STATISTICS IN TRANSITION-new series, October 2010
Vol. 11, No. 2, pp. 403—422

INFLUENCE OF NON-RESPONSE IN BUSINESS TENDENCY SURVEYS ON PROPERTIES OF EXPECTATIONS

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ABSTRACT

Expectations concerning key economic variables certainly influence decisions undertaken by economic agents. Since assumption of rationality forms the basis of neoclassical economic theory, question of whether expectations of industrial enterprises are indeed formed rationally deserves careful attention. Direct data on expectations are available mainly through business tendency surveys. Non-response problem is present in almost every survey, and much higher non-response rates are observed for expectations than for realizations. Weighting systems used to control for size of respondents may also introduce bias into expectations data derived from business tendency surveys. In this paper, we analyze two basic properties of expectations rational in the sense introduced by J. F. Muth – that is, unbiasedness and orthogonality – taking into account issue of non-response and weighting schemes. We propose several sample balance statistics to correct for changing sample structure that results from non-response; it depends on time, and is different from general population. We find that rationality of expectations of Polish industrial firms is not sensitive to these factors: independently from non-response and weighting issues, expectations concerning relative changes in production remain unbiased but not efficient with respect to freely available information.

Key words: expectations, rationality, tendency surveys, industrial production, non-response, weighting, survey data, qualitative data, post-stratification

1. Introduction

Economic agents are usually assumed to be rational; and while the term itself is variously defined, ranging from strict to bounded to imperfect rationality, the rationality assumption remains at the core of modern economics. Yet its accuracy

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and realism are often called into question, and tests of rationality constitute a major branch of modern economic research.

In this paper, we analyze properties of rational expectations, as introduced in 1961 by J. F. Muth, taking several weighting systems and non-response issues into consideration. Our previous work on influence of non-response on rationality (Kowalczyk, Tomczyk [2008]) was based on contingency tables summarizing individual-level data; now we turn to classical rationality tests and in addition to non-response problem, we also consider several weighting systems employed to scale survey data.

In section 2 we briefly describe Muth's Rational Expectations Hypothesis and methods of testing properties of rational expectations. In section 3 we employ three different weighting systems to business tendency survey data, and in section 4, we present problems emerging from non-response and propose a balance statistic that accounts for sample structure variability. In sections 5 and 6, we present and compare balance statistics, taking into account non-response and various weighting schemes, and describe quantification procedures. In section 7, we present results of unbiasedness and orthogonality tests with respect to production expectations expressed by Polish firms in business tendency surveys, taking a range of weighting schemes as well as and non-response into consideration. Section 8 concludes.

2. Rational Expectations Hypothesis and its testing

Tests of rationality constitute major part of the economic research on expectations; popularity of this branch of analysis is well documented in both theoretical and empirical literature. Numerous publications focus on the Rational Expectations Hypothesis (REH), introduced in 1961 by J. F. Muth. He defines expectations as rational if, being educated forecasts of future values of economic variables, they are equal to expected values of these variables as reflected in predictions formed on the basis of the relevant economic theory. REH postulates that economic agents make use of all available (and pertinent) information in timely and effective manner, and that they understand their environment well enough to correctly predict its future behaviour. While many criticisms have been aimed at REH since its introduction, majority of them citing information asymmetries, information selection and processing costs, and influence of learning processes, its importance as an empirical hypothesis subject to empirical verification has not been questioned.

Muth's formulation of REH is very general. Several specific tests of rationality of expectations have been proposed for the purpose of its empirical verification, the most common being tests of unbiasedness and orthogonality.

Expectations are considered unbiased if they do not systematically overestimate or underestimate values of an economic variable. Let ${}_t x_{t+s}$ stand for relative change in variable x between t and $t + s$, as noted in official statistics, and

${}_t x^e_{t+s}$ – expected relative change in the same period, as derived from survey data.[1] The standard unbiasedness test of expectations is defined by the hypothesis

$$\mathrm{H}_0\colon\ \alpha_0 = 0\,,\ \ \alpha_1 = 1\,, \tag{2.1}$$

where α_0 and α_1 are parameters of the regression equation

$${}_t x_{t+s} = \alpha_0 + \alpha_1 \cdot {}_t x^e_{t+s} + \xi_t\,, \tag{2.2}$$

and error term ξ_t is assumed to be a white noise process.[2]

Property of orthogonality is defined through expectations error, that is, difference between observed and expected values of a variable. Expectations are termed orthogonal if expectations error is uncorrelated with information available at the moment when expectations were formed; that is, all relevant information has already been incorporated into the forecast. Test of orthogonality of expectations error in relation to information set **Π** is described by the hypothesis

$$\mathrm{H}_0\colon\ \alpha_i = 0\,,\quad i = s,\, s+1,\, ...,\, T, \tag{2.3}$$

where α_i are parameters of the regression equation

$$\left({}_t x_{t+s} - {}_t x^e_{t+s}\right) = \alpha_0 + \sum_{i=t+s}^{T} \alpha_i z_{t-i} + \xi_t\,, \tag{2.4}$$

$z_{t-i} \in \mathbf{\Pi}$, and error term ξ_t is a white noise process. Orthogonality tests require that elements of information set faced by economic agents (that is, variables z_{t-i}) be specified. In empirical setting, they include arbitrarily selected set consisting of series that are likely to have been considered relevant by economic agents. If expectation errors are not orthogonal to freely available and relevant information, then forecasting process may be interpreted as inefficient because expectations could be improved by incorporating information provided by variables z_{t-i}.

Standard approach to evaluating REH is based on tests if observed expectations series fulfill conditions for unbiasedness (2.1) and orthogonality (2.3). Before tests of these properties can be undertaken, expectations series ${}_t x^e_{t+s}$ must be obtained – typically on the basis of survey data or, rarely, controlled experiments. Rapid development of questionnaires as source of information on expectations dates back to the second half of the 20th century and coincides with development of business conditions surveys. They combine assessment of current situation with expectations (forecasts) and constitute a promising source of data

[1] Methods of derivation of quantitative expectations series on the basis of qualitative survey data are briefly described in section 5.

[2] The RC (restricted cointegration) unbiasedness test (Liu, Maddala [1992]) is not considered here due to small sample available for analysis.

for tests of rationality (as well as data necessary for quantification procedures; see section 6). It must be stressed that in surveys expectations are declared and not directly observed.[1]

Since the 1970s extensive literature on rationality of expectations has been published. Empirical results have generally been inconclusive, and highly dependent on time period considered, variables selected for analysis, methods of data aggregation, forecast horizon, specification of econometric tests, and other factors. In Poland, subject of rationality of economic agents emerged along with transformation of the Polish economic system from centrally planned to market economy in the early 1990s. Tests of properties of REH carried out on Polish data on expectations provided results similar to those obtained from research conducted in the United States and Western Europe, that is, sensitive to several factors and not leading to unambiguous results (see Osińska [2000], Łyziak [2003], Tomczyk [2004, 2008]).

In this paper, we aim to re-address the issue and to contribute to the still relatively new field of tests of rationality for Polish economic agents. In addition to testing properties exhibited by expectations rational in the sense introduced by J. F. Muth, we consider two additional dimensions: problem of non-response in business tendency surveys that supply expectations data, and weighting systems employed to adjust the original data for differences in respondent size.

Non-response is widely cited as the main source of non-sampling errors in survey data. Errors resulting from non-response are probably non-random; it cannot be safely assumed that non-response has no systematic effect on results of tests of rationality because respondents who refuse to answer may also exhibit unique characteristics that influence their answers and are correlated with their degree of rationality. Non-response also introduces variability of sample structure in time; we address this problem in section 4.

As far as we are aware, weighting systems have not been analyzed from the point of view of properties of expectations formation processes. In case of industrial enterprises, weight is assigned according to size reflected in employment numbers or value of production. We propose to test if various weighting schemes influence the results of rationality tests. Since weighting amounts to granting more influence to data supplied by a large enterprise than a small one, expectations count 'more' if expressed by a large firm. We propose to verify if the results of rationality tests differ when every respondent is treated equally, or according to several reasonable weighting systems, described in the next section.

[1] In macroeconomic modeling, indirect measurement of expectations is also considered; for summary, see Sheffrin [1996].

3. Weighting systems

The unweighted balance statistics are defined for current situation evaluated by survey respondents as

$$ {}_{t}BA_{t+k} = {}_{t}A^{1}_{t+k} - {}_{t}A^{3}_{t+k}, \tag{3.1} $$

and for expectations as

$$ {}_{t}BP_{t+k} = {}_{t}P^{1}_{t+k} - {}_{t}P^{3}_{t+k}, \tag{3.2} $$

where

${}_{t}A^{1}_{t+k}$ – percentage of respondents reporting improvement between t and $t + k$,

${}_{t}A^{2}_{t+k}$ – percentage of respondents reporting no change between t and $t + k$,

${}_{t}A^{3}_{t+k}$ – percentage of respondents reporting decline between t and $t + k$,

${}_{t}P^{1}_{t+k}$ – percentage of respondents expecting improvement between t and $t + k$,

${}_{t}P^{2}_{t+k}$ – percentage of respondents expecting no change between t and $t + k$,

${}_{t}P^{3}_{t+k}$ – percentage of respondents expecting decline between t and $t + k$.

In case of industrial enterprises, size of employment or value of turnover are typically used as weights. Data on expectations of Polish industrial enterprises have been collected since 1986 by the Research Institute for Economic Development (RIED) at the Warsaw School of Economics through business tendency surveys. Launched for manufacturing industry, currently they also cover households, farming sector, exporters, construction industry, and banking sector. Empirical part of this paper is based on the monthly survey addressed to industrial enterprises. Each survey question asks respondents to evaluate both current situation (as compared to last month) and expectations for the next 3 – 4 months by assigning them to one of three categories: increase / improvement, no change, or decrease / decline (see Appendix 1). Aggregated survey results are regularly published and commented on in RIED bulletins: each month, a number of respondents is announced, along with a percentage of respondents who observed increase / no change / decline and who expect increase / no change / decline in a given area of economic activity, along with a balance statistic calculated as a difference between percentage of 'optimists' (those who judge current situation favorably or predict improvement) and 'pessimists' (those who evaluate present situation unfavorably or predict decline), according to formulas (3.1) and (3.2). Because of ambiguous wording of the questionnaire ("expectations for the next 3 – 4 months"), clarification of the forecast horizon is necessary. On the basis of previous analysis of the RIED data (see Tomczyk [2004]) we are able to limit our attention to the three-month horizon. That is, for the remaining part of the paper,

expectations horizon $k = 3$. When evaluating the current state, respondents are asked for comparison with previous month, hence for realizations $k = 1$.

In RIED survey, neither size of employment nor turnover are known; only the interval to which employment belongs is given. Five intervals are distinguished:

- up to 50 persons,
- 51 to 250 persons,
- 251 to 500 persons,
- 501 to 2000 persons,
- over 2000 persons.

In the RIED survey, respondents are weighted by 1, 2, 3, 4 and 5 respectively, depending to which employment interval the given enterprise belongs (see RIED [2008]). This arbitrarily chosen system of weights, and consequently results obtained on its basis, may be questioned. As far as we are aware, no comparison of values of balance statistics calculated for different weighting systems, or of expectations series derived on the basis of these systems, has been attempted so far for Polish survey data.

We propose to analyze three different systems of weights:

1. **No weighting.** Respondents are not weighted – that is, every respondent receives the same weight equal to 1.
2. **RIED weighting.** Respondents are weighted by 1, 2, 3, 4 and 5 respectively, depending on which employment interval they belong to.
3. **Weighting by lower limit of the employment interval.** Respondents are weighted by 1, 51, 251, 501 and 2001 respectively, depending on which employment interval they belong to.[1]

To obtain the mathematical form of balance statistics, first we define the variables x_A, x_P and y_A, y_P as:

$$x_A = \begin{cases} 1 & \text{if respondent reported improvement between t and } t+k \\ 0 & \text{in other case} \end{cases}$$

$$y_A = \begin{cases} 1 & \text{if respondent reported detoriation between t and } t+k \\ 0 & \text{in other case} \end{cases}$$

$$x_P = \begin{cases} 1 & \text{if respondent is expecting improvement between t and } t+k \\ 0 & \text{in other case} \end{cases}$$

$$y_P = \begin{cases} 1 & \text{if respondent is expecting detoriation between t and } t+k \\ 0 & \text{in other case} \end{cases}$$

[1] The lower limit has been chosen because the upper limit is not attained in case of the largest enterprises, and the lower limit seems to adequately account for differences in sizes of enterprises.

Weighted balance statistics defined for current situation evaluated by survey respondents are then obtained as[1]:

$$ {}_t BA_{t+k} = \frac{\sum w_1 x_{Ai} + ... + \sum w_5 x_{Ai}}{n_1 w_1 + ... + n_5 w_5} \cdot 100 - \frac{\sum w_1 y_{Ai} + ... + \sum w_5 y_{Ai}}{n_1 w_1 + ... + n_5 w_5} \cdot 100 \quad (3.3) $$

and for expectations as:

$$ {}_t BP_{t+k} = \frac{\sum w_1 x_{Pi} + ... + \sum w_5 x_{Pi}}{n_1 w_1 + ... + n_5 w_5} \cdot 100 - \frac{\sum w_1 y_{Pi} + ... + \sum w_5 y_{Pi}}{n_1 w_1 + ... + n_5 w_5} \cdot 100 \quad (3.4) $$

It is clear that for $w_i = 1$, i =1, 2, …, 5 formulas (3.3) and (3.4) reduce to (3.1) and (3.2), respectively.

4. Problem of non-response

Non-response is present in almost all surveys, but the extent and the effect of non-response can vary greatly from one type of survey to another. In RIED business tendency survey the problem of non-response is very significant. Table 4.1 shows the planned sample sizes (number of questionnaires sent), and the actual sample sizes (number of questionnaires received) from January to December 2009.[2]

Table 4.1. Sample sizes and non-response rates.

Period	Planned sample size	Actual sample size	Non-response rate
08.01	1275	362	71.6
08.02	1272	339	73.3
08.03	3303	675	79.6
08.04	2218	530	76.1
08.05	1359	533	60.8
08.06	1353	562	58.5
08.07	1358	512	62.3
08.08	1348	484	64.1
08.09	1346	493	63.4
08.10	1486	431	71.0
08.11	1479	475	67.9
08.12	1479	443	70.0

Source: Authors' calculations.

[1] In all expressions, $\sum x_i$ is abbreviated notation for $\sum_{i \in S} x_i$, where *S* stands for appropriate sample strata. When elements are summed over another set, it is clearly stated.

[2] Non-response has been recorded by RIED only since 2008; previous non-response rates are not known.

The unit non-response rates are very high – in 2008, they oscillate from 58.5% to 79.6%. There may be different causes for such a visible non-response in RIED business tendency survey; experience shows that refusal is its most frequent reason. Two main problems related to non-response are the following:

- structure of the sample does not reflect the structure of the population,
- structure of the sample changes in time.

Table 4.2 shows the structure of the population of manufacturing firms with respect to size of employment according to The Central Statistical Office (CSO) of Poland (GUS [2008]).

Table 4.2. Structure of the population, Central Statistical Office

Employment strata	2007 population	2007 population, %
up to 9 persons	333,426	88.91
10-49	32,100	8.56
50-249	7864	2.10
250-999	1406	0.37
1000 and more	219	0.06

Source: Central Statistical Office of Poland.

Combining employment strata available from The Central Statistical Office data and employment strata available from RIED sample, we compute the following structure of the population and the sample[1] and present the results in Table 4.3, with detailed results provided in Appendix 2.

Table 4.3. Comparison of population and RIED sample structures

Employment level	2007 population, %	December 2008 sample, %
To 50 persons	97.47	43.3
51-250	2.10	31.6
Over 250	0.43	25.1

Source: Authors' calculations on the basis of Central Statistical Office data.

From Table 4.3 it is clear that the structure of the population differs significantly from the structure of the sample. Moreover, the structure of the sample also changes considerably in time. The share of industrial enterprises with employment level up to 50 persons oscillates from 36.9% to 57.2%; with employment level 51-250 persons – from 24.7% to 32.3%; and with employment level over 250 persons – from 17.7% to 32.3% (see Appendix 2). Such significant

[1] The few enterprises with undefined employment level are assumed by RIED to belong to the interval "up to 50 persons"; we follow this practice in our calculations.

disproportions should not be neglected, but have not been analyzed so far. More precisely, although the structure of the sample is different from the structure of the population and changes significantly in time (e.g. the largest industrial enterprises represent in one month 17.7% of the sample and in another month 32.3% of the sample, and their answers are additionally weighted by the factor of 5), original RIED balance statistics do not address this issue.

In order to account for variable structure of the sample and its divergence from population structure we propose a balance statistics, which for current situation is evaluated by survey respondents and is given as[1]:

$$
\begin{aligned}
{}_{t}BA_{t+k} = & \frac{\frac{N_1}{n_1}\sum w_1 x_{Ai} + \frac{N_2}{n_2}\sum w_1 x_{Ai} + \frac{N_3}{n_3}\sum w_3 x_{Ai}}{N_1 w_1 + N_2 w_2 + N_3 w_3} \cdot 100 - \\
& - \frac{\frac{N_1}{n_1}\sum w_1 y_{Ai} + \frac{N_2}{n_2}\sum w_1 y_{Ai} + \frac{N_3}{n_3}\sum w_3 y_{Ai}}{N_1 w_1 + N_2 w_2 + N_3 w_3} \cdot 100
\end{aligned}
\tag{4.1}
$$

and for expectations as:

$$
\begin{aligned}
{}_{t}BP_{t+k} = & \frac{\frac{N_1}{n_1}\sum w_1 x_{Pi} + \frac{N_2}{n_2}\sum w_1 x_{Pi} + \frac{N_3}{n_3}\sum w_3 x_{Pi}}{N_1 w_1 + N_2 w_2 + N_3 w_3} \cdot 100 - \\
& - \frac{\frac{N_1}{n_1}\sum w_1 y_{Pi} + \frac{N_2}{n_2}\sum w_1 y_{Pi} + \frac{N_3}{n_3}\sum w_3 y_{Pi}}{N_1 w_1 + N_2 w_2 + N_3 w_3} \cdot 100
\end{aligned}
\tag{4.2}
$$

Combining employment strata available from The Central Statistical Office data and employment strata available in RIED sample we obtain three pooled strata for employment intervals:

- up to 50 persons,
- 51–251 persons,
- over 250 persons,

for which 2007 population sizes are known, and are equal to: [2]

- $N_1 = 365526$,
- $N_2 = 7864$,
- $N_3 = 1625$,

[1] This form of balance statistics corresponds to post-stratification estimator (non-response weighting). Let us note that for proportional sample formulas (4.1) and (4.2) reduce to formulas (3.3) and (3.4) respectively.

[2] Empirical analysis described in sections 6 and 7 is based on data from January 2006 to January 2009; year 2007 was selected as a base year since population data for 2008 is not yet available.

and n_i, $i = 1, 2, 3$ stand for sample sizes in respective strata.

As far as weights w_i are concerned, we have the following alternatives:

- in case of no weighting, $w_i = 1$,
- in case of RIED weighting, we consider two variants of weights: $w_1 = 1$, $w_2 = 2$, $w_3 = 3$, and $w_1 = 1$, $w_2 = 2$, $w_3 = 4$,[1]
- in case of weighting by the lower limit of the employment level, $w_1 = 1$, $w_2 = 51$, and $w_3 = 251$.

5. Comparison of alternative balance statistics

Our empirical analysis focuses on question number 1, industrial production, for two reasons: first, production expectations influence numerous decisions of firms (among them, investment and employment levels); second, it has well-defined counterpart in official statistics which is necessary to employ quantification methods described below. Our dataset covers monthly data from January 2006 to January 2009 ($n = 37$).[2]

Let us introduce the following notation. On the basis of formulas (3.3) and (3.4) (that is, before consequences of non-response are taken into consideration), the following alternatives are analyzed:

A – no weighting (all respondents are weighted by 1),

B – RIED weighting (respondents are weighted by 1, 2, 3, 4 and 5 according to employment level),

C – weighting by lower limit of the employment interval (that is, by 1, 51, 251, 501 and 2001 respectively).

On the basis of formulas (4.1) and (4.2), when consequences of non-response addressed in this paper are taken into account, the following alternatives are analyzed:

D – no weighting (all respondents are weighted by 1),

E – RIED weighting (respondents are weighted by 1, 2, and 3, respectively),

F – RIED weighting (respondents are weighted by 1, 2, and 4, respectively),

G – weighting by lower limit of the employment interval (that is, by 1, 51, 251, 501 and 2001 respectively).

Current state balance statistics calculated on the basis of formulas (3.3) and (4.1) for different systems of weights of course differ one from another, as do balance statistics for expectations obtained from formulas (3.4) and (4.2). In Appendix 3, we present comparison of balances, both for current state and

[1] Intervals defined by RIED do not correspond to those defined by CSO and consequently unambiguous definition of weights in not possible. In order to make our analysis more general we consider two weighting schemes.

[2] For analysis of weighting and non-response patterns, access to individual-level data was necessary. Authors wish to thank employees of the Research Institute for Economic Development (RIED) at the Warsaw School of Economics for data pre-processing to permit empirical analysis without compromising confidentiality of survey information.

expectations. On the basis of the empirical results we arrive at the conclusion that balances calculated on the basis of formulas (4.1) and (4.2), which take into account variable structure of the sample, are less sensitive to the choice of weights as compared to balances calculated on the basis of formulas (3.3) and (3.4) where the structure of the sample is not taken into consideration. As far as evaluation of current state is concerned, mean of absolute values of differences between balances for any two alternatives and 37 time periods oscillate from 2.23 to 6.72 for balances calculated from (3.3), and from 0.21 to 5.28 for balances calculated from (4.1). Range of differences for 37 time periods oscillates from 6.27 to 24.89 for balances calculated from (3.3), and from 0.6 to 15.63 for balances calculated from (4.1). Turning to expectations series, mean of absolute values of differences between balances for any two alternatives and 37 time periods oscillates from 1.54 to 6.56 for balances calculated from (3.4), and from 0.18 to 3.64 for balances calculated from (4.2). Range of differences for 37 time periods oscillates from 4.25 to 16.74 for balances calculated from (3.4) and from 0.7 to 15.08 for balances calculated from (4.2); for details see Appendix 3.

Empirical results are consistent with our intuition that balance statistics which takes into account variable, and different from population, structure of the sample should be less sensitive to choice of weights than balance statistics obtained in case when structure of the sample is ignored.

6. Quantification of survey data

Balance statistic given by (3.2) is a very simple quantitative measure of qualitative expectations expressed in business surveys. More advanced options are offered by probabilistic and regressive quantification methods.[1] In this paper, two versions of regression method are employed: Anderson and Thomas' models. In Anderson's model, introduced in 1952, the following equation is estimated:

$$ {}_t x_{t+1} = \alpha \cdot {}_t A^1_{t+1} + \beta \cdot {}_t A^3_{t+1} + \nu_t , \tag{6.1} $$

where ${}_t x_{t+1}$ describes relative changes in value of variable x noted in official statistic between t and $t + 1$. Assuming that the same relationship holds true for expectations reported in surveys, and that error term in equation (6.1) meets standard OLS assumptions,[2] parameters α and β are estimated, and quantitative measure of expectations is constructed on the basis of the following equation:

$$ {}_t \hat{x}^e_{t+1} = \hat{\alpha} \cdot {}_t P^1_{t+3} + \hat{\beta} \cdot P^3_{t+3} , \tag{6.2} $$

[1] For a concise review of basic quantification methods and their modifications see Pesaran [1989].

[2] In practice, HAC standard errors are used to account for possible serial correlation and/or heteroskedasticity of the error term in (6.1) and (6.3).

where $\hat{\alpha}$ and $\hat{\beta}$ are OLS-estimators of (6.1) and reflect average change in variable ${}_t x_{t+1}$ for respondents expecting, respectively, increase and decrease of this variable. Let us note that expectations balance statistic (3.2) is a special case of Anderson's expectations series (6.2) for $\hat{\alpha} = -\hat{\beta} = 1$.

To tailor the (very general) Anderson's model for the case when normal or typical situation that respondents compare their current situation to include a certain growth rate, making downward corrections more essential than upward, D. G. Thomas, in 1995, offered a modification. To account for the asymmetry he proposes to estimate

$$ {}_t x_{t+1} = \gamma + \beta \cdot {}_t A^3_{t+1} + \xi_t , \tag{6.3}$$

where $\beta < 0$, and constant γ is interpreted as typical growth rate. Model described by (6.3) reflects assumption that behaviour of economic agents is dependent on growth rate of a variable (usually production or prices) that the enterprise typically observes, and limits the degree of multicollinearity which often emerges in Anderson's model. Thomas' quantitative measure of expectations is given by the formula

$$ {}_t \hat{x}^e_{t+1} = \hat{\gamma} + \hat{\beta} \cdot {}_t P^3_{t+3} , \tag{6.4}$$

where $\hat{\gamma}$ and $\hat{\beta}$ are estimates obtained on the basis of (6.3).

Quantification procedures described above apply also in cases when weighted data are used (see formula (3.3)) and non-response is taken into account (see formula (4.1)).

None of the quantification methods proposed in literature proved to be generally superior; their performance depends on several factors, including dynamics of forecasted variables and time horizon considered. Quantified expectations series do not provide a perfect reflection of true expectations because in addition to measurement errors present in all economic data series, they are also burdened with aggregation and quantification errors introduced by imperfect quantification procedures. Even though both models considered in this section are rather simple, they provide encouraging results, and often prove superior to balance statistics. In the next section, both methods are used to quantify expectations concerning industrial production.

7. Results of rationality tests

We use both Anderson (6.1) and Thomas' (6.3) methods to quantify expectations data provided by the RIED survey in cases **A** – **G**. All quantification models are estimated by OLS with HAC standard errors to account for possible serial correlation of the error term (due to inertia often observed in expectations

series) and heteroskedasticity (likely to result from learning patterns imbedded in expectations formation processes). Both methods provide very similar results for all seven expectations series considered; neither weighting scheme nor non-response issues considered in this paper seem to influence results of quantification procedures. All explanatory variables exhibit correct signs and are statistically significant at the 5% significance level; RESET test also does not allow to differentiate between two competing methods (for summary of estimation results, see Appendix 4). On the basis of slightly better measures of fit, Anderson's models are selected for further analysis.

To confirm similarity of results across expectations series, averages and standard deviations of quantitative expectations series derived for **A–G** are compared in Table 7.1.

Table 7.1. Basic descriptive statistics for expectations data series

	A	B	C	D	E	F	G
Average	0.0238	0.0241	0.0243	0.0223	0.0225	0.0225	0.0238
Standard deviation	0.0168	0.0174	0.0232	0.0157	0.0158	0.0158	0.0171

Source: Authors' calculations.

It is clear that Anderson's quantification model (as well as Thomas'; see Appendix 4) is not sensitive to weighting or non-response issues considered, and quantitative series obtained on its basis are likely to have similar properties. This finding seems favorable from practical point of view because properties of expectations series analyzed in this paper appear to be insensitive to modifications of survey weighting schemes and sample structure, and therefore more reliable.

Let us note that expectations series derived for case **C** exhibits noticeably higher variation than other series due to wide range of weights used (from 1 to 2001) combined with significant changes in sample structure that are not corrected by balance statistic formula. After taking non-response into consideration by applying formula (4.2), variation reduces to levels observed for other cases, as can be seen from **F** and **G**.

To verify if results of rationality tests depend on non-response or weighting schemes, all seven series **A–G** are submitted to unbiasedness test described by hypothesis (2.1). In each case, dependent variable $PP3_t$ is defined as currently observed relative change in industrial production as compared to three months ago; independent variable E_t represents expectations series calculated on the basis of expectations expressed three months earlier on the basis of Anderson's method. All models are estimated by OLS with HAC standard errors; estimation results are presented in Appendix 5, table A5.1. They provide evidence that all expectations series, independently from weighting systems and non-response issues considered, remain unbiased estimates of relative changes in production.

The final step in assessing whether results of rationality tests depend on abovementioned factors consists of orthogonality test defined by hypothesis (2.3). We define information set **Π** to include the following variables: *PP3* (relative change in industrial production as compared to three months ago); *AS* (current state balance statistic) and *PS* (expectations balance statistic) because all three variables are available to industrial enterprises at no additional costs. All variables are lagged two and three months to account, on one hand, for delay in availability of the data, and on the other hand for relatively short attention span that may be expected from managers who are not professional forecasters. All models are estimated with HAC standard errors; detailed results are presented in Appendix 5, table A6.2. They show that none of the expectations error series is orthogonal to the variables included in the information set, independently from weighting system and non-response issues considered; specifically, variables $PP3_{t-3}$ and PS_{t-2} are significant in all cases. This result suggests that industrial enterprises do not efficiently use information included in these series, and incorporating them in firms' information set could improve quality of their forecasts.

8. Concluding comments

We conclude that expectations concerning relative changes in industrial production expressed by Polish industrial enterprises in RIED business tendency surveys are unbiased but do not efficiently use all available information, namely, observed relative changes in production (lagged three months) and expectations balance (lagged two months).

These results remain in line with previous research on the subject. Prior tests of rationality of production expectations in Poland have given mixed results, but generally exhibited unbiasedness and lack of orthogonality with respect to lagged expectations balance statistics and observed changes in production (see Tomczyk [2001, 2004]). Review of rationality tests conducted on the basis of RIED data in 1997–2006 proved rationality an exception rather than a rule, and production expectations being relatively rational when compared to other variables (Tomczyk [2008 b]). Results of econometric tests of REH are confirmed by analyses of contingency tables: production expectations proved to be more rational, as measured by frequency with which they meet rationality condition imposed by the Gourieroux–Pradel theorem, than expectations on prices, employment, and general business situation (Tomczyk [2008 a]). Generally, expectations concerning changes in production proved to be either irrational but relatively precise when compared with other economic variables (in tests based on individual data aggregated in contingency tables), or unbiased and not orthogonal to freely available information (in standard econometric tests of REH). The latter result is confirmed in this paper.

The main objective of the paper was to test if properties of expectations series, particularly those pertaining to their rationality, are influenced by weighting

schemes and two major problems introduced by non-response, namely, the fact that structure of the sample does not reflect the structure of the population, and that it changes in time. We found that they are not; for every expectation series considered, results of standard rationality tests remain the same. Therefore, properties of expectations of Polish industrial enterprises are proved to be independent from modifications of survey weighting schemes and sample structure, and therefore more reliable.

Appendix 1. Monthly RIED questionnaire in industry

		Observed within last month	Expected for next 3–4 months
01	Level of production (value or physical units)	up unchanged down	will increase will remain unchanged will decrease
02	Level of orders	up normal down	will increase will remain normal will decrease
03	Level of export orders	up normal down not applicable	will increase will remain normal will decrease not applicable
04	Stocks of finished goods	up unchanged down	will increase will remain unchanged will decrease
05	Prices of goods produced	up unchanged down	will increase will remain unchanged will decrease
06	Level of employment	up unchanged down	will increase will remain unchanged will decrease
07	Financial standing	improved unchanged deteriorated	will improve will remain unchanged will deteriorate
08	General situation of the economy regardless of situation in your sector and enterprise	improved unchanged deteriorated	will improve will remain unchanged will deteriorate

Source: the RIED database.

Appendix 2. Sample structure with respect to combined RIED and CSO employment levels

Employment level	Period	Percentage	Period	Percentage	Period	Percentage
Up to 50 persons	0601	40.5	0701	48.5	0801	44.8
51-250	0601	32.8	0701	29.5	0801	32.3
Over 250	0601	26.7	0701	22.0	0801	22.9
Up to 50 persons	0602	46.5	0702	47.5	0802	47.5
51-250	0602	33.2	0702	31.2	0802	30.7
Over 250	0602	20.3	0702	21.4	0802	21.8
Up to 50 persons	0603	57.2	0703	46.8	0803	36.9
51-250	0603	24.7	0703	31.9	0803	30.8
Over 250	0603	18.1	0703	21.3	0803	32.3
Up to 50 persons	0604	50.3	0704	45.5	0804	51.7
51-250	0604	30.2	0704	31.2	0804	27.4
Over 250	0604	19.5	0704	23.3	0804	20.9
Up to 50 persons	0605	46.6	0705	44.0	0805	38.5
51-250	0605	31.6	0705	32.6	0805	31.3
Over 250	0605	21.8	0705	23.4	0805	30.2
Up to 50 persons	0606	52.2	0706	47.5	0806	40.4
51-250	0606	30.1	0706	31.7	0806	31.0
Over 250	0606	17.7	0706	20.9	0806	28.6
Up to 50 persons	0607	49.7	0707	47.4	0807	44.1
51-250	0607	30.4	0707	30.0	0807	30.3
Over 250	0607	19.9	0707	22.5	0807	25.6
Up to 50 persons	0608	48.6	0708	44.2	0808	44.4
51-250	0608	28.4	0708	33.2	0808	28.7
Over 250	0608	23.0	0708	22.6	0808	26.9
Up to 50 persons	0609	47.9	0709	47.1	0809	44.6
51-250	0609	29.9	0709	31.6	0809	27.6
Over 250	0609	22.2	0709	21.4	0809	27.8
Up to 50 persons	0610	47.1	0710	46.7	0810	42.0
51-250	0610	30.7	0710	30.9	0810	29.5
Over 250	0610	22.2	0710	22.4	0810	28.5
Up to 50 persons	0611	49.0	0711	47.4	0811	44.2
51-250	0611	30.1	0711	30.2	0811	26.5
Over 250	0611	20.9	0711	22.3	0811	29.3
Up to 50 persons	0612	45.2	0712	48.5	0812	43.3
51-250	0612	31.3	0712	30.1	0812	31.6
Over 250	0612	23.5	0712	21.4	0812	25.1

Source: Authors' calculations on the basis of RIED data.

Appendix 3. Comparison of alternative balance statistics

Table A3.1. Comparison of alternative balance statistics – current state[1]

	A-B	A-C	B-C	D-E	D-F	D-G	E-F	E-G	F-G
MAE	2.23	6.72	5.20	0.21	0.24	5.28	0.04	5.09	5.04
min	0.02	0.01	0.37	0.01	0.00	0.14	0.00	0.17	0.16
max	6.30	24.90	21.75	0.61	0.67	15.77	0.14	15.23	15.10
range	6.27	24.89	21.38	0.60	0.67	15.63	0.14	15.07	14.94

Source: Authors' calculations.

Table A3.2. Comparison of alternative balance statistics – expectations

	A-B	A-C	B-C	D-E	D-F	D-G	E-F	E-G	F-G
MAE	1.54	6.56	5.58	0.18	0.19	3.64	0.03	3.47	3.46
min	0.05	0.86	0.04	0.02	0.03	0.01	0.00	0.08	0.05
max	4.30	17.60	14.61	0.72	0.79	15.08	0.07	14.37	14.30
range	4.25	16.74	14.57	0.70	0.76	15.08	0.07	14.29	14.24

Source: Authors' calculations.

[1] MAE – mean of absolute values of differences between two balances for 37 periods; min – minimum difference between two balances for 37 periods; max – maximum difference between two balances for 37 periods; range = max – min.

Appendix 4. Quantification models: estimation results

Table A4.1. Anderson's model (6.1) with HAC standard errors

	A	B	C	D	E	F	G
A	0.0014	0.0014	0.0016	0.0014	0.0015	0.0015	0.0014
B	-0.0016	-0.0016	-0.0019	-0.0015	-0.0015	-0.0015	-0.0016
centered R^2	0.1048	0.1160	0.1784	0.0977	0.0985	0.0988	0.1089
AIC	-85.2921	-85.7601	-88.4678	-85.0023	-85.0302	-85.0428	-85.4593
RESET *p*-value	0.894	0.598	0.171	0.861	0.873	0.877	0.679

Table A4.2. Thomas' model (6.3) with HAC standard errors

	A	B	C	D	E	F	G
Γ	0.0669	0.0665	0.0669	0.0644	0.0648	0.0648	0.0664
B	-0.0027	-0.0027	-0.0028	-0.0024	-0.0025	-0.0025	-0.0027
R^2	0.1119	0.1207	0.1577	0.1100	0.1020	0.1022	0.1169
adjusted R^2	0.0865	0.0957	0.1337	0.0753	0.0764	0.0766	0.0916
AIC	-85.5852	-85.9576	-87.5477	-85.1343	-85.1764	-85.1845	-85.7929
RESET *p*-value	0.978	0.781	0.105	0.671	0.689	0.695	0.857

Appendix 5. Tests of rationality of expectations: estimation results

Table A5.1. Unbiasedness test (2.1) with HAC standard errors

	A	B	C	D	E	F	G
H_0 *p*-value	0.6163	0.5367	0.5684	0.7323	0.7244	0.7226	0.5796
α_0	-0.0385	-0.0413	-0.0300	-0.0320	-0.0325	-0.0326	-0.0398
α_1	2.0340	2.1270	1.6424	1.8826	1.8894	1.8909	2.0873
adjusted R^2	0.0974	0.1206	0.1298	0.0653	0.0671	0.0676	0.1091
Akaike IC	-63.9821	-64.8619	-65.2207	-62.7897	-62.8553	-62.8741	-64.4227
RESET *p*-value	0.408	0.316	0.172	0.391	0.397	0.397	0.344

Values on grey background are not statistically different from zero at 5% significance level.

Table A5.2. Orthogonality test (2.3) with HAC standard errors

	A	B	C	D	E	F	G
H_0 *p*-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
adjusted R^2	0.6774	0.6681	0.5464	0.6454	0.6491	0.6495	0.6828
Akaike IC	-98.048	-97.571	-87.972	-94.095	-94.503	-94.555	-98.863
RESET *p*-value	0.224	0.127	0.288	0.546	0.526	0.526	0.165

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