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Application of selected ideas from statistical overlapping samples theory to tendency surveys: Designed panel vs resulting overlapping samples

Abstract

Most tendency surveys are organized to be based on a fixed sample of units across time. This fixed panel constitutes a designed sample. But in practice the resulting sample always differs from the designed one, sometimes quite considerably. In tendency surveys, like in all real surveys, some sampled units refuse to participate, some agree to cooperate but forgo several periods later, some respond irregularly. Consequently, the resulting samples across time never constitute a perfect panel, they form an overlapping sample pattern. In the paper we propose a formula for adjusted balance statistics that takes into account distortion of a sample. The main idea of adjusted balance statistics is analogous to estimators known from statistical overlapping samples theory. Theoretical part of the paper is extended by empirical analysis of monthly business tendency survey data. In particular, the response pattern is studied and comparison of original and adjusted balance statistics is conducted.

Keywords: overlapping samples, repeated surveys, business tendency surveys, balance statistics

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1. Introduction

Most tendency surveys are organized to be based on a fixed sample of units across time. This fixed panel of respondents constitute a designed sample. Using a panel has many advantages. It increases efficiency of net changes estimation (see e.g. *Panel surveys*, 1989; *Sample surveys*, 2009) and allows for better cooperation with the enterprises during successive periods of time (see e.g. OECD, 2003).

Although a designed sample is usually a panel, the resulting one is typically not. In almost all surveys a designed sample and resulting sample differs from each other, sometimes quite considerably. Analogously, resulting samples differ from each other across time. This is mainly due to nonresponse. There is an extensive literature as far as nonresponse is considered (see e.g. Groves *et al.*, 2002; Little & Rubin, 2002; Longford, 2005) but majority of it refers to various theoretical issues. Measuring the real impact of nonresponse on obtained results in particular surveys is extremely difficult.

The present paper refers directly to nonresponse problems in tendency surveys, in particular, to the changing structure of a sample across time due to a variable under a study. The structure of a sample can also change as far as NACE classification or companies' size are concerned. But both NACE classification and companies' size constitute attributes of respondents, and earlier empirical studies have shown that changes in the structure of these attributes do not seem to influence tendency surveys results (see e.g. Tomczyk & Kowalczyk, 2010; Kowalczyk & Witkowski, 2011). It is common statistical knowledge that nonresponse dependent on a variable under a study is the most dangerous one for survey results. Some more theoretical problems, different from the ones studied in the present paper, connected with not-missing-at-random nonresponse type in tendency surveys were also analyzed in Kowalczyk & Tomczyk (2011) and Seiler (2012).

In tendency surveys some sampled reporting units refuse to participate, some agree to cooperate but forgo several periods later, some respond irregularly and their response frequency depends on their internal problems, condition, memory, leaves, personal changes etc. Consequently, the resulting samples across time almost never constitute a panel. They form an overlapping sample pattern.

Technically, an overlapping sample pattern can be illustrated as follows: some respondents who gave answers in a previous period t - 1 also participate in a survey in the current month t and some do not. Or in other way: in every time period t there are respondents in the resulting sample who also gave their answers in a previous t - 1 period and there are respondents who did not.

So, the samples S_{t-1} and S_t from two successive periods, t - 1 and t, respectively, can be divided into different subsamples: a matched subsample S_M, that is a subsample of those respondents who gave their answers in both periods, and unmatched subsamples, S_{t-1U} and S_{tU}, respectively, that is subsamples of those respondents who gave their answers only in one period, either t - 1 or t , which can be illustrated as below:

S_{t-1U}	S_M	
	S_M	S_{tU}

We have respectively:

$$S_{t-1} = S_{t-1U} \cup S_M$$

and

$$S_t = S_M \cup S_{tU}.$$

Now let us analyze some hypothetical numerical examples and then state an important problem for resulting overlapping samples in the context of tendency surveys.

Let n_{t-1} denote the number of respondents who returned[1] their questionnaires in period t – 1, and let n_t denote the number of respondents who returned their questionnaires in period t, respectively. Let us say, for instance, that the coverage of the samples for two successive periods is 80%. Let’s further say that about 79% of respondents who reported improvement in a previous period also gave their answers in a current survey, and that about 81% of respondents who reported worsening in a previous period gave their answers in the current survey. Transition of respondents from one period to another seems to be random in this case and the difference between these 79% and 81% seems to be negligible. This reasoning can be also supported for real data by a proper statistical test.

But what if the situation looks differently? What if, for instance, only about 60% of respondents who reported improvement in a previous period also gave their answers in a current survey and up to 95% of respondents who reported worsening in a previous period gave their answers in a current

[1] More precisely, the questionnaire was returned and the question under the study was answered.

survey? In this case the sample from a previous period and its subsample of respondents who continued to participate in the survey differs substantially as far as variable under the study is concerned. So, an important question arises. Is balance statistics for the current period distorted because of the fact that the sample is biased, that is because of the fact that substantially more companies that reported worsening continued to give their answers in the current occasion compared to those that reported improvement? And the other question. Can we compare two balances for successive periods if they refer to completely different samples, i.e. if the matched subsample substantially differs from the sample from previous occasion as far as the variable under the study is concerned?

Let us examine the issue in more detail. Let us assume for a moment that the sample size in period *t* - 1 is n_{t-1} = 500. Assume further that exactly 200 out of these 500 respondents reported increase (above normal), 100 reported decrease (below normal) and 200 reported normal situation (no change) in period *t* - 1. Difference between the percentage of respondents who reported improvement and those who reported worsening, i.e. the balance statistics for period *t* - 1 is equal in this case to:

$$B_{t-1} = 100 \cdot \left(\frac{200}{500} - \frac{100}{500}\right) = 20.$$

Let us study now three different hypothetical cases. Let us assume that in all three cases 80% of respondents from period *t* - 1 also gave their answers in period *t*, that is the matched subsample consists of 0.8×500 = 400 respondents.

Case 1. Let assume that the distribution of the matched respondents was approximately random, so 79% of those who reported improvement in period *t* - 1 also gave their answers in period *t*, and 81% of those who reported worsening in period *t* - 1 also gave their answers in period *t*. The matched part of the sample consists then of 158 respondents who reported improvement in period *t* - 1, 81 respondents who reported worsening and 161 respondents who reported no change. The balance statistics obtained on the basis of the matched subsample is equal in this case to:

$$B_{t-1M} = 100 \cdot \left(\frac{158}{400} - \frac{81}{400}\right) = 19.25.$$

Case 2. Let us assume that the distribution of the matched respondents is not proportional. Let us assume that 70% of those who reported improvement in period t - 1 also gave their answers in the next period, and 90% of those who reported worsening in period t - 1 also gave their answers in period t. The matched part of the sample consists in this case of 140 respondents who reported improvement in period t - 1, 90 respondents who reported worsening and 170 respondents who reported no change. The balance obtained on the basis of the matched subsample is equal to:

$$B_{t-1M} = 100 \cdot \left(\frac{140}{400} - \frac{90}{400}\right) = 12.5.$$

Case 3. Let us assume that the distribution of the matched respondents is not proportional. Assume now that only 60% of those who reported improvement in period t - 1 also gave their answers in period t, and 95% of those who reported worsening in period t - 1 also gave their answers in period t. The matched part of the sample consists in this case of 120 respondents who reported improvement in period t - 1, 95 respondents who reported worsening and 185 respondents who reported no change. The balance obtained on the basis of the matched subsample is equal in this case to:

$$B_{t-1M} = 100 \cdot \left(\frac{120}{400} - \frac{95}{400}\right) = 6.25.$$

We have three different hypothetical cases here. In each case the balance statistics obtained on the basis of the whole sample from period t - 1 is equal to 20 but the balances obtained on the matched part of the sample differs widely. By comparing this cases it is clear that the subsample of respondents who continue to answer in the next period can be seriously biased, and hence the sample for period t can also be biased. Hypothetically, we can imagine even an extreme scenario when only those respondents who reported a decrease in period t - 1 continue to answer in period t, and none of those who reported an increase in period t - 1 takes part in the survey in the next period. Fortunately, this extreme scenario doesn't happen in real surveys. Nevertheless when respondents who reported an increase or a decrease in period t - 1 do not tend to participate in the survey in the next period t with approximately the same frequencies we can surmise the sample to be biased.

2. Overlapping (rotating) samples theory

Problems related to overlapping samples can be found in statistical theory. Various composite estimators based on overlapping (rotating) samples that use information also from previous surveys are known in literature. Rotating surveys constitute an established branch of statistical science. First concepts of improving efficiency of the estimation for the current period in surveys based on overlapping samples were introduced by Jessen (1942). He suggested to use information not only from the current sample but also from the sample from a previous period in the case of overlapping samples.

The estimator of the population mean for the second period proposed by Jessen (1942) is of the form:

$$e_2 = Q\bar{y}_{2U} + (1 - Q)\bar{y}_{2M}^*,$$

where

$$\bar{y}_{2M}^* = \bar{y}_{2M} + b(\bar{y}_1 - \bar{y}_{1M}).$$

Notation used here is the following:

- Q and 1 - Q are coefficients of the linear combination;
- b is the regression coefficient between the variable under the study on the second and first occasions;
- $\bar{y}_{2U}$ and $\bar{y}_{2M}$ are sample means on the second occasion based on the unmatched and matched part of the sample, respectively;
- $\bar{y}_{1M}$ and $\bar{y}_1$ are sample means on the first occasion based on the matched part of the sample and on the whole sample from the first period, respectively.

So the estimator proposed by Jessen is the convex linear combination of two estimators: one based on the unmatched part of the sample from second period, which is a common sample mean $\bar{y}_{2U}$, and an estimator based on the matched part of the sample, which is the so called two-phase regression estimator $\bar{y}_{2M}^*$ incorporating information not only from the sample on the current occasion but also from the first occasion. The heuristic idea supporting this type of estimator is the following. If two sample means $\bar{y}_1$ and $\bar{y}_{1M}$ on the first occasion based on the whole sample from period one ($\bar{y}_1$), and based only on the matched part of the sample from period one ($\bar{y}_{1M}$) differ substantially, then it is highly probable that $\bar{y}_{2M}$ is also distorted. As we believe that $\bar{y}_1$ is more reliable than $\bar{y}_{1M}$, because $\bar{y}_1$ is based on the whole sample while $\bar{y}_{1M}$ only on its part, thus the reliability of $\bar{y}_{2M}$ can be increased (and hence reliability of the final estimator using the matched and unmatched part) by adjusting to the differences between $\bar{y}_1$ and $\bar{y}_{1M}$, and using regression estimation.

Jessen did not supply any mathematical theory to support his suggestions. But subsequent works by e.g. Yates (1949) and Hansen *et al*. (1953) have mathematically confirmed this first heuristic idea. Since that time mathematical theory devoted to rotating surveys has grown substantially.

One of the most influential paper was presented by Patterson (1950). He delivered a recursive formula for the best linear unbiased estimator (BLUE) for the current occasion based on rotating samples on h occasions, $h \geq 2$ under the so called Patterson's rotation pattern. BLUE estimator provided by Patterson (1950) is of the form:

$$e_h = c_h \bar{y}_{hU} + (1 - c_h)[\bar{y}_{hM} + \rho(e_{h-1} - \bar{y}'_{h-1M})],$$

where

$$1 - c_h = \frac{p}{1 - \rho^2(q - c_{h-1}p)},$$

and

$$c_1 = q,\ e_1 = \bar{y}_1.$$

By $\bar{y}_{hU}$ we note the sample mean on occasion h based on the part of the sample that has not been examined on the previous occasion, $\bar{y}_{hM}$ denote the sample mean on occasion h based on the part of the sample that has also been examined on the previous occasion, $\bar{y}'_{h-1M}$ denotes the sample mean on occasion h - 1 based on the part of the sample that has passed to examination on occasion h.

We denote here the sample size on each occasion[2] equal to n, p is the matched fraction, i.e. $n_M = np$, and q is the unmatched fraction of the sample, i.e. $n_U = nq$.

The variance of the estimator is of the recursive form:

$$D^2(e_h) = c_h \frac{\sigma^2}{nq}.$$

One practical problem that arises with a powerful theoretical Patterson's result is that formula for the coefficients of linear combination in the definition of the estimator involves knowledge of the correlation coefficient between the variable under a study in successive periods, which is usually unknown. Another serious restrictions in practice comes from strict model assumptions and specific rotating pattern[3]. It is worth to mention that although mathematically the Patterson's result is much more advanced, the basic idea under the proposed estimator is similar to the Jessen's simplified estimator. It still can be presented as a liner convex combination of two

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[2] Results obtained for equal sample sizes on each occasion can be easily generalized to the unequal sample sizes case.

[3] For detailed examination of rotating pattern and assumptions involved see Patterson (1950).

estimators: those based on the unmatched part of the sample (common mean) and matched part of the sample (recursive regression type estimator).

Many authors have continued studies on different aspects of rotating surveys. It has included different rotating schemes (e.g. Kowalski, 2009; Wesołowski, 2010), composite estimators (e.g. Rao & Graham, 1964; Ciepiela *et al*., 2012), different variables under study (e.g. Okafor & Arnab 1987; Kowalczyk, 2003), different theoretical approaches (Scott & Smith, 1974; Binder & Hidiroglou, 1988) and various particular problems connected with rotating samples (e.g. Holt & Farver, 1992; Park *et al*., 2001; Zou *et al*., 2002; Steel, 2004; Berger, 2004; Kim *et al*., 2005; Steel && McLaren, 2009; Nedyalkova *et al*., 2009; Degras, 2012; Kowalczyk, 2013). Special attention in literature is also devoted to particular surveys designed as overlapping samples, like Household Budget Surveys and Labour Force Surveys (see e.g. Bell, 2001; Fuller & Rao, 2001; Gambino *et al*., 2001; Betti & Verma, 2007; Gagliardi *et al*., 2009; Wesołowski, 2010; Kordos, 2012).

Now, following Kowalczyk (2013), let us present a ratio-type estimator of the population mean on the current occasion based on rotating survey:

$$e_{t+1} = q \cdot \bar{y}_{t+1U} + p \cdot \frac{\bar{y}_{t+1M} \cdot \bar{y}_t}{\bar{y}_{tM}}.$$

For finite population of N elements and simple random sampling without replacement, MSE of the estimator is given by an approximate formula:

$$MSE(e_{t+1}) \approx \left(\frac{1}{n}(1 - pq\nabla) - \frac{1}{N}\right) S^2(Y_{t+1}),$$

where

$$\nabla = 2\frac{V(Y_t)}{V(Y_{t+1})}\rho(Y_t, Y_{t+1}) - \frac{V^2(Y_t)}{V^2(Y_{t+1})},$$

and:

- $V(Y_t)$ and $V(Y_{t+1})$ are the coefficients of variation of the variable under the study in specified periods,
- t corresponds here to the first (basic) occasion, $t + 1$ corresponds to the next (second) occasion,
- n is a sample size (assumed equal), p is the matched fraction of the sample, i.e. $n_M = np$, and q is the unmatched fraction of the sample, i.e. $n_U = nq$.

MSE for the estimator have been derived assuming the same sample sizes but the form of the estimator can be of course generalized to the formula:

$$e_{t+1} = \frac{n_{t+1U}}{n_{t+1}} \cdot \bar{y}_{t+1U} + \frac{n_{t+1M}}{n_{t+1}} \cdot \frac{\bar{y}_{t+1M} \cdot \bar{y}_t}{\bar{y}_{tM}}.$$

Let us notice that the idea of this estimator is very similar to the idea justifying the estimators presented earlier. It is a convex linear combination of two estimators. But this time the second one is the ratio-type estimator. Its main practical advantage is that it has relatively a simple form and does not demand any information about population parameters. This form of the estimator will be thus applied later in Section 4 (after adapting to estimating the balance statistics).

It has to be emphasized that classical rotating (overlapping) samples theory cannot be applied entirely into tendency surveys because its theoretical assumptions are different, i.e. formulas for the variances and MSE are derived under assumption that overlapping is due to a particular rotating pattern and particular sampling scheme and hence all inclusion probabilities are known. In the problem analyzed in the present paper an overlapping pattern can be observed and described accurately but only *ex post*, so probabilities of such a pattern are not known in advance. Thus, only some of the ideas of the rotating samples theory can be implemented to adjust for overlapping samples in tendency surveys, including formulas for the estimators and conclusions drawn on the basis of the structure of the estimator but excluding exact formulas for their variances or mean square errors. Thus, in the present paper no mathematical formulas for MSE or the variance will be given.

3. Empirical study

The empirical study presented in this paper is based on the monthly business survey of manufacturing firms conducted by the Research Institute for Economic Development (RIED), Warsaw School of Economics in Poland.[4] For definiteness, the level of production (state) is taken into account, i.e. question number 1 in the RIED business survey questionnaire. Selected elements of analysis for other key RIED variables are given in Appendix 3.

For the level of production respondents assess changes on three-scale level, i.e. they may report:

– increase (above normal),
– decrease (below normal),
– same as usually (no changes).

The empirical study presented in this paper covers the period from January 2006 to February 2014, i.e. 98 months.

As it was stated in Section 1 most tendency surveys are designed to be based on a fixed panel. But in the real world to get a panel is almost

[4] The Author would like to thank dr Robert Wieczorkowski for transforming RIED data bases into a form suitable for the current analysis.

impossible. Due to different kinds of nonresponse resulting samples in successive periods usually overlap. This also applies to the business survey in the manufacturing industry conducted by RIED. Before we give a detailed analysis of the overlapping structure across time, let us first introduce some conceptual shortcuts:

By *the proportion of matched sample* we mean a proportion of respondents[5] from period t - 1, t = 2,…,98 who also gave their answers in the next period t. The proportion of matched sample tells how many percent of respondents from period t - 1 also responded in period t.

By *the proportion of above normal respondents* we mean a proportion of respondents who reported an increase (above normal) in period t - 1, t=2,…,98, and also gave their answers in period t. The proportion of above normal respondents tells how many percent of respondents who reported increase in period t - 1 also responded in period t.

By *the proportion of below normal respondents* we mean a proportion of respondents who reported worsening (below normal) in period t - 1, t=2,…,98, and also gave their answers in period t. The proportion of below normal respondents tells how many percent of respondents who reported worsening in period t - 1 also responded in period t.

By *the difference between proportions* we mean the proportion of above normal respondents minus the proportion of below normal respondents.

By *the absolute difference between proportions* we mean an absolute value of difference between proportions.

In Table 1 we give a summarized report of elementary descriptive statistics for the variable under the study - level of production (state). All detailed calculations are given in Appendix 1. Comparison of basic descriptive statistics for various RIED business survey variables is presented in Appendix 3.

During 98 months under the study the average coverage of samples in two successive periods was 74.3%. This means that on average 74.3% of respondents who answered in one month also answered in the next month.

[5] We include here respondents who fulfill two conditions: they returned their questionnaires and reported their current the level of production.

The lowest proportion of the matched sample in two successive months was 57.3%. More precisely, only 57.3% of respondents who gave their answers in April 2006 also gave their answers in May 2006. The highest observed proportion of matched sample was 83%. Up to 83% of respondents who answered in September 2012 also answered in October 2012.

Table 1: Basic descriptive statistics in % for samples in two successive periods from January 2006 to February 2014.

	Proportion of matched sample	Proportion of above normal respondents	Proportion of below normal respondents	Difference between proportions	Absolute difference
min	57.3	51.3	55.4	-16.8	0.1
max	83	86.9	86.3	14.8	16.8
mean	74.3	73.4	73.9	-0.5	5.7

Source: own calculations on the basis of RIED data.

Let us analyze now respondents who reported an increase in period t - 1, t = 2,…,98. On average 73.4% of them also gave their answers in the next period. The lowest proportion of above normal respondents in two successive months was 51.3%. Only 51.3% of respondents who reported an increase in March 2008 gave also their answers in April 2008 (the proportion of below normal respondents in this particular period was 62,7%). The highest proportion of above normal respondents was observed from February to March 2010, it was 86.9% (the proportion of below normal respondents in this period was 82.9%).

Let us analyze now respondents who reported a decrease in period t - 1, t = 2,…,98. It can be seen from Table 1 that on average 73.9% of them also gave their answers in the next month. The lowest proportion of below normal respondents was 55.4%, from March to April 2006 (the proportion of above normal respondents was in this particular period 62.9%). The highest proportion of below normal respondents was 86.3%, from April to May 2011 (the proportion of above normal respondents was in this particular period only 73.2%).

On average the proportions of above normal and below normal respondents, that is proportions of respondents who reported an increase or, respectively, a decrease, and continued to give their answers in the next period were very similar in the analyzed period: 73.4% versus 73.9%. This means that on average respondents who report an increase or a decrease tend to participate in the next period in the survey with the same frequency. This result is very optimistic. But, of course, analyzing averages is not enough, particular differences between the proportions of above and below normal respondents for each month have to be taken into account[6].

On average absolute difference was not high, it amounted to 5.7%. The highest absolute difference[7] was 16.8%, as observed from December 2010 to January 2011. More precisely, only 67.5% of respondents who reported an increase in December 2010 gave their answers also in January 2011, while up to 84.4% of respondents who reported a decrease in December answered also in January 2011.

Now we test how many differences between the proportions of above and below normal respondents who continued to answer the questionnaire in the next month are statistically significant. We can apply here a standard two-tailed test of the equality of two population proportions. Detailed calculations are given in Appendix 1. Here we give only a brief report.

At the standard significance level $\alpha = 0.05$ out of 97 differences (for 98 analyzed months) 9 differences are statistically significant. The differences statistically significant are:

- -15.4% (61.1% proportion of above normal, 76.5% proportion of below normal, 01-02, 2007);
- -16.4% (57% proportion of above normal, 73.4% proportion of below normal, 06-07, 2007);
- -13.9% (66.4% proportion of above normal, 80.3% proportion of below normal, 08-09, 2007);
- -11.4% (51.3% proportion of above normal, 62.7% proportion of below normal, 03-04, 2008);
- +12.6% (84.5% proportion of above normal, 72% proportion of below normal, 10-11, 2008);
- -16.8% (67.5% proportion of above normal, 84.4% proportion of below normal, 12.2010-01.2011);
- -13.1% (73.2% proportion of above normal, 86.3% proportion of below normal, 04-05, 2011);

[6] We focus in the paper on respondents who reported an increase or a decrease because the balance statistics obtained in tendency surveys are based solely on them; respondents who reported no change are not taken into account when calculating a balance.

[7] All percentages in the paper are originally calculated with greater accuracy than one decimal place and rounding of numbers comes from these more accurate calculations. In particular, 67.5% comes from 67.5438%; 84.4% comes from 84.375%, hence the difference is 16.8312%, which gives 16,8% after rounding. An analogous remark applies to all calculations presented in this paper.

- +13.0% (80% proportion of above normal, 67.0% proportion of below normal, 06-07, 2012);
- +14.8% (82.8% proportion of above normal, 67.9% proportion of below normal, 08-09, 2013).

4. Adjustment of balance statistics

In this section we will analyze balance statistics in the context of different response patterns from one period to another. For better comparison it would be convenient to consider two kinds of balances.

Firstly, let us consider usual unweighted balance statistics obtained as common differences between percentage of respondents reporting improvement of situation (above normal) and percentage of respondents reporting worsening of situation (below normal) in a given month. We denote it as B_U (U stands here for unweighted). Secondly, let us consider weighted balance statistics, more precisely original balances calculated by RIED[8] that incorporate weights referring to the size of industrial enterprises. We denote these balances as B_W (W stands for weighted).

Let us come back now to the example presented in the previous section. 74,4% of respondents who were examined in December, 2010 were also examined in January, 2011. But the structure of respondents who continued to answer was different. Only 67.5% of respondents who reported increase in December 2010 gave their answers also in January 2011, while up to 84.4% of respondents who reported a decrease in December, 2010 answered also in January. Let us consider balance statistics for December:

unweighted balance B_U = -3.2, and weighted B_W = -1.3.

These are the balances calculated on the basis of the whole sample S_{t-1} for December, more precisely on the basis of 433 respondents. But not all respondents continued to answer in the next month. If we narrow the number of respondents to those only who continued to answer in the next month, i.e. if we consider for December the matched subsample S_M only and calculate on its basis the balances for December once again, we get:

unweighted balance B_{UM} = -9.6, and weighted B_{WM} = -7.7.[9]

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[8] Detailed description of weights used by RIED are given e.g. in Tomczyk & Kowalczyk (2010).

[9] In the subscripts M stands for the matched subsample, U for the unweighted balance, and W for the weighted balance.

It is very clear that respondents who continued to answer the business tendency survey questionnaire[10] in January didn't reflect the whole sample of December. Their reported states, as far as the level of production was concerned, were different from that reported by the whole sample.

Let us take another example. Only 51.3% of respondents who reported an increase in March 2008 also gave their answers in April 2008, while 62.7% of respondents who reported a decrease in March gave their answers also in April. The balances calculated on the basis of the whole sample in March are, respectively, as follow:

unweighted $B_U = 16.7$, and weighted $B_W = 23$.

The balances calculated on the basis of the matched sample only, that is on the basis of those respondents who gave their answers also in April, are, respectively, as follow:

unweighted $B_{UM} = 10.8$, and weighted $B_{WM} = 15.6$.

In both examples differences in the balances are visible. As in these periods respondents who reported improvement and those who reported worsening didn't pass to another period with similar frequencies, samples for next periods are biased, and hence balances for next periods can be also distorted. Unfortunately, we cannot calculate how much the distortion is because we do not know the real values of the balances. We do not have any knowledge about that. We have only information from the sample and we know that a part of this sample (the matched one) is biased.

What we can do is to adjust the balances to take into account all described above differences. We can use theory for rotating (overlapping) surveys here. But it has to be emphasized that business tendency surveys are not designed as rotating surveys. Only the resulting (not designed) samples overlap across time, and resulting inclusion probabilities of particular respondents are not known *a priori*. Thus, as it was stated in Section 2, formulas for the variances or the mean square error adequate for rotating surveys are definitely not adequate in this case. But the form of the estimator itself that adjusts for the information from previous period can be used, and its descriptive properties can be characterized.

[10] By this we mean that the respondents return a questionnaire and answer the question about the level of production.

We propose[11] the following form of the adjusted balance statistics:

$$\left(\frac{n_{tM}}{n_t}\cdot Ab_{tM}\frac{Ab_{t-1}}{Ab_{t-1M}}+\frac{n_{tU}}{n_t}\cdot Ab_{tU}\right)-\left(\frac{n_{tM}}{n_t}\cdot Be_{tM}\frac{Be_{t-1}}{Be_{t-1M}}+\frac{n_{tU}}{n_t}\cdot Be_{tU}\right). \quad (1)$$

We use here the following notation:

- n_t – number of respondents who gave their answers in period t;
- n_{tM} – number of respondents who gave their answers both in periods t and t - 1 (matched part);
- n_{tU} – number of respondents who gave their answers in period t but did not give answers in period t - 1 (unmatched part);
- Ab_{tM} – percentage of respondents who reported an increase (above normal) for current period t calculated on the basis of the matched part of the sample from period t, that is calculated on the basis of the part of the sample that was also examined in a previous period;
- Ab_{tU} – percentage of respondents who reported an increase (above normal) for current period t calculated on the basis of the unmatched part of the sample from period t, that is calculated on the basis of the part of the sample that was not examined in a previous period (on the basis of those respondents who did not respond in a previous month);
- Be_{tM} – percentage of respondents who reported a decrease (below normal) for current period t calculated on the basis of the matched part of the sample from period t, that is calculated on the basis of the part of the sample that was also examined in a previous period;
- Be_{tU} – percentage of respondents who reported a decrease (below normal) for current period t calculated on the basis of the unmatched part of the sample from period t, that is calculated on the basis of the part of the sample that was not examined in a previous period (on the basis of that respondents who did not respond in a previous month);
- Ab_{t-1} – percentage of respondents who reported an increase (above normal) in previous period t - 1 calculated on the basis of the whole sample from period t - 1;

[11] The estimator is analogous to the ratio estimator presented in Kowalczyk (2013), i.e. it uses ratio-type estimation based on information from the sample for present and previous periods. The formula for the estimator is adapted to the definition of balance statistics as a difference between percentages of those who reported an increase and a decrease, respectively.

- Ab_{t-1M} – percentage of respondents who reported an increase (above normal) in previous period t - 1 calculated on the basis of the matched part of the sample, that is calculated on the basis of the part of the sample that was also examined in period t (on the basis of that respondents who did respond also in period t);
- Be_{t-1} – percentage of respondents who reported a decrease (below normal) in previous period t - 1 calculated on the basis of the whole sample from period t - 1;
- Be_{t-1M} – percentage of respondents who reported a decrease (below normal) in previous period t - 1 calculated on the basis of the matched part of the sample, that is calculated on the basis of the part of the sample that was also examined in period t (on the basis of that respondents who did respond also in period t).

Of course, we have $n_t = n_{tM} + n_{tU}$.

It is convenient to emphasize that usual balance statistics (not adjusted), that is the difference between the percentages of those respondents who reported an increase and those who reported a decrease can be expressed by slightly complicated but useful for our future analysis formula[12]:

$$\left(\frac{n_{tM}}{n_t} \cdot Ab_{tM} + \frac{n_{tU}}{n_t} \cdot Ab_{tU} \right) - \left(\frac{n_{tM}}{n_t} \cdot Be_{tM} + \frac{n_{tU}}{n_t} \cdot Be_{tU} \right) = Ab_t - Be_t. \quad (2)$$

So the balance statistics is usually known as the right hand side of the equation (2) but for our analysis its left hand side form will be also useful.

The most important thing now is to give properties of the proposed estimator given by formula (1), which is called the adjusted balance statistics.

Properties of the proposed adjusted balance statistics given by formula (1):

Property 1:

If respondents pass from the sample in period t - 1 to the sample in the next period t randomly, that is if the percentage of respondents from period t - 1 who continued to answer in period t is the same as the percentage of respondents who reported an increase in period t - 1 and continued to answer, and the same as respondents who reported a decrease and continue to answer, then we have:

$$Ab_{t-1} = Ab_{t-1M} \text{ and } Be_{t-1} = Be_{t-1M},$$

[12] The same formula applies both for unweighted or weighted percentages/balances.

and hence:

$$\left(\frac{n_{tM}}{n_t}\cdot Ab_{tM}\frac{Ab_{t-1}}{Ab_{t-1M}}+\frac{n_{tU}}{n_t}\cdot Ab_{tU}\right)-\left(\frac{n_{tM}}{n_t}\cdot Be_{tM}\frac{Be_{t-1}}{Be_{t-1M}}+\frac{n_{tU}}{n_t}\cdot Be_{tU}\right)$$
$$=\left(\frac{n_{tM}}{n_t}\cdot Ab_{tM}+\frac{n_{tU}}{n_t}\cdot Ab_{tU}\right)-\left(\frac{n_{tM}}{n_t}\cdot Be_{tM}+\frac{n_{tU}}{n_t}\cdot Be_{tU}\right)=Ab_t-Be_t.$$

This means that if respondents pass to another period randomly, estimator (1), that is the adjusted balance statistics, is equal to the usual balance statistics. If they pass approximately randomly, estimator (1) is approximately equal to the usual balance statistics, i.e. its value is very similar to that obtained as the usual balance.

Let us present here some exemplary empirical results. The proportion of respondents from July 2010 who continued to answer in August was similar to the proportion of those who reported an increase and continued to answer, and to those who reported a decrease and reported to answer, exact proportions were: 63.3%, 61.8%, 61.7%. In this case the original and adjusted balance statistics for August 2010 are approximately equal:

B_U = 2.1; B_{UA} = 2 (A stands for *adjusted*, U for *unweighted*),

B_W = 4.7; B_{WA} = 5.1 (A stands for *adjusted*, W for *weighted*).

Property 2

Another property of estimator (1) is the following. It is constructed as a convex linear combination of the balances obtained from the part of the sample that was also examined in a previous month (adjusted):

$$\left(Ab_{tM}\frac{Ab_{t-1}}{Ab_{t-1M}}\right)-\left(Be_{tM}\frac{Be_{t-1}}{Be_{t-1M}}\right),$$

and obtained from the part of the sample that was not examined in a previous month:

$$(Ab_{tU})-(Be_{tU}).$$

Coefficients of the linear combination are equal to $\frac{n_{tM}}{n_t}$ and $\frac{n_{tU}}{n_t}$, respectively.

It means that the higher is the unmatched part of the sample in period *t*, the higher weight is applied to the balance obtained from this part. The lower is the unmatched part of the sample, the higher weight is applied to the balance obtained on the basis of the matched sample (this balance is adjusted).

Property 3

In a particular situation, when in a given period the sample is completely new, that is there are no elements which were also examined in a previous period, the estimator given by (1) gives us the same formula as the usual balance statistics. In this case we have $n_M = 0$, $n_{tU} = n_t$, $S_t = S_{tU}$, and hence:

$$\left(\frac{n_{tM}}{n_t} \cdot Ab_{tM} \frac{Ab_{t-1}}{Ab_{t-1M}} + \frac{n_{tU}}{n_t} \cdot Ab_{tU}\right) - \left(\frac{n_{tM}}{n_t} \cdot Be_{tM} \frac{Be_{t-1}}{Be_{t-1M}} + \frac{n_{tU}}{n_t} \cdot Be_{tU}\right) = \\ = \left(\frac{n_t}{n_t} \cdot Ab_{tU}\right) - \left(\frac{n_t}{n_t} \cdot Be_{tU}\right) = Ab_t - Be_t.$$

Property 4

In the other case, when we have exactly the same sample in two successive periods, that is when we have a real panel, the estimator given by (1) gives us the same formula as the usual balance statistics. In this case we have $S_{t-1} = S_t = S_M$; $n_U = 0$, hence $Ab_{t-1} = Ab_{t-1M}$ and $Be_{t-1} = Be_{t-1M}$, and finally:

$$\left(\frac{n_{tM}}{n_t} \cdot Ab_{tM} \frac{Ab_{t-1}}{Ab_{t-1M}} + \frac{n_{tU}}{n_t} \cdot Ab_{tU}\right) - \left(\frac{n_{tM}}{n_t} \cdot Be_{tM} \frac{Be_{t-1}}{Be_{t-1M}} + \frac{n_{tU}}{n_t} \cdot Be_{tU}\right) = \\ = \left(\frac{n_t}{n_t} \cdot Ab_{tM} \cdot 1\right) - \left(\frac{n_t}{n_t} \cdot Be_{tM} \cdot 1\right) = Ab_t - Be_t.$$

Property 5

When respondents who are examined do not pass to another period randomly, that is when the proportions of respondents who reported an increase (decrease) and continued to answer in another month are not approximately equal to the proportions of respondents in the sample who reported an increase (decrease), estimator (1) adjusts for these differences.

Let us illustrate this by some exemplary empirical results.

The proportion of respondents from January 2007 who reported an increase and continued to answer in February 2007 was only 61.1%, and the proportion of those who reported a decrease and continued to answer in February 2007 was up to 76.5%. The balance statistics calculated on the basis of the whole sample from January is $B_U = 7$ (for unweighted balance) and $B_W = 9,8$ (for weighted balance). But the subsample of those who continued to answer in the next month was not random. If we would like to compute once again the balance statistics for January based only on that subsample, we would obtain B_{UM} = 1.5 (for unweighted balance) and B_{WM} = 3.3 (for weighted balance). So the real balances were higher than those obtained for respondents who continued to answer. The usual balances calculated for February are in this case 11.01 (for unweighted balance) and B_W = 10 (for weighted balance). And the adjusted balances calculated on the basis of formula (1) are, respectively: B_{UA} = 14.4 and B_{WA} = 13.5.

The proportion of respondents from June 2012 who reported an increase and continued to answer in July 2012 was 80%, and the proportion of those who reported a decrease and continued to answer in July 2012 was only 67%. The balance statistics calculated on the basis of the whole sample from June is B_U = -0.5 (for unweighted balance) and B_W = 2.2 (for weighted balance). The subsample of those who continued to answer in the next month either was not random in this case. If we would computed once again the balance statistics for June based only on the matched subsample, we would obtain B_{UM} = 3.5 (for unweighted balance) and B_{WM} = 6.5 (for weighted balance). So the real balances were lower than those obtained for respondents who continued to answer. The usual balances calculated for July are in this case -16.58 (for unweighted balance) and B_W = -16.76 (for weighted balance). And the adjusted balances calculated on the basis of formula (1) are, respectively: B_{UA} = -21.13 and B_{WA} = -21.46, so they are lower.

5. Comparison of original and adjusted balance statistics

Now we compare resulting time series of the balances. Detailed results are given in Appendix 2 and 4. Here we give a summarized report. First let us recall the notation:

- B_U – unweighted original balance statistics, i.e. difference between the percentages of respondents reporting improvement and those reporting worsening;
- B_W – weighted original balance statistics, i.e. difference between the weighted percentages of respondents reporting improvement and those reporting worsening; weights are due to sizes of the enterprises (these are the balances published by RIED);
- B_{UA} – unweighted adjusted balance statistics computed on the basis of formula (1);
- B_{WA} – weighted adjusted balance statistics computed on the basis of formula (1).

First we give descriptive statistics for obtained time series for the differently calculated balances.

Table 2: Basic descriptive statistics for different balance statistics time series.

	B_U	B_{UA}	B_W	B_{WA}
mean	-2.4	-2.3	0.3	0.4
variance	220.7	234.3	231.3	240.6
min	-43.9	-46.2	-44.8	-45.7
max	26.3	26.6	27.7	27.9

Source: own calculations on the basis of RIED data

Table 3: Basic descriptive statistics for differences between the original and adjusted balances.

	B_U - B_{UA}	Absolute value of (B_U - B_{UA})	B_W - B_{WA}	Absolute value of (B_W - B_{WA})
mean	-0.1	1.5	-0.1	1.7
min	-4.6	0.0	-5.4	0.0
max	4.5	4.6	4.7	5.4

Source: own calculations on the basis of RIED data

Additionally, correlation coefficient between the difference between the proportions and the difference between the original and adjusted balance statistics is 0.979 for the unweighted balances and 0.876 for the weighted balances. It means that the higher difference between the proportions of 'above normal' and 'below normal' respondents that continued to give their answers in the next month, the higher the difference between the original and adjusted statistics. This result is very coherent with the whole analysis and theory. The higher is the difference between the proportions, the more balance should be adjusted.

The differences for the proportions were not so high for the RIED data. And, hence, the differences for obtained balances are not high either, the maximum absolute difference between original and adjusted balance statistics was 4,6 for the unweighted balances and 5,4 for the weighted balances.

Apart from absolute values of the balances, tendencies are of utmost importance. During the analyzed period, i.e. from January 2006 to February 2014, seven times the sign of the difference between the balance for period $t + 1$ and the balance for period t was different for the unweighted original and uweighted adjusted balances. More precisely, by using original unweighted balances 3 times upward tendency was observed while in the same periods these tendencies were downward by using the adjusted unweighted balances. And 4 times downward tendency was observed by using original unweighted balances while in the same periods these tendencies were upward by using the adjusted unweighted balances.

But these differences in tendencies were not high. For example: in December 2007 the original unweighted balance was -9.4 and in January 2008 it was -8.3. So, a very small growth was observed (almost no changes). The adjusted unweighted balances were -7.1 in December and -8.6 in January. Again, a very small fall was observed. Another example: in January 2010 the unweighted original balance was -19.7 and in February -21.8. A small fall was observed once again. The adjusted balances for the same period were, respectively: -22.4 and -22.1. A small growth was observed, but in these cases almost all results could be interpreted as no changes. The most visible difference as far as different tendencies are taken into account was the following: in May 2009 the unweighted original balance was -15.8 and -16.9 in June. So, a very small fall was observed. The adjusted balances were: -18.2 in May and -14. 5 in June. So, now a growth was observed.

As far as the weighted balances are concerned, different tendencies for the original and adjusted balances were observed 8 times. A difference in tendency was observed e.g. from May 2009 to June 2009, when the calculated original weighted balance statistics was -15.53 in May and -16.14 in June, which implied a very slight decrease, while the calculated adjusted weighted balances were -19.64 and -13.75, respectively, which implied a visible increase. Similar situation took place from December 2011 to January 2012. The calculated weighted balances were -8.24 in December and -8.61 in January, which implies almost no change (very low decrease), while the adjusted weighted balances were -12.21 and -6.18, which indicates a visible increase. All details are presented in Appendix 4, where exact graphs of the original and adjusted balances are presented.

At the end of this section it would be beneficial to refer to some alternative adjustment procedures and compare the resulting time series of balances. It has to be emphasized that in practice negative results of non-response are usually not limited to one specified problem, the resulting problems are spread. Due to non-response the received sample structure can significantly vary over time. It can also differ from the population structure. Additionally, this can occur as far as enterprise's NACE groups, the size of employment, voivodeship etc. are concerned. Furthermore, not only structure of firm's attributes can be affected. Also the resulting set of respondents' answers can be distorted. The variability of possible effects of non-response involves many different approaches to the problem of adjusting the balance statistics. Descriptions of various adjustment formulas can be found e.g. in

Wang (2004), Tomczyk & Kowalczyk (2010), and Kowalczyk & Witkowski (2011).

To present the problem in more detail and to enable the comparison of the adjusted balances, let us focus now on the adjustment procedure first introduced in Tomczyk & Kowalczyk (2010) and applied more widely in Kowalczyk & Witkowski (2011). The adjustment procedure refers to changing sample structure across time and to its diversity from the population structure as far as the firms' size of employment is taken into account. The adjusting method assumes double weighting. Enterprises are first weighted by the lower limit of employment interval into which they belong and then are adjusted (weighted in a post-stratification manner) according to the population enterprises' employment structure in Poland[13]. Let us denote the balances obtained on the basis of this procedure as B_{WAP} (weighted and adjusted to the population structure). The choice of this particular adjustment method is justified by two main reasons. Firstly, as it was shown in two cited earlier papers, it is a very reasonable method of adjusting as far as differences between sample and population employment structure are concerned. Secondly, this type of adjustment perfectly corresponds to the original RIED idea of weighting according to the employment size (but original RIED weights are arbitrary and stable over time regardless changing sample structure) and thus enables comparison of the time series of balances.

To allow comparison, as the weighted and adjusted to the population structure balances B_{WAP} are available only up to January 2009, let us limit ourselves for the purpose of this comparison to the period from February 2006 to January 2009 (36 months). Comparison of basic descriptive statistics of three time series of the balances (original weighted balances; weighted adjusted balances introduced in this paper and weighted and adjusted to the population structure balances, i.e. balances adjusted by an alternative method) is presented in Table 4. Exact time series figure is presented in Appendix 5.

As it is seen in Table 4, basic descriptive statistics of all three time series of balances are quite similar. The mean absolute difference between the original weighted RIED balances and the adjusted balances suggests that the adjustment method presented in the present paper have larger impact on the results than the alternative method. This empirical result is consistent with generally accepted statistical belief that non-response correlated with a variable under a study is usually the most dangerous for survey results.

[13] For details see Tomczyk & Kowalczyk (2010), p. 412.

Table 4. Basic descriptive statistics of various balances for the level of production – state.

	B_W	B_{WA}	B_{WAP}	Absolute difference $\|B_W - B_{WA}\|$	Absolute difference $\|B_W - B_{WAP}\|$
min	-43.4	-44.1	-42.2	0.05	0.04
max	27.7	27.8	27.4	5.4	5.1
mean	5.4	5.9	5.0	1.8	0.9

Source: own calculations on the basis of RIED data

6. Conclusions

When respondents who participated in a survey in period t - 1 tend to participate in the next period randomly, the proportions of those who continued to answer should be distributed equally among all groups, i.e. among those who reported an increase, a decrease and no change. But sometimes these proportions can be substantially different and hence the sample for period t can be seriously biased. Because of the biased structure of the sample the obtained balance statistics can also be distorted. In such cases a formula for adjusting of balance statistics introduced in this paper can be of use. The presented formula for adjusted balances have many desirable properties:

- if respondents pass to another period randomly, the adjusted balance statistics is equal to the usual balance statistics; if they pass approximately randomly, the adjusted balance statistics is approximately equal to the usual balance statistics;
- the higher is the unmatched part of the sample in period t, the higher weight is applied to the balance obtained from this part; the lower is the unmatched part of the sample, the higher weight is applied to the balance obtained on the basis of the matched sample (this balance is adjusted);
- if in a given period the sample is completely new, that is there are no elements that were also examined in a previous period, the adjusted balance gives the same formula as the usual balance statistics, as there is no subsample to adjust;
- if we have exactly the same sample in two successive periods, that is when we have a real panel, the adjusted balance statistics gives us the same formula as the usual balance statistics;
- if respondents who are examined do not pass to another period randomly, that is when the proportions of respondents who reported an

increase (decrease) and continued to answer in another month are not approximately equal to the proportions of respondents in the sample who reported an increase (decrease), estimator (1) adjusts for these differences.

There is of course some room for further research in this field. The given above properties, although greatly desirable for the analyzed problem, are not accompanied by any formula for the MSE of the proposed estimator. So in future theoretical research it would be convenient to explore more advanced mathematical theory for this problem.

As empirical study for the monthly business tendency survey of manufacturing industry conducted by RIED has shown respondents pass from one period to another in most – but not all – cases randomly. Always special attention should be put on those non-random cases. For 9 periods out of 98 studied differences between the proportions of respondents who reported an increase and continued to answer, and those who reported a decrease and continued to answer in the next month, were statistically significant. The highest absolute difference observed among 98 months was 16.8%.

To take into account different structure of the original sample for period t - 1 and the matched part of the sample, that is the part of respondents which continued to answer in the next period, the adjusted balance statistics were calculated. Some differences between the original and adjusted balances were observed. The highest absolute difference between the original and adjusted balance statistics was 5.4 for the weighted balances (April 2008) and 4,6 for the unweighted balances (July 2007). It has to be emphasized that both April 2008 and July 2007 respondents did not pass from the previous month randomly.

During the analyzed period also some different tendencies were observed from one month to another as far as the original and adjusted balances were concerned. The substantial difference in tendency was observed e.g. from May 2009 to June 2009, when the calculated original weighted balance statistics was -15.53 in May and -16.14 in June, which implied a very slight decrease, while the calculated adjusted weighted balances were -19.64 and -13.75, respectively, which implied a visible increase. Similar situation took place from December 2011 to January 2012. The calculated weighted balances were -8.24 in December and -8.61 in January, which implies almost no change (very low decrease), while the adjusted weighted balances were -12.21 and -6.18, which indicates a visible increase. In total during the analyzed period different tendencies were observed 8 times for the weighted balances and 7 times for the unweighted balances.

In future research it would be advisable to conduct an empirical analysis also for other tendency surveys conducted by RIED.

References

Bell, P. A. (2001). Comparison of alternative labour force survey estimators, *Survey Methodology*, 27 (1), 53-63.

Berger, Y. G. (2004). Variance estimation for measures of change in probability sampling, *Canadian Journal of Statistics*, 32 (9), 451-467.

Betti, G., Verma, V. (2007). *Rotational panel designs for surveys of income and living conditions in Europe*, invited paper, International Statistical Institute 56th Session, Lisbon.

Binder, D. A., Hidiroglou, M. A. (1988). *Sampling in time*, in *Handbook of Statistics*, P. R. Krishnaiah, R. Rao (eds.), vol. 6, 187-211.

Ciepiela, P., Gniado, K., Wesołowski, J., Wojtyś, M. (2012). Dynamic K-composite estimator for an arbitrary rotation scheme, *Statistics in Transition* (New Series), 13 (1), 7-20.

Degras, D. (2012). *Rotation sampling for functional sata*, Cornell University Library: http://arxiv.org/abs/1204.4494v2

Fuller, W. A., Rao, J. N. K. (2001). A regression composite estimator with application to the Canadian Labour Force Survey, *Survey Methodology*, 27 (1), 45-51.

Gagliardi, F., Verma, V., Ciampalini, G. (2009). *Methodology of European labour force surveys: Sample design and implementation*, Working Paper No. 79, Dipartimento di Metodi Quantitativi, Università di Siena.

Gambino, J., Kennedy, B., Singh, M. P. (2001). Regression composite estimation for the Canadian Labour Force Survey: Evaluation and implementation, *Survey Methodology*, 27 (1), 65-74.

Groves, R. M., Dillman, D. A., Eltinge, J. L., Little, R. J. A. (2002). *Survey nonresponse*, New York: John Wiley & Sons.

Hansen, M. H., Hurwitz, W. N., Madow, W. G. (1953). *Sample survey methods and theory*, New York: John Wiley & Sons.

Holt, D., Farver, T. (1992). The use of composite estimators with two-stage repeated sample designs, *Journal of Official Statistics*, 8 (4), 405-416.

Jessen, R. (1942). Statistical investigation of a farm survey for obtaining farm facts, *Iowa Agricultural Station Research Bulletin*, 304, 54-59.

Kasprzyk, D., Duncan, G., Kalton, G., Singh, M. P. (eds.) (1989), *Panel surveys*, New York: John Wiley & Sons.

Kim, K. W., Park, Y. S., Kim, N. Y. (2005). l-step generalized composite estimator under 3-way balanced rotation design, *Journal of the Korean Statistical Society*, 34 (3), 219-233.

Kordos, J. (2012). Review of application of rotation methods in sample surveys in Poland, *Statistics in Transition* (New Series), 13 (2), 47-64.

Kowalczyk, B. (2003). Estimation of the population total on the current occasion under second stage unit rotation pattern, *Statistics in Transition*, 6 (4), 503-513.

Kowalczyk, B. (2013). *Zagadnienia estymacji złożonej w badaniach reprezentacyjnych opartych na próbach rotacyjnych*, Warszawa: Oficyna Wydawnicza SGH.

Kowalczyk, B., Tomczyk, E. (2011). Non-response and weighting systems in business tendency surveys: Are expectations influenced?, *Prace i Materiały Instytutu Rozwoju Gospodarczego SGH*, 86, 101-119.

Kowalczyk, B., Witkowski, B. (2011). O wpływie metod ważenia na własności szeregów czasowych statystyk bilansowych IRG, *Prace i Materiały Instytutu Rozwoju Gospodarczego SGH*, 87, 65-85.

Kowalski, J. (2009). Optimal estimation in rotation patterns, *Journal of Statistical Planning and Inference*, 139 (4), 2429-2436.

Little, R. J. A., Rubin, D. B. (2002). *Statistical analysis with missing data*, New York: John Wiley & Sons.

Longford, N. T. (2005). *Missing data and small-area estimation*, New York: Springer Science + Business Media.

Nedyalkova, D., Qualite, L., Tille, Y. (2009). General framework for the rotation of units on repeated survey sampling, *Statistica Neerlandica*, 63 (3), 269-293.

OECD (2003). *Business tendency surveys. A handbook*, Statistics Directorate, Paris.

Okafor, F., Arnab, R. (1987). Some strategies of two-stage sampling for estimating population ratios over two occasions, *Australian Journal of Statistics*, 29 (2), 128-142.

Park, Y. S., Kim, K. W., Choi, J. W. (2001). One-level rotation design balanced on time in monthly sample and in rotation group, *Journal of the American Statistical Association*, 96 (456), 1483-1496.

Patterson, H. D. (1950). Sampling on successive occasions with partial replacement of units, *Journal of the Royal Statistical Society* (Series B), 12 (2), 241-255.

Rao, J., Graham, J. (1964). Rotation designs for sampling on repeated occasions, *Journal of the American Statistical Association*, 59 (306), 492-509.

RIED (2014). *Business survey in manufacturing. February*, Warsaw School of Economics.

Pfefferman, D., Rao, C. R. (eds.) (2009). *Handbook of statistics*, vol. 29A, Amsterdam: Elsevier.

Särndal, C., Swensson, B., Wretman, J. (1992). *Model assisted survey sampling*, New York: Springer-Verlag.

Scott, A., Smith, T. (1974). Analysis of repeated surveys using time series methods, *Journal of the American Statistical Association*, 69 (347), 674-678.

Seiler, Ch. (2012). *On the robustness of the balance statistics with respect to non-response*, Ifo Working Paper No. 126.

Steel, D. G. (2004). *Sampling in time*, in *Encyclopedia of social measurement*, K. Kempf-Leonard (ed.), Amsterdam: Elsevier Academic Press.

Steel, D., McLaren, C. (2009). *Design and analysis of surveys repeated over time,* in *Handbook of statistics*, D. Pfeffermann, C. R. Rao (eds.), vol. 29B, Amsterdam: Elsevier.

Tomczyk, E., Kowalczyk, B. (2010). Influence of non-response in business tendency surveys on properties of expectations, *Statistics in Transition* (New Series), 11 (2), 403-422.

Wang, H. J. (2004). *Non-response in the Norwegian business tendency survey*, Statistics Norway, Department of Economic Statistic Document No 2004/3.

Wesołowski, J. (2010). Recursive optimal estimation in Szarkowski rotation scheme, *Statistics in Transition* (New Series), 11 (2), 267-285.

Yates, F. (1949), *Sampling methods for censuses and surveys*, London: Charles Griffin.

Zou, G., Feng, S., Qin, H. (2002). Sample rotation theory with missing data, *Science in China* (Series A: *Mathematics*), 45 (1), 42-63.

Appendix 1

Proportions (in fractions) of matched sample, above normal and below normal respondents and differences between them together with value of the test statistic in equality test for fractions.

Period	Proportion of matched sample	Proportion of above normal respondents	Proportion of below normal respondents	Difference between proportions	Value of the test statistic
2006. 01-02	0.796	0.782	0.783	-0.001	-0.02
2006. 02-03	0.678	0.672	0.662	0.010	0.17
2006. 03-04	0.623	0.629	0.554	0.075	1.34
2006. 04-05	0.573	0.571	0.605	-0.034	-0.51
2006. 05-06	0.722	0.714	0.706	0.008	0.12
2006. 06-07	0.663	0.685	0.632	0.053	0.74
2006. 07-08	0.721	0.698	0.781	-0.084	-1.22
2006. 08-09	0.731	0.723	0.750	-0.027	-0.38
2006. 09-10	0.770	0.752	0.674	0.077	1.00
2006. 10-11	0.728	0.677	0.808	-0.131	-1.76
2006. 11-12	0.620	0.611	0.581	0.030	0.37
2006.12 -2007.01	0.736	0.754	0.727	0.027	0.36
2007. 01-02	0.674	0.611	0.765	-0.154	-2.29
2007. 02-03	0.655	0.706	0.667	0.039	0.58
2007. 03-04	0.673	0.620	0.732	-0.112	-1.48
2007. 04-05	0.774	0.746	0.745	0.001	0.01
2007. 05-06	0.721	0.690	0.806	-0.117	-1.69
2007. 06-07	0.630	0.570	0.734	-0.164	-2.25
2007. 07-08	0.705	0.613	0.699	-0.086	-1.15
2007. 08-09	0.719	0.664	0.803	-0.139	-2.01
2007. 09-10	0.775	0.702	0.793	-0.091	-1.28
2007. 10-11	0.720	0.737	0.742	-0.006	-0.08
2007. 11-12	0.712	0.690	0.764	-0.074	-1.10
2007.12-2008.01	0.743	0.727	0.722	0.005	0.08
2008. 01-02	0.701	0.679	0.676	0.004	0.05
2008. 02-03	0.778	0.716	0.785	-0.069	-1.05
2008. 03-04	0.593	0.513	0.627	-0.114	-2.09
2008. 04-05	0.642	0.610	0.624	-0.014	-0.23
2008. 05-06	0.709	0.651	0.667	-0.016	-0.28
2008. 06-07	0.700	0.691	0.731	-0.040	-0.72

2008. 07-08	0.657	0.664	0.615	0.048	0.80
2008. 08-09	0.747	0.784	0.729	0.055	0.99
2008. 09-10	0.673	0.657	0.600	0.057	0.94
2008. 10-11	0.781	0.845	0.720	0.126	2.34
2008. 11-12	0.743	0.736	0.738	-0.002	-0.04
2008.12-2009.01	0.774	0.786	0.778	0.008	0.13
2009. 01-02	0.722	0.769	0.691	0.078	1.13
2009. 02-03	0.767	0.814	0.757	0.057	0.80
2009. 03-04	0.724	0.797	0.694	0.104	1.77
2009. 04-05	0.765	0.822	0.722	0.100	1.80
2009. 05-06	0.719	0.671	0.768	-0.097	-1.61
2009. 06-07	0.682	0.716	0.651	0.065	1.06
2009. 07-08	0.708	0.671	0.732	-0.062	-1.01
2009. 08-09	0.773	0.743	0.788	-0.046	-0.85
2009. 09-10	0.797	0.780	0.748	0.032	0.58
2009. 10-11	0.819	0.816	0.806	0.009	0.17
2009. 11-12	0.727	0.694	0.732	-0.037	-0.61
2009.12- 2010.01	0.744	0.814	0.708	0.106	1.81
2010. 01-02	0.793	0.806	0.791	0.015	0.26
2010. 02-03	0.828	0.869	0.829	0.040	0.72
2010. 03-04	0.759	0.750	0.675	0.075	1.22
2010. 04-05	0.794	0.785	0.776	0.008	0.14
2010. 05-06	0.723	0.760	0.714	0.045	0.73
2010. 06-07	0.617	0.630	0.558	0.072	1.25
2010. 07-08	0.633	0.618	0.617	0.001	0.01
2010. 08-09	0.732	0.721	0.722	-0.002	-0.03
2010. 09-10	0.800	0.777	0.798	-0.021	-0.38
2010. 10-11	0.802	0.817	0.789	0.028	0.51
2010. 11-12	0.734	0.752	0.711	0.040	0.70
2010.12-2011.01	0.744	0.675	0.844	-0.168	-3.08
2011. 01-02	0.756	0.756	0.745	0.011	0.19
2011. 02-03	0.790	0.824	0.736	0.088	1.65
2011. 03-04	0.760	0.738	0.786	-0.049	-0.85
2011. 04-05	0.785	0.732	0.863	-0.131	-2.20
2011. 05-06	0.769	0.709	0.760	-0.051	-0.83
2011. 06-07	0.719	0.703	0.726	-0.023	-0.37
2011. 07-08	0.779	0.795	0.792	0.003	0.06
2011. 08-09	0.769	0.768	0.748	0.020	0.33

2011. 09-10	0.784	0.806	0.770	0.036	0.64
2011. 10-11	0.769	0.752	0.790	-0.039	-0.71
2011. 11-12	0.756	0.763	0.694	0.069	1.24
2011.12-2012.01	0.757	0.687	0.753	-0.066	-1.15
2012. 01-02	0.755	0.711	0.818	-0.106	-1.91
2012. 02-03	0.817	0.793	0.784	0.010	0.18
2012. 03-04	0.790	0.781	0.831	-0.050	-0.94
2012. 04-05	0.798	0.817	0.727	0.089	1.50
2012. 05-06	0.821	0.802	0.846	-0.044	-0.79
2012. 06-07	0.764	0.800	0.670	0.130	2.04
2012. 07-08	0.786	0.819	0.759	0.060	1.00
2012. 08-09	0.783	0.714	0.788	-0.074	-1.20
2012. 09-10	0.830	0.815	0.850	-0.035	-0.67
2012. 10-11	0.781	0.739	0.752	-0.013	-0.22
2012. 11-12	0.764	0.763	0.821	-0.058	-0.98
2012.12-2013.01	0.780	0.855	0.797	0.057	0.98
2013. 01-02	0.747	0.721	0.733	-0.011	-0.17
2013. 02-03	0.774	0.725	0.794	-0.069	-1.12
2013. 03-04	0.774	0.831	0.745	0.086	1.32
2013. 04-05	0.823	0.833	0.795	0.039	0.68
2013. 05-06	0.813	0.835	0.792	0.044	0.77
2013. 06-07	0.798	0.778	0.795	-0.017	-0.31
2013. 07-08	0.743	0.804	0.697	0.107	1.86
2013. 08-09	0.771	0.828	0.679	0.148	2.36
2013. 09-10	0.769	0.778	0.760	0.017	0.29
2013. 10-11	0.771	0.754	0.764	-0.010	-0.16
2013. 11-12	0.763	0.673	0.775	-0.101	-1.60
2013.12-2014.01	0.805	0.769	0.805	-0.036	-0.61
2014. 01-02	0.769	0.732	0.822	-0.090	-1.51

Note: Differences with grey background are statistically significant at 0.05 significance level.
Source: own calculations on the basis of RIED data.

Appendix 2

Original and adjusted balance statistics (unweighted and weighted).

Period	Difference between proportions	B_U	B_{UA}	B_W	B_{WA}
2006. 02	-0.001	-7.128	-7.226	-3.257	-4.600
2006. 03	0.010	5.626	5.426	11.555	10.434
2006. 04	0.075	21.042	19.268	22.769	20.108
2006. 05	-0.034	12.500	13.334	12.632	14.339
2006. 06	0.008	26.341	26.399	27.147	26.789
2006. 07	0.053	18.106	16.553	21.093	19.911
2006. 08	-0.084	7.143	8.789	11.747	13.992
2006. 09	-0.027	26.039	26.582	27.663	27.846
2006. 10	0.077	20.604	19.738	22.384	20.948
2006. 11	-0.131	9.649	12.476	10.301	12.384
2006. 12	0.030	-4.286	-5.393	-1.294	-3.473
2007. 01	0.027	7.018	6.583	8.445	8.715
2007. 02	-0.154	11.083	14.380	9.973	13.472
2007. 03	0.039	21.039	19.506	20.828	18.620
2007. 04	-0.112	21.186	24.412	21.606	23.167
2007. 05	0.001	17.448	17.845	11.590	13.103
2007. 06	-0.117	19.647	21.957	18.952	21.355
2007. 07	-0.164	6.079	10.685	0.635	4.076
2007. 08	-0.086	14.324	16.898	17.107	20.016
2007. 09	-0.139	15.013	17.961	15.909	17.870
2007. 10	-0.091	16.877	19.670	18.709	19.277
2007. 11	-0.006	12.088	11.984	15.607	14.864
2007. 12	-0.074	-9.366	-7.061	-11.254	-8.097
2008. 01	0.005	-8.310	-8.641	-7.593	-7.249
2008. 02	0.004	-3.550	-3.711	-3.571	-1.277
2008. 03	-0.069	16.716	17.708	23.012	23.355
2008. 04	-0.114	2.095	6.301	2.746	8.195
2008. 05	-0.014	3.208	3.602	4.456	4.509
2008. 06	-0.016	-3.929	-3.609	-2.602	-1.194
2008. 07	-0.040	-5.882	-4.761	-2.595	-0.070
2008. 08	0.048	-8.768	-10.230	-9.559	-10.218
2008. 09	0.055	-12.245	-13.544	-9.100	-11.638

2008. 10	0.057	-5.128	-7.450	-4.805	-6.139
2008. 11	0.126	-20.382	-23.626	-21.136	-25.247
2008. 12	-0.002	-38.497	-38.687	-41.483	-40.670
2009. 01	0.008	-41.561	-41.520	-43.431	-44.088
2009. 02	0.078	-43.936	-46.224	-44.844	-45.712
2009. 03	0.057	-29.485	-30.606	-26.437	-27.772
2009. 04	0.104	-10.118	-13.030	-4.887	-8.735
2009. 05	0.100	-15.789	-18.174	-15.527	-19.635
2009. 06	-0.097	-16.883	-14.475	-16.136	-13.747
2009. 07	0.065	-16.822	-18.768	-15.947	-17.029
2009. 08	-0.062	-12.615	-10.906	-9.579	-7.390
2009. 09	-0.046	-2.074	-0.800	1.738	2.939
2009. 10	0.032	-4.762	-5.730	-2.093	-4.082
2009. 11	0.009	-14.097	-14.427	-11.381	-11.957
2009. 12	-0.037	-16.873	-15.898	-16.688	-15.222
2010. 01	0.106	-19.689	-22.429	-17.795	-20.537
2010. 02	0.015	-21.795	-22.080	-13.889	-14.848
2010. 03	0.040	-4.878	-5.730	4.321	2.619
2010. 04	0.075	17.481	15.923	23.438	22.081
2010. 05	0.008	1.538	1.374	7.801	8.098
2010. 06	0.045	7.101	6.149	10.938	10.840
2010. 07	0.072	5.370	3.520	8.970	7.869
2010. 08	0.001	2.079	2.032	4.649	5.053
2010. 09	-0.002	15.909	16.105	20.730	21.643
2010. 10	-0.021	18.182	18.950	21.002	22.462
2010. 11	0.028	10.480	9.722	15.000	15.055
2010. 12	0.040	-3.233	-4.438	-1.293	-2.962
2011. 01	-0.168	-17.995	-13.702	-11.412	-7.113
2011. 02	0.011	-7.709	-8.041	-2.022	-3.230
2011. 03	0.088	4.176	2.024	10.997	8.131
2011. 04	-0.049	19.672	20.988	25.957	27.865
2011. 05	-0.131	0.685	3.558	3.855	5.951
2011. 06	-0.051	5.336	6.772	7.271	9.559
2011. 07	-0.023	-3.385	-2.767	-2.130	-3.414
2011. 08	0.003	-1.003	-1.088	1.832	-0.002
2011. 09	0.020	9.882	9.510	13.275	12.515
2011. 10	0.036	7.982	7.012	13.002	12.207
2011. 11	-0.039	-7.112	-6.066	-1.513	0.250

2011. 12	0.069	-11.184	-13.629	-8.237	-12.205
2012. 01	-0.066	-12.918	-11.540	-8.608	-6.180
2012. 02	-0.106	-13.115	-9.967	-9.553	-6.060
2012. 03	0.010	-2.961	-3.290	2.398	0.998
2012. 04	-0.050	5.172	6.315	10.286	10.795
2012. 05	0.089	-4.478	-6.960	-3.255	-4.299
2012. 06	-0.044	-0.481	0.422	2.209	2.927
2012. 07	0.130	-16.582	-21.129	-16.755	-21.462
2012. 08	0.060	-13.854	-15.339	-8.136	-9.157
2012. 09	-0.074	-3.817	-2.021	0.795	1.774
2012. 10	-0.035	-9.204	-8.231	-4.314	-3.284
2012. 11	-0.013	-6.824	-6.661	-3.760	-3.489
2012. 12	-0.058	-25.197	-22.897	-24.586	-21.821
2013. 01	0.057	-28.682	-29.088	-27.724	-27.381
2013. 02	-0.011	-18.663	-18.740	-14.137	-15.015
2013. 03	-0.069	-22.590	-21.035	-16.138	-13.977
2013. 04	0.086	-7.735	-9.957	-1.613	-4.286
2013. 05	0.039	-11.141	-12.248	-7.582	-8.413
2013. 06	0.044	-9.227	-10.244	-5.753	-6.167
2013. 07	-0.017	-3.676	-3.198	0.414	2.169
2013. 08	0.107	-4.935	-7.593	-0.579	-2.941
2013. 09	0.148	2.920	-0.564	7.692	4.857
2013. 10	0.017	7.305	6.846	13.117	13.100
2013. 11	-0.010	-1.018	-0.786	4.853	4.437
2013. 12	-0.101	-11.719	-9.378	-9.610	-7.342
2014. 01	-0.036	-16.623	-15.994	-10.725	-9.350
2014. 02	-0.090	-9.499	-7.411	-6.051	-3.751

Source: own calculations on the basis of RIED data.

Appendix 3

Basic descriptive statistics in % for various variables (state) gathered by RIED business tendency survey of industrial enterprises.

	Proportion of matched sample	Proportion of above normal respondents	Proportion of below normal respondents	Difference between proportions	Absolute difference
		Level of production			
min	57.3	51.3	55.4	-16.8	0.1
max	83.0	86.9	86.3	14.8	16.8
mean	74.3	73.4	73.9	-0.5	5.7
		Total orders			
min	57.6	50.5	59.6	-17.9	0.0
max	83.0	90.9	86.5	13.6	17.9
mean	74.3	73.5	75.0	-1.5	5.1
		Finished goods inventories			
min	57.2	56.4	58.6	-24.4	0.1
max	82.6	90.8	88.2	22.3	24.4
mean	74.0	74.0	73.7	0.3	6.1
		Prices			
min	57.3	51.5	48.1	-26.5	0.0
max	82.9	90.7	92.1	21.9	26.5
mean	74.2	72.2	73.6	-1.4	7.9
		Employment			
min	56.9	43.5	52.5	-26.1	0.1
max	82.8	92.7	86.2	19.3	26.1
mean	74.3	70.3	72.6	-2.2	7.1
		Financial standing			
min	57.2	49.3	57.6	-28.5	0.1
max	82.8	95.0	87.2	14.3	28.5
mean	74.3	73.3	73.8	-0.5	5.8

Source: own calculations on the basis of RIED data.

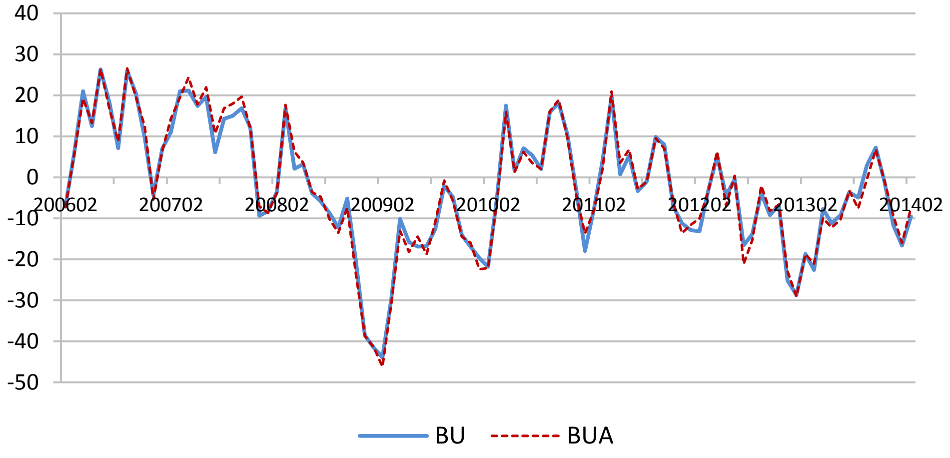
Basic descriptive statistics in % for various variables (forecast) gathered by RIED business tendency survey of industrial enterprises.

	Proportion of matched sample	Proportion of above normal respondents	Proportion of below normal respondents	Difference between proportions	Absolute difference
			Level of production		
min	57.2	53.2	54.5	-25.4	0.1
max	82.8	88.1	88.1	18.7	25.4
mean	74.1	71.9	74.4	-2.5	5.7
			Total orders		
min	57.2	54.5	58.0	-18.3	0.0
max	82.9	93.2	87.4	16.3	18.3
mean	74.1	72.6	75.0	-2.4	5.6
			Finished goods inventories		
min	57.2	51.8	56.3	-21.3	0.4
max	82.7	90.5	89.6	27.6	27.6
mean	73.8	73.5	73.7	-0.2	7.4
			Prices		
min	57.2	45.3	44.4	-20.6	0.3
max	83.5	95.7	93.6	31.1	31.1
mean	74.1	71.9	73.6	-1.7	7.8
			Employment		
min	57.1	49.2	54.3	-27.1	0.0
max	83.1	94.7	86.7	20.8	27.1
mean	74.1	69.1	72.8	-3.7	8.2
			Financial standing		
min	57.1	52.5	56.7	-19.3	0.1
max	82.8	93.0	88.5	14.8	19.3
mean	74.2	72.7	74.9	-2.1	6.4

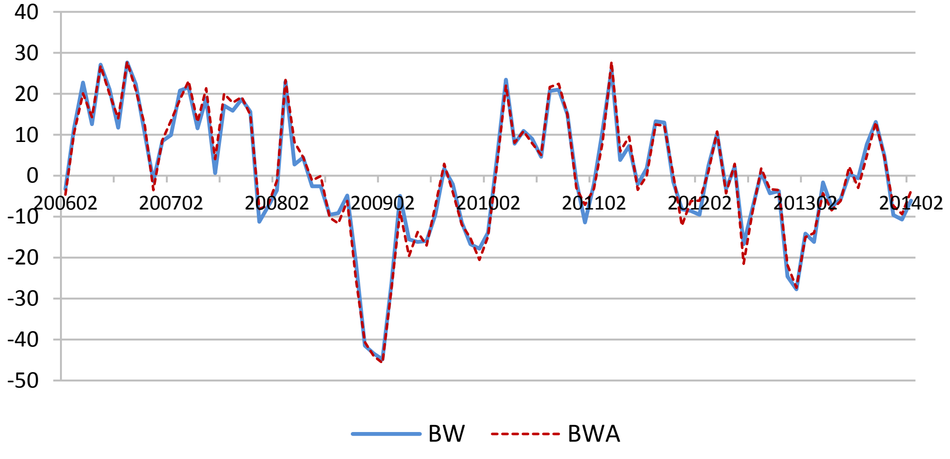
Source: own calculations on the basis of RIED data.

Appendix 4

Unweighted original (BU) and adjusted (BUA) balance statistics: level of production – state.



Weighted original (BW) and adjusted (BWA) balance statistics: level of production – state



Appendix 5

Time series of three types of balances: original weighted; weighted adjusted (introduced in this paper), and weighted and adjusted to the population structure (adjusted by an alternative method) for level of production (state).