteed to exist for more than two-way tables although it often works for three-way tables as well. The method presented here relaxes these tight restrictions somewhat by replacing them with item c above.

V DESCRIPTION OF THE METHOD

12. The description will be given by an example. The example is real, but not from the Census 2001. The original table and a rounded version are presented in the appendix. Assume we have six categorical variables which we for short call **V1, …, V6**. They span a six-way table and we want to publish six two-way marginals from this table and round them in a consistent manner. In SAS macro language the six variables and the rounding base are specified by specifying their joint table:

```
%LET BASETAB=V1*V2*V3*V4*V5*V6;
%LET BASE=3;
```

The linking pattern of the six two-way tables to be published and from which we want to remove 1 and 2 is shown in table 1. The pattern is specified to the program with

```
%LET TABLES=V2*V1 V3*V1 V4*V1 V6*V1 V6*V3 V6*V5;
```

There were 450 cells in the six two-way marginals and 56 cells in the one-way marginals. The six-way table contained 559872 cells of which 2591 cells were filled with 7491 households. Among the 450 two-way cells, 44 were zeroes, 30 were ones and 23 were twos, making up $t = 76$ households.

Variables	V1(8)	V2(12)	V3(6)	V4(9)	V5(12)
V2(12)	x				
V3(6)	x				
V4(9)	x				
V5(12)					
V6(9)	x		x		x

Table 1 A linking pattern for 6 two-way tables based on 6 variables. Number of categories are in parentheses.

13. In order to manage requirement d, consistency, rounding had to take place inside the six-way table. To minimise the amount of rounding nesseccary, the table was reduced. The 30 ones and 23 twos in the six two-way tables were aggregates from altogether 60 cells in the basic six-way table containing 44 ones and 16 twos. Only these 60 cells were rounded, using base $b = 3$. In order to control the rounding error induced on the table total, exactly $[t/b] = 25$ cells were rounded to 3. 35 cells were rounded to zero. Thus, for the rounded total, $t^* = [t/b]b = 75$. The 25 cells to be rounded up were drawn as a probability sample without replacement where in each sample the twos had twice the probability of the ones for being rounded up.

14. The distance between the original table **X** and the rounded table **Y** was calculated as the maximum difference between a rounded and unrounded cell counts in a specified set *S* of marginals. The marginals of choice for this example are those to be published, all six two way marginals and the six one.way marginals. *S* was specified to the program with

```
%LET CONTROL=V1 V2 V3 V4 V5 V6 V2*V1 V3*V1 V4*V1 V6*V1 V6*V3 V6*V5;
```

Let x_c, y_c be the cell count of cell c in the original and the rounded table respectively. The distance between the two tables is then defined as

$$d(\mathbf{X}, \mathbf{Y}) = \max_{c \in S} |y_c - x_c|$$

It is sufficient to calculate the marginals in S and $d(\mathbf{X}, \mathbf{Y})$ based on the reduced six-way table (60 cells) rather than all the populated cells (2591). This significantly reduces the amount of computing.

15. The algorithm continues by repeating the procedures described in paragraph 13 and 14 until a given stopping criterion is met. This generates a sequence of solutions $\mathbf{Y}_1, \mathbf{Y}_2, \mathbf{Y}_3, \ldots$ and the solutions with the smallest *d* is preferred. To distinguish between solutions with the same *d*, the number of occurences of d in the table, $n_d = \#(d)$ is counted. The solution with the smallest n_d is chosen.

16. This random search is primitive, but given enough computer time it can reach any possible solution. In this actual example there are $\binom{60}{25} \approx 5{,}19 \cdot 10^{16}$ possible solutions and for this example we ran through a sample of 10000 of them. Finding an optimal solution is a *Np*-hard problem (Fischetti and Salazar-Gonzalez 1998, Kelley et al. 1990), meaning that there is no short cut to the best solution. For problems with two and three variables the methods of ARGUS would offer the best available solu-

tions. Systematic search algorithms that can be applied to higher dimensional tables exist and will be implemented. See Chapter VII.

17. The random search method can be reasonably efficient in the beginning, but as improved solutions are found the expected number of new iterations needed to find a further improvement increases rapidly. The waiting time from an improvement to the next is negative binomial with a decreasing success probability at each improvement. In a sample run of 10000 iterations, the improvemnts came as shown in table 2.

Iterations	1	4	7	16	32	43	111	1885
(d, n_d)	(9, 1)	(8, 1)	(7, 2)	(6, 4)	(6, 2)	(6, 1)	(5, 3)	(5, 1)

Table 2: Improvements in d and #(d) in a sample run of 10000.

The realised distribution of deviations from this sample run in one and two way marginals is given in table 3.

$y_c - x_c$	-5	-4	-3	-2	-1	0	1	2	3	4
$\#(y_c - x_c)$ in one-way cells	0	2	6	9	7	7	9	9	6	0
$\#(y_c - x_c)$ in two-way cells	1	0	5	17	78	262	54	29	2	2

Table 3: Distribution of differences in one and two-way cells.

Table 3 implies a standard rounding deviation of approximately 2 across all one-way cells and 1 across all two-way cells. Such average measures of deviations can be submitted to the users along with the rounded tables to describe the uncertainty imposed by the rounding. Perturbation of counts 3 and 4 to counts 2 occurred in three cells.

VI ROUNDING IN THE CENSUS

18. The application of the rounding procedure in the census was seen as a experiment. The method had never been tested on any data of similar size and detail.The rounded figures would be used for publication if the method proved to be successful in the sense that the rounded tables did not deviate too much from the original counts.

19. The dissemination of tables from the housing part of the census consisted of 26 tables ranging in size from two to five variables and 12 to 450 cells. All cells with one and two at the most detailed level were rounded. In this case no new (secondary) ones and twos can occur. As already mentioned in paragraph 3, these tables were published for 434 municipalities, 52 urban districts and 19 counties, ranging in size from a population of 250 to 500 000. For the smallest tables there were few counts that had to be dealt with. Table 4 shows an overview of the tables. Tables with the same background colour have the same combination of units. Red crosses marks variables that link tables. There are several links. We had hoped to round the linked tables jointly as was done in the example in chapter V, but the available computing time did not allow it. For each table a minimum and maximum number of iterations (searches) permitted for the rounding procedure was set for each matrix, (**MINIT,MAXIT**). If, for a municipality, a maximum deviation less than or equal to a prescribed value **MAXDIFF** was achieved within **MINIT** iterations, the procedure stopped and went to the next municiplity. Otherwise it continues with new iterations until **MAXDIFF** was achieved or until **MAXIT** iterations. **MINIT** allows a minimum number of iterations even if **MAXDIFF** is achieved in hope of finding even better solutions. **MAXDIFF** was set to 4 for all tables and municipalities. (**MINIT, MAXIT**) ranged from (50, 200) for the smallest tables to (400, 2000) in the largest.

20. The largest deviations between rounded and original cell counts in any aggregated cell at any aggregation level in any of the 434 municipalities ranged from 2 in ten of the 26 tables which effectively is as good as controlled rounding, to 6 in table 1 and 2. The deviation 6 occurred in one cell in one municipality for each of the two tables.

VII IMPROVEMENTS OF THE PROCEDURE

21. The rounding procedure can be improved significantly by using systematic instead of only random search. Some main features of the procedure, like the controlled selection with a fixed number of uproundings (to *b*) and downroundings (to 0), will be retained. The present random search algorithm or some restriction of it thought to be close to good solutions can be applied to find start values for a systematic search. To keep the number of up and down roundings controlled, the search will be based on swapping of zeroes and *b*s in the rounded reduced elementary table with all variables included. Then there are two goals for this search procedure.

a. Remove secondary perturbations that produce new counts less than *b*. There exist situations where it is not possible within the swapping framework to remove all counts less than *b* without creating new ones.
b. Minimise the largest absolute deviations while controlling for a. In each swap an uprounding contributing to the largest positive deviation will be swapped with a downrounding contributing to the largest negative deviation. Among candidate couples, one that when swapped does not generate equally large or larger extremes in other cells belonging to *S* (see paragraph 14) is chosen.

The process in b is iterated until no further improvement can be reached. If the maximum deviation in *S*, *d*, is small enough, the solution is accepted and the search stops. If not, a new random start value can be selected for a new search.

22. Before a search is initiated, stopping criteria (**`MAXDIFF`**, **`MAXIT`**) must be set. For this purpose it would be desirable to know in advance how small maximal deviations can be realistically obtained. Some theorem that allows a calculation of how small deviations are at least obtainable would be useful.

VIII DISCUSSON

23. Statistics Norway has found the described rounding method promising as a confidentiality measure for frequency tables and has applied the method in the publication of the Census 2001 in SBN. SN will follow up the method with implementation and testing of the proposed improvements. If successful, the method will be approved as the standard for frequency count tables in SBN and will, as far as possible, be integrated into our standard software for table production. Proposals for improvement of the suggested procedure will be welcomed.

Table Table 4. Summary of tables published for the Housing Census in SBN

Table number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
	Dwelling/dwelling				Dwelling/-household		Household/ dwelling						Person/ dwelling												Housh/-dwelling	
Construction year short (3 categories)								x					x								x					
Construction year long (9 categories)		x																								
Cat. of building (5)	x	x		x				x					x						x							
Number of rooms (5)						x																				
Number of rooms/kitchen (9)				x											x			x		x						x
Utility floor space long (12)	x																									
Utility floor space short (5)						x																				
Tenure status short (2)					x																					
Tenure status medium (3)									x															x		
Tenure status long (7)	x						x							x			x								x	
Heating systems (10)		x																				x				
Wheel chair accessibility, dwelling (2)			x							x						x							x			
Wheel chair accessibility, rooms (2)			x																				x			
Floors/lift (6)			x						x														x			
Sanitary (3)			x													x										
Garden (3)										x																
Balcony, veranda, terrace (2)										x																
Garage/carport/parking space (3)											x	x														
Number of cars (3)											x	x														
Occupants in dwelling (5)						x																				
Age of oldest occupant (6)					x			x	x	x	x															
Kind of household I (6)												x					x	x							x	x
Elderly household (4)																			x	x	x	x	x	x		
Children/not children (2)								x	x	x	x															
Kind of household II (9)							x																			
Age (7)													x	x	x	x										
# cells	420	450	72	45	12	125	63	180	216	144	108	54	105	49	63	42	42	54	20	36	12	40	96	12	42	54
# variables	3	3	4	2	2	3	2	4	4	5	4	3	3	2	2	3	2	2	2	2	2	2	4	2	2	2

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APPENDIX UNROUNDED AND ROUNDED EXAMPLE TABLE FROM CHAPTER V.

Table A.1.[2]

Utility floor space	Total	Tenure status Home-owner	Coop/-Association	Private Hire	Hiress from assoc	Muni-cipal hire	Hires trough work	Others	Not reported
Total	7 491 ? 7 490	5 645 ? 5 648	198 ? 200	681 ? 683	51 ? 50	360 ? 357	82 ? 80	346 ? 345	128 ? 127
< 25 Sqm	41 ? 39	3	-	8	2 ? -	9	3	12	4
25-49	162 ? 160	10	1 ? -	55	15	55	3	19 ? 18	4
50-74	924	294	68	216 ? 217	23 ? 22	198 ? 199	22	66	37 ? 36
75-99	1 831 ? 1 828	1 332 ? 1 331	90 ? 92	183	8 ? 7	72 ? 70	13	87 ? 86	46
100-124	1 736	1 502	22 ? 21	107	-	15 ? 14	14 ? 16	63	13
125-149	1 127 ? 1 128	1 012 ? 1 013	7	56	-	2 ? 3	9 ? 8	34	7
150-174	711 ? 712	639 ? 641	4 ? 3	27	-	1 ? -	7	31	2 ? 3
175-199	357 ? 360	321 ? 323	1 ? 3	11	2 ? 3	1 ? -	1 ? -	13	7
200-224	211	193	-	5	-	2 ? 3	5	5	1 ? -
225-249	146	131	2 ? 3	6	-	1 ? -	1 ? -	3	2 ? 3
250-274	84 ? 86	74	3	2 ? 3	-	-	2 ? 3	2 ? 3	1 ? -
275 eller mer	161 ? 160	134 ? 133	-	5	1 ? 3	4	2 ? -	11	4

Table A.2

Type of building									
	7 491 ? 7 490	5 645 ? 5 648	198 ? 200	681 ? 683	51 ? 50	360 ? 357	82 ? 80	346 ? 345	128 ? 127
Detached house or farm house	5 769 ? 5 766	4 936 ? 4 940	11 ? 12	437 ? 436	13 ? 14	32 ? 27	33 ? 32	226	81 ? 79
Linked house, row house, terraced house or vertically divided two-dwelling building	440 ? 439	241 ? 240	51 ? 52	39	13 ? 12	42 ? 43	7 ? 6	38	9
Horizontally divided two-dwelling building or other house with less than 3 floors	298 ? 299	147	-	76 ? 77	4	49	3	11	8
Block of flats, or other building with 3 or more floors	199 ? 202	11	120 ? 121	1 ? 3	6	29	19	7	6
Commercial building etc. or residential building for communities	416 ? 418	45	16 ? 15	67	13 ? 14	207 ? 209	15	41	12
Not reported	369 ? 366	265	-	61	2 ? -	1 ? -	5	23 ? 22	12 ? 13

[2] Original counts are in black, rounded counts are in red. Deviation ±4 has yellow bacground, –5 has green background.

Tabell A.3

Type of household	Total	Tenure status: Home-owner	Coop/-Associ-ation	Private Hire	Hiress from assoc	Muni-cipal hire	Hires trough work[3]	Others	Not reported
Total	7 491 ? 7 490	5 645 ? 5 648	198 ? 200	681 ? 683	51 ? 50	360 ? 357	82 ? 80	346 ? 345	128 ? 127
Single person	2 202	1 202 ? 1 203	112 ? 113	294 ? 296	35 ? 32	270	27 ? 26	189	73
Couple without children living at home.	1 974 ? 1 971	1 671	29 ? 32	124 ? 123	12 ? 9	25 ? 24	4 ? 2	79	30 ? 31
Couple with small children (Youngest child 0-5 years)	742	636	15	47	1 ? 3	11 ? 10	20 ? 19	7	5
Couple with large children (Youngest child 6-17 år)	939 ? 942	851 ? 855	8	38	1 ? 3	14 ? 13	15 ? 14	9	3 ? 5
Mother/father with small children (Youngest 0-5 years)	119 ? 121	62	-	37	2 ? 3	10 ? 11	-	4	4
Mother/father with large children (Youngest 6-17 years)	269 ? 268	166	9	61	-	16 ? 15	-	17	-
One family households with adult children (Yongest child 18 years or more)	833 ? 831	745 ? 743	17	30	-	5	9 ? 11	14 ? 13	13 ? 12
Multiple family households with children 0-17 years	253 ? 255	192	6	33 ? 34	-	5	2 ? 3	15	-
Multiple family households without children 0-17 years	160 ? 158	120	2 ? -	17	-	4	5	12	-

Tabell A.4.

Type of building	Total	Year of construction: -1920	1921-1940	1941-1945	1946-1960	1961-1980[4]	1981-1990	1991-2000	Vet ikke
Total	7 491 ? 7 490	1 018 ? 1 014	391 ? 392	53 ? 54	1 414 ? 1 415	2 633	832 ? 831	845 ? 846	305
Detached house or farm house	5 769 ? 5 766	860 ? 857	323	49 ? 51	1 197 ? 1 198	2 171 ? 2 170	678	365 ? 366	126 ? 123
Linked house, row house, terraced house or vertically divided two-dwelling building	440 ? 439	18	11 ? 12	1 ? -	36	180 ? 181	43 ? 42	137 ? 136	14
Horizontally divided two-dwelling building or other house with less than 3 floors	298 ? 299	30	9	-	53	53	17	91	45 ? 46
Block of flats, or other building with 3 or more floors	199 ? 202	2 ? 3	-	-	-	80 ? 81	48	45	24 ? 25
Commercial building etc. or residential building for communities	416 ? 418	36	8	-	31	52	27	194 ? 195	68 ? 69
Not reported	369 ? 366	72 ? 70	40	3	97	97 ? 96	19	13	28

[3] Grey background shows roundings to less than three.

[4] Years 1961-80 was rounded as two categories, 1961-70 and 1971-80. One 0, one 1 and two 2s are hidden.

Tabell A.5.

Tenure status	Total	Year of construction -1920	1921-1940[3]	1941-1945	1946-1960	1961-1980[4]	1981-1990	1991-2000	Not reported
Total	7 491 **? 7 490**	1 018 **? 1 014**	391 **? 392**	53 **? 54**	1 414 **? 1 415**	2 633	832 **? 831**	845 **? 846**	305
Home owner	5 645 **? 5 648**	738	315	49 **? 51**	1 194	2 151 **? 2 153**	641 **? 640**	530	27
Cooperation/-Association	198 **? 200**	12 **? 14**	-	-	-	99	42 **? 41**	43	2 **? 3**
Private Hire	681 **? 683**	122	48	3	133	135 **? 137**	42	47 **? 46**	151 **? 152**
Hiress from cooperation/ association/ housing company	51 **? 50**	1 **? -**	1 **? 3**	-	6 **? 8**	15 **? 12**	6	11	11 **? 10**
Municipal hire	360 **? 357**	21 **? 18**	4 **? 5**	-	10 **? 9**	75	40 **? 39**	163 **? 164**	47
Hires trough work	82 **? 80**	22 **? 21**	3 **? 2**	-	5	27	8	2 **? 3**	15 **? 14**
Others	346 **? 345**	75	17	1 **? -**	50	96	37	32	38
Not reported	128 **? 127**	27 **? 26**	3 **? 2**	-	16	35 **? 34**	16 **? 18**	17	14

Table A.6
Source of heating

Source of heating	Total	-1920	1921-1940	1941-1945	1946-1960	1961-1980	1981-1990	1991-2000	Not reported
Total	7 491 **? 7 490**	1 018 **? 1 014**	391 **? 392**	53 **? 54**	1 414 **? 1 415**	2 633	832 **? 831**	845 **? 846**	305
Electric	881 **? 884**	34 **? 35**	14	1 **? 3**	43	199	138 **? 136**	340 **? 342**	112
Radiators	192 **? 194**	17	3	2 **? 3**	28 **? 30**	98	5	14 **? 13**	25
Solid fuel	197 **? 195**	43 **? 42**	14	4 **? 3**	53	59	13	5	6
Liquid fuel	94 **? 91**	24	1 **? -**	2 **? 3**	19	42 **? 40**	1 **? -**	-	5
Heat pump	4 **? 6**	1 **? -**	-	-	-	1 **? 3**	1 **? 3**	1 **? -**	-
Others	14 **? 10**	2 **? -**	-	-	4	3	2 **? -**	2 **? 3**	1 **? -**
Electric and solid fuel	2 733 **? 2 734**	417 **? 416**	159	20	488 **? 487**	733 **? 735**	458 **? 460**	361	97 **? 96**
Electric and liquid fuel	517 **? 520**	66 **? 68**	23 **? 24**	6	118	265	21	10	8
Solid and liquid fuel	111	18	8	-	51	27	4	-	3
Electric, solid and liquid fuel	1 185 **? 1 183**	147 **? 145**	94	6 **? 5**	325	503	70	27	13 **? 14**
Radiatorers in combination	471 **? 469**	65 **? 64**	23 **? 24**	1 **? -**	86	207 **? 205**	28	49	12 **? 13**
Other combinations	1 092 **? 1 093**	184 **? 185**	52	11	199	496	91	36	23

[3] Grey background shows roundings to less than three.
[4] Years 1961-80 was rounded as two categories, 1961-70 and 1971-80. One 0, one 1 and two 2s are hidden.