Abstract

Expectations of economic agents exert unquestionable influence on their decisions. Not surprisingly, analysis of properties of expectations formation processes often provides valuable insight for both explanation and prediction of economic behavior. The paper proposes to test whether expectations of Polish industrial enterprises are rational. Analysis of the rationality of expectations is based on direct tests of unbiasedness and orthogonality (in respect to selected elements of information set) within the framework of the Rational Expectations Hypothesis introduced by J. F. Muth. Both properties are necessary (though not sufficient) conditions for the expectations to be considered rational.

Empirical analysis is based on firm-level data collected by the Research Institute for Economic Development of the Warsaw School of Economics through business tendency surveys. In monthly surveys of industrial enterprises, respondents evaluate changes in selected areas of economic activity by assigning these changes to three categories: increase, decrease, or no change. Use of qualitative survey data makes it necessary to employ quantification methods in order to compare expectations series with observed changes in variables. In the paper, regression method is used. Questions of expectations measurement and quality of expectations measures are also briefly addressed.

Empirical results of rational expectations tests for Polish industrial enterprises exhibit dependence on econometric tools used, such as quantification and estimation methods. Generally, expectations of Polish industrial enterprises show only limited rationality. Widely available information, such as previous forecasts and recently observed changes in forecasted variables, could be employed for the purpose of improving quality of predictions. Differences in the level of rationality of production, price, and employment expectations have been observed; we try to provide explanation for this variation.

Key Words: expectations, rationality, quantification, survey data
1. Introduction

Features of expectations formation processes – among them, their rationality – may be analyzed either directly or indirectly. Indirect studies of various hypotheses as to the way expectations are formed are based on cross-restrictions tests in simultaneous equations systems and therefore are dependent on structural relationship described by a model. Direct analysis of expectations formation processes consists of verifying if expectations observed in experiments or surveys meet certain requirements, for example, unbiasedness or efficiency.

The feature of expectations that proved to be of particular interest in economics is certainly their rationality. Results of tests performed so far proved to be inconclusive and in high degree dependent on time period considered, variables selected, methods of aggregation, forecast horizon and other factors. Such sensitivity of results does not allow to safely extrapolate findings from U.S. and Western European studies to expectations formation processes of Polish entrepreneurs. Independent analysis seems therefore justified.

The paper aims to formulate and verify the hypothesis that expectations of Polish industrial enterprises are formed in a rational manner. For this purpose it is necessary to describe properties of rationally formed expectations and methods of testing these properties, but also to touch on other subjects, such as measuring and quantification of expectations, description of expectations data stemming from business survey tests, and econometric issues involved in estimating test equations.

Section 2 focuses on data used in empirical analysis, especially issues of comparability of questionnaires and official statistics. Section 3 presents expectations quantification methods and their results as applied to Polish business tendency survey data. Section 4 describes basic properties of rational expectations along with tests widely used for the purpose of verifying unbiasedness and orthogonality of expectations. Section 5 concludes.

2. RIED business tendency surveys

Data on expectations of Polish industrial enterprises have been collected through business tendency surveys conducted by the Research Institute for Economic Development (RIED) at the Warsaw School of Economics. The surveys, launched in 1986 within the framework of centrally planned economy, have been redesigned in 1991 to reflect system transformation and to conform to standards set in leading business survey research centers. Since then, continuing efforts to improve data collection procedures and ensure reliability of collected data resulted in establishing
an unique database that encompasses data on current situation faced by Polish households and enterprises as well as their expectations for the future.

For the purpose of empirical analysis, expectations of manufacturing industry enterprises (jointly in public and private sectors) have been selected. Monthly observations on these series are available since March 1997. Expectations of industrial enterprises have traditionally been a topic of interest for many researchers and therefore international comparisons are possible.

In monthly surveys of industrial enterprises, respondents evaluate changes in eight selected areas of economic activity by assigning them to three categories: increase, decrease, or no change. Each survey question asks respondents to evaluate both present situation and expectations for the next 3 – 4 months. Raw data is therefore qualitative in nature. Aggregated survey results are regularly published and commented on in RIED bulletins: each month, a number of respondents is given along with a percentage of respondents who noted increase / no change / decline and who expect increase / no change / decline in a given area of economic activity.

Of the eight questions included in monthly industrial tendency surveys, three have been selected for further analysis:

01 change in level of production,
05 change in prices of products manufactured,
06 change in level of employment.

For these three categories, it is possible to define precise equivalents in Polish Central Statistical Office (CSO) publications. Comparison of survey and “official” data is necessary for the purpose of quantification of expectations (see section 3).

The three areas of economic activity selected above (changes in production, prices, and employment) will be thereafter referred to as “categories” and not variables to avoid confusion with actual variables defined for each category. The three categories offer an additional advantage: none of them includes “not applicable” as a possible answer. The problem of introducing additional assumptions to take the “not applicable” percentage of answers into account is therefore avoided.

Wording of the RIED questionnaires and description of their ongoing adjustment to the EU standards (see Adamowicz (1998)) do not unequivocally explain if questions regarding observed changes in variables require comparisons to situation considered by the enterprise as “normal” or to situation in previous month. Furthermore, “normal situation” may be interpreted as “equal to average” over some longer time period (usually a year) or as “normal for a given month” in case of data exhibiting significant seasonal variation. In this case, comparison with corresponding period of previous
year is necessary. As seasonal variation is typical for economic data, all three interpretations are discussed in this paper.

For each category (that is, changes in production, prices, and employment), three variables are defined:

- relative change in comparison to previous month,
- relative change in comparison to corresponding period of previous year,
- relative change in comparison to average value of a given variable across the previous 12 months.

The notation is summarized in Table 1. To establish which of the three variables in each category most closely corresponds to respondents’ answers, correlation coefficients with balance of observed changes (see equation (1)) have been calculated and presented in brackets. Empirical analysis is based on a sample of size $T = 82$ (March 1997 – December 2003).

**Table 1. Basic descriptive statistics for expectations series**

<table>
<thead>
<tr>
<th></th>
<th>Production</th>
<th>Prices</th>
<th>Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative change in comparison to previous month</td>
<td>$IP_t^1$</td>
<td>$CP_t^1$</td>
<td>$ZP_t^1$</td>
</tr>
<tr>
<td></td>
<td>(0.239)</td>
<td>(0.424)</td>
<td>(0.450)</td>
</tr>
<tr>
<td>Relative change in comparison to corresponding period of previous year</td>
<td>$IP_t^S$</td>
<td>$CP_t^S$</td>
<td>$ZP_t^S$</td>
</tr>
<tr>
<td></td>
<td>(0.408)</td>
<td>(0.861)</td>
<td>(0.857)</td>
</tr>
<tr>
<td>Relative change in comparison to average value of a given variable across the previous 12 months</td>
<td>$IP_t^A$</td>
<td>$CP_t^A$</td>
<td>$ZP_t^A$</td>
</tr>
<tr>
<td></td>
<td>(0.456)</td>
<td>(0.495)</td>
<td>(0.545)</td>
</tr>
</tbody>
</table>

For all categories considered, variables defined in relation to corresponding period of previous year and to average over last year exhibit highest correlation with changes observed by respondents of RIED business tendency surveys.

**3. Quantification of expectations**

As a first step in analysis of expectations formation processes, question of appropriate forecast horizon must be addressed. Respondents of RIED business surveys are asked for their expectations for the next 3 – 4 months. For the purpose of empirical analysis, specification of forecast horizon is necessary. Previous study based on RIED survey data (see Tomczyk (2001)) suggests that there are only minor
differences between expectations series defined for three and four month horizons, but the former exhibit slightly better statistical properties. Three-month forecast horizon ($k = 3$) is therefore used in this paper.

Let us define the following:

- $A_{t+1}^1$ – percentage of respondents who observed increase between $t$ and $t + 1$,
- $A_{t+1}^2$ – percentage of respondents who observed no change between $t$ and $t + 1$,
- $A_{t+1}^3$ – percentage of respondents who observed decrease between $t$ and $t + 1$,
- $P_{t+1}^1$ – percentage of respondents who expect increase between $t$ and $t + 1$,
- $P_{t+1}^2$ – percentage of respondents who expect no change between $t$ and $t + 1$,
- $P_{t+1}^3$ – percentage of respondents who expect decrease between $t$ and $t + 1$.

Percentages defined above are usually weighted in order to take into consideration differentiation in size of respondents. In case of industrial enterprises, most commonly used weights are size of employment or turnover value.

Traditionally, some measure of sample distribution of respondents’ answers has been used as a basic aggregated measure of their expectations. Alternatively, balance statistics, introduced by O. Anderson (1952) as difference between percentage of answers noting increase and decrease of a given category, may be employed. For observed changes in variables, balance is given as

\[ BA_{t+1} = A_{t+1}^1 - A_{t+1}^3 \]

and for expectations as

\[ BP_{t+1} = P_{t+1}^1 - P_{t+1}^3. \]

Balances defined by equations (1) and (2) facilitate quantification of expectations. They are, however, only one of many possible methods of quantification, convenient in case when changes in levels of selected variables observed among respondents registering (or expecting) increase, and among respondents registering (or expecting) decrease are constant in time (see Anderson (1952)).

If this is not the case, two widely used methods of quantification of expectations are available: probability method and regression method. The latter has been introduced by M. H. Pesaran (1984) on the basis of earlier work of O. Anderson and has been generally preferred to probability method in empirical applications on the grounds of its less restrictive set of assumptions and convenient economic interpretation of results.
Regression method can be used when questionnaires report both observed and expected direction of changes. It is based on a relationship between changes noted in official statistical reporting and those observed by respondents (and consequently measured in surveys.) Two variants of regression method are widely used in quantification of expectations. O. Anderson (1952) introduced the following model:

\[ x_{t+1} = \alpha x_t + \beta A_{t+1}^1 + \nu_t, \]

where \( x_{t+1} \) denotes observed (and noted in the official statistical reporting) change in a given variable between \( t \) and \( t+1 \). Under the assumption that relationship (3) holds for expectations expressed in surveys and that disturbance term \( \nu_t \) is a white noise process, parameters \( \alpha \) and \( \beta \) may be estimated by OLS. On the basis of these estimates, a qualitative measure of expectations may be calculated. Equation (4) describes average expected changes in level of a given variable

\[ \bar{x}_{t+1}^e = \bar{\alpha} x_t + \bar{\beta} A_{t+1}^3, \]

where \( \bar{\alpha} \) and \( \bar{\beta} \) are OLS estimates of parameters in equation (3) and are interpreted as average levels of changes in \( x_{t+1} \) for respondents expecting increase and decrease in value of the variable, respectively. It should be clear that expectations balance (2) is a special case of (4) for \( \bar{\alpha} = -\bar{\beta} = 1 \).

D. G. Thomas (1995) suggested a modification of model (3) especially useful for analysis of production and price changes when normal situation, to which current values are compared, usually includes (though not necessarily constant) rate of growth. This is why there is greater pressure on correct forecasting downward of changes. In order to account for this asymmetry, D. G. Thomas introduced the following model:

\[ x_{t+1} = c + \beta A_{t+1}^3 + \xi_t, \]

where \( \beta < 0 \), and \( c \geq 0 \) is interpreted as normal (typical) growth rate of dependent variable. The model has been designed for production expectations and can be also applied to price expectations. Anderson’s model (3), on the other hand, is universal and can be also applied to employment expectations.

Quantitative measure of expectations based on model (5) is given by:

\[ \bar{x}_{t+1}^e = \bar{c} + \bar{\beta} A_{t+1}^3, \]

where \( \bar{c} \) and \( \bar{\beta} \) are estimated parameters of equation (5).

In Table 2, OLS estimates of quantification equations (3) and (5) are presented.
Table 2. Parameter estimates of quantification equations

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Anderson’s model (3)</th>
<th>Thomas’s model (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\alpha$</td>
<td>$\beta$</td>
</tr>
<tr>
<td>$IP_t^s$</td>
<td>0.030</td>
<td>-0.006</td>
</tr>
<tr>
<td>$IP_t^A$</td>
<td>0.336</td>
<td>-0.127</td>
</tr>
<tr>
<td>$CP_t^s$</td>
<td>0.038</td>
<td>-0.008</td>
</tr>
<tr>
<td>$CP_t^A$</td>
<td>0.480</td>
<td>-0.117</td>
</tr>
<tr>
<td>$ZP_t^s$</td>
<td>0.014</td>
<td>-0.014</td>
</tr>
<tr>
<td>$ZP_t^A$</td>
<td>0.188</td>
<td>-0.165</td>
</tr>
</tbody>
</table>

Interpretation of results – using the example of estimates obtained through Anderson’s model (3) with dependent variable $IP_t^s$ – is the following: in enterprises that within last month noted increase in production, average increase amounted to 3.0%; on the other hand, in enterprises that within last month noted decrease in production, average decrease was equal to 0.6%. All the remaining results presented in Table 2 are interpreted in a similar way. From the assumption that these estimates hold also for expectations of respondents, it follows that in enterprises that express expectations that production will increase in the following 3 months, production will in fact increase by, on average, 3.0%; in enterprises that express expectations that production will decrease in the following 3 months, production will decrease by, on average, 0.6%. One-month observed changes and three-month expectations are therefore described by an equation of the same regression parameters. It constitutes a significant weakness of regression method, shared by all commonly used quantification methods.

All estimates presented in Table 2 exhibit proper signs from theoretical point of view. However, sizes of estimates obtained for variables defined in relation to corresponding period of previous year ($IP_t^A$, $CP_t^A$ and, to smaller degree, $ZP_t^A$) are doubtful. It seems unlikely, for example, that average increase in prices in enterprises reporting price increase amounted to as high as 48.0% in comparison to corresponding
month of last year. Models with dependent variables defined on the basis of previous year's values are therefore not included in further analysis. Remaining results presented in Table 2 are economically sensible and similar in magnitude to results found in empirical literature.

For each of the three categories, two models are selected: one based on variable defined in relation to previous month, and one based on variable defined in comparison to last year's average. Choice between Anderson and Thomas models has been made on the basis of statistical performance of these models. In case of employment, only Anderson's model is available. In case of production and prices, Thomas's model exhibited slightly better quality, especially in regard to statistical significance of the explanatory variable.

Expectations series calculated for all three variables on the basis of both models are summarized in Table 3.

**Table 3. Expectations series**

<table>
<thead>
<tr>
<th>Category</th>
<th>Dependent variable in quantification model</th>
<th>Quantification model</th>
<th>Expectations series</th>
<th>Expectations error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>$IP_t^1$, $IP_t^S$</td>
<td>(5)</td>
<td>$IE_t^3$, $IE_t^S$</td>
<td>$e_{IP} = IP_t^3 - IE_t^3$, $e_{IPS} = IP_t^S - IE_t^S$</td>
</tr>
<tr>
<td>Prices</td>
<td>$CP_t^1$, $CP_t^S$</td>
<td>(5)</td>
<td>$CE_t^3$, $CE_t^S$</td>
<td>$e_{CP} = CP_t^3 - CE_t^3$, $e_{CPS} = CP_t^S - CE_t^S$</td>
</tr>
<tr>
<td>Employment</td>
<td>$ZP_t^1$, $ZP_t^S$</td>
<td>(3)</td>
<td>$ZE_t^3$, $ZE_t^S$</td>
<td>$e_{ZP} = ZP_t^3 - ZE_t^3$, $e_{ZPS} = ZP_t^S - ZE_t^S$</td>
</tr>
</tbody>
</table>

Different superscripts used in expectations series and in dependent variables reflect one of the weaknesses of quantification methods, namely, that the same model is used to describe both changes observed within last month and changes expected over the next three months.

In Table 4, basic descriptive statistics (means $m$ and standard deviations $d$) are presented as a first step in evaluating quality of various expectations series. For comparison purposes, an unscaled expectations balance (2) has been included in a last
column as a measure of respondents’ expectations; it has traditionally been used as an expectations measure in empirical analysis.

**Table 4. Basic descriptive statistics for expectations series**

<table>
<thead>
<tr>
<th></th>
<th>(IP_t^3)</th>
<th>(IE_t^3)</th>
<th>(IP_t^S)</th>
<th>(IE_t^S)</th>
<th>(IBP_t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(m)</td>
<td>0.0192</td>
<td>0.0288</td>
<td>0.0065</td>
<td>0.0091</td>
<td>0.1385</td>
</tr>
<tr>
<td>(d)</td>
<td>0.0786</td>
<td>0.0144</td>
<td>0.0049</td>
<td>0.0018</td>
<td>0.1198</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>(CP_t^3)</th>
<th>(CE_t^3)</th>
<th>(CP_t^S)</th>
<th>(CE_t^S)</th>
<th>(CBP_t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(m)</td>
<td>0.0117</td>
<td>0.0048</td>
<td>0.0043</td>
<td>0.0061</td>
<td>0.0944</td>
</tr>
<tr>
<td>(d)</td>
<td>0.0108</td>
<td>0.0011</td>
<td>0.0029</td>
<td>0.0017</td>
<td>0.1089</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>(ZP_t^3)</th>
<th>(ZE_t^3)</th>
<th>(ZP_t^S)</th>
<th>(ZE_t^S)</th>
<th>(ZBP_t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(m)</td>
<td>-0.0104</td>
<td>-0.0057</td>
<td>-0.0407</td>
<td>-0.0507</td>
<td>-0.3164</td>
</tr>
<tr>
<td>(d)</td>
<td>0.0120</td>
<td>0.0030</td>
<td>0.0266</td>
<td>0.0159</td>
<td>0.0935</td>
</tr>
</tbody>
</table>

Table 4 confirms that most expectation measures overestimate the average value of observed changes. Two exceptions must be noted: changes in prices and employment defined in comparison to previous month. However, expectations series derived from equations (4) and (6) exhibit much closer relationship with observed changes than expectations balance (2), generally by an order of magnitude. All expectations series exhibit smaller variation than corresponding observed changes; all expectations balances exhibit larger variation, also generally by an order of magnitude. It is fair to conclude that balances do not constitute a reliable measure of survey expectations. Although they have traditionally formed a basis for analysis of survey expectations, they inadequately describe both average and variability of variables considered.

Comparison of results summarized above with world literature is rendered difficult by the fact that findings presented in empirical literature exhibit significant variation. Many authors suggest that expectations expressed in business tendency surveys exhibit, in the long run, lower average that actually observed changes, both on individual and aggregate levels. The results are sometimes dependent on the analyzed variable itself. For example, R. A. Batchelor (1982) observed downward bias for price changes and upward bias for production changes, both small in absolute values. Tendency for underestimation is, however, much stronger in case of quantitative data and this perhaps explains why results presented in Table 4, based on qualitative data, it is not visible. In world literature, comparatively low variability of expectations is also
observed. It is also visible in results presented in Table 4, with an exception of unscaled expectations balances.

Conclusions may be summarized as follows: The least reliable measure of expectations are survey balances. Of expectations series designed on the basis of quantification methods, most of them overestimate observed level of changes and underestimate its variability. Results are, however, better than in previous paper that analyzed expectations of Polish industrial enterprises (see Tomczyk (2001)) on the basis of 46 observations. This may suggest that relatively small number of observations may be to blame. As the length of available time series increases, further improvements in quality of expectations series may be expected.

4. Rationality tests

John F. Muth is widely credited as the author of Rational Expectations Hypothesis (REH). In his classic 1961 paper, he compared subjective expectations of economic agents to real life behavior of the economic system. REH is usually stated in the following way:

$$x_t^e = E(x_t|\Omega_{t-1})$$

(7)

where $x_t^e$ denotes subjective expected value of random variable $x_t$, formed at time $t - 1$ (or, in other words, expectations formed in time $t - 1$ about the value of variable $x_t$ in period $t$), $E$ is an expected value operator, and $\Omega_{t-1}$ is an information set of economic agents in time $t - 1$. Equation (7) states that subjective – and generally unobservable – expectations of economic agents are jointly equal to conditional expected value of the forecasted variable, and identical to predictions made on the basis of model describing the economy. Rational expectations theory is therefore based on the assumption that economic agents do not form expectations that are at odds with real paths of development of economic phenomena, but build them on the basis of their best knowledge of the economic system. It is also assumed that the agents know the system well enough to be able to forecast its behavior from experience and do not systematically disregard information that could be used in improving their decisions. Subjective expectations are then, on average, equal to true values of variables in question.
Several statistical properties must be met in order for expectations to be considered rational.¹ In this paper, two of these properties are discussed: unbiasedness and orthogonality (or forecast-error unpredictability). Tests of other properties of rational expectations require either additional information or stringent assumptions (see Pesaran (1989)) and are not considered in this paper.

Let us define a vector of forecast error as a difference between vectors of observed and expected values of a given variable:

\[ \varepsilon_t = x_t - x_t^e. \] (8)

Respondents’ expectations may be considered unbiased if value expected by them is not systematically underestimated or overestimated. Unbiasedness property states that

\[ E(\varepsilon_t) = 0 \] (9)

and may be interpreted as the requirement that expected value of a variable is its unbiased predictor. A standard test of unbiasedness of expectations is a test of joint hypothesis

\[ \alpha_0 = 0, \quad \alpha_1 = 1 \] (10)
in equation

\[ x_t = \alpha_0 + \alpha_1 x_t^e + \xi_t. \] (11)

Unbiasedness is a frequently tested property of rational expectations even though it is only a special case of orthogonality property. Results of unbiasedness tests are especially sensitive to measurement errors in expectations time series and therefore rarely conclusive and unequivocal.

Orthogonality property is considered by many researchers to be the essential property of REH. If expectations are rational, using information available in the period expectations were formed will not cause improvement in forecasts. Consequently, forecast error must be uncorrelated with information available at the time forecast was made, that is, with every element of the information set \( \Omega_{t-1} \) and its every subset \( \Pi_{t-1} \):

\[ E(\varepsilon_t \cdot z_{t-1} | \Pi_{t-1}) = 0, \quad \text{where } z_{t-1} \in \Pi_{t-1}. \] (12)

If orthogonality condition (12) is true, then forecast error is a white noise stochastic process and it is orthogonal to the information set and every its subset.

¹ Rational expectations hypothesis and properties of rationally formed expectations are extensively discussed in economic literature. For an overview see Pesaran (1989) and Sheffrin (1996).
Orthogonality test may be expanded to include longer forecast horizon. Let $x_t^e_{t-s}$ be expectations series build in time $t-s$ for time $t$. Test of orthogonality of forecast errors in relation to a given information subset $\Pi_r$ ($r = t-N_s, \ldots, t-s$) of information set $\Omega_{t-1}$ requires testing of the hypothesis

$$\alpha_i = 0, \quad i = s, s+1, \ldots, N$$

in an equation on the form

$$x_t^e - x_t^e = \alpha_0 + \sum_{i=s}^{N} \alpha_i z_{t-i} + \eta_{st}, \quad z_{t-i} \in \Pi_r.$$  \hspace{1cm} (13)

Orthogonality test is then a joint test of hypothesis

$$H_0 : \alpha_0 = \alpha_1 = \alpha_2 = 0.$$  \hspace{1cm} (14)

Orthogonality tests may be further classified as weak (based on an information set including only lagged values of forecasted variable, that is, $x_{t-1}, x_{t-2}, \ldots$) or strong (when forecast errors are uncorrelated with any variable included in the agents’ information set).

4.1. Results of unbiasedness test

In order to perform the test of unbiasedness of expectations, equation (11) must be estimated. OLS estimates of this model will be, however, inefficient, as autocorrelation and heteroscedasticity of error term in the test equation may be expected. Autocorrelation is caused mainly by overlapping forecast horizons: expectations are formed for the next three months, but changes in variable levels are observed every month. Resulting autocorrelation process with a moving average component will lead to OLS estimators that are unbiased but will also underestimate variances of parameter estimates (see Hamilton (1994)). Error term in equation (11) may also be heteroscedastic due to variable sample size, limitations of aggregation techniques used, or the fact that some periods may be for the respondents easier to forecast than others. Learning processes and improvements in information collecting and analyzing techniques may also cause variance of error term to decline in time.

Due to both potential autocorrelation and heteroscedasticity, it is necessary to introduce corrections to estimate the covariance matrix. In this paper, a Newey-West (1987) HAC (heteroscedasticity and autocorrelation consistent) covariance matrix estimator is used. It is robust in presence of heteroscedasticity of unknown form and higher order autocorrelation, and such may be expected in equations based on three-month forecast horizon.
Table 5 presents results of OLS estimation (with HAC standard errors) of equation of the form (11) for all production, price, and employment expectations equations. Values of $t$-Student statistics are reported in brackets, and $F$ is value of Wald statistics of null hypothesis described by equation (10).

**Table 5. Results of unbiasedness test**

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Constant</th>
<th>Coefficient</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_P^{1}$</td>
<td>-0.052</td>
<td>2.363</td>
<td>4.439</td>
</tr>
<tr>
<td></td>
<td>(-2.912)</td>
<td>(4.907)</td>
<td></td>
</tr>
<tr>
<td>$I_P^{5}$</td>
<td>-0.004</td>
<td>1.128</td>
<td>6.190</td>
</tr>
<tr>
<td></td>
<td>(-1.200)</td>
<td>(3.504)</td>
<td></td>
</tr>
<tr>
<td>$C_P^{1}$</td>
<td>-0.004</td>
<td>3.092</td>
<td>7.142</td>
</tr>
<tr>
<td></td>
<td>(-0.620)</td>
<td>(2.458)</td>
<td></td>
</tr>
<tr>
<td>$C_P^{5}$</td>
<td>-0.004</td>
<td>1.311</td>
<td>21.173</td>
</tr>
<tr>
<td></td>
<td>(-3.077)</td>
<td>(6.658)</td>
<td></td>
</tr>
<tr>
<td>$Z_P^{1}$</td>
<td>0.003</td>
<td>2.398</td>
<td>6.136</td>
</tr>
<tr>
<td></td>
<td>(1.185)</td>
<td>(4.161)</td>
<td></td>
</tr>
<tr>
<td>$Z_P^{5}$</td>
<td>0.002</td>
<td>1.294</td>
<td>6.920</td>
</tr>
<tr>
<td></td>
<td>(2.887)</td>
<td>(7.306)</td>
<td></td>
</tr>
</tbody>
</table>

Interpretation of results depends on level of statistical significance selected. At 5% level of significance, critical value of $F$ statistics (for $r_1 = 1$ and $r_2 = 77$ degrees of freedom) is equal to $F_{0.05}^* = 3.97$ and null hypothesis (10) may be rejected for all expectations series. However, at 1% level of significance, critical value of $F$ statistics is equal to $F_{0.01}^* = 6.98$ and the hypothesis may be rejected only for price expectations series. Production and employment expectations series may be considered unbiased at this significance level.

What may be the source of systematic errors that entrepreneurs make in evaluating their environment, especially concerning price changes? Limited number of observations may be partly to blame. Expectations may appear biased *ex post* if they were formed rationally but including a small probability of a crisis – or a boom – that did not occur in small sample on which the analysis had been based.
Another source of bias in expectation series may be attributed to measurement errors that have been neglected in this paper but which constitute an important issue when analyzing expectations in general and qualitative surveys results in particular (as an additional problem of imperfections in quantification methods appears.) Measurement errors in expectations series cause parameter estimates in unbiasedness test to be biased downwards, making the test biased in direction of rejecting the REH. In orthogonality test, reduction of its power may be expected (see Evans and Gulamani (1984)). Earlier analysis of expectations of Polish enterprises (see Tomczyk (2002)) has shown that efforts to limit the extent of expectations measurement errors lead to better fit of expected value and variation of observed changes in forecasted variables, but do not eliminate the problem entirely. Further work on reducing measurement errors in expectations series is clearly necessary.

4.2 Results of orthogonality test

On the basis of the general form of the orthogonality test (14), the following equation has been estimated by OLS (with HAC standard errors) for every variable $x$:

\[
\tilde{\epsilon}_t^x = \alpha_0 + \alpha_1 \cdot BP_{t-2}^x + \alpha_2 \cdot x_{t-2} + \alpha_t,
\]

where:

$\tilde{\epsilon}_t^x$ – forecast error of variable $x$ (see Table 3),

$BP_{t-2}^x$ – expectations balance for variable $x$ (see equation (2)), lagged two periods,

$x_{t-2}$ – observed change in variable $x$, lagged two periods.

Table 6 presents estimation results for all production, price, and employment expectations equations. Values of $t$-Student statistics are reported in brackets, and $F$ is value of Wald statistics of null hypothesis described by (15).
At 5% level of significance, critical value of $F$ statistics (for $r_1 = 2$ and $r_2 = 76$ degrees of freedom) is equal to $F_{0.05} = 3.12$ and null hypothesis (15) may be rejected for all equations considered. However, at 1% level of significance, critical value of $F$ statistics is equal to $F_{0.01} = 4.89$; changes in employment measured by variable $ZP_t^l$ are in fact orthogonal in relation to information subset considered.

A practical conclusion from the orthogonality test is that employing widely available information on aggregated forecasts and recently observed changes in variables considered, especially in case of production and price changes, would allow respondents to improve quality of their forecasts and possibly profit from more accurate predictions.

### 5. Summary and conclusions

On the basis of unbiasedness and orthogonality tests conducted for expectations of Polish industrial enterprises, it can be inferred that it is possible to design a rational (that is, both unbiased and orthogonal to selected elements of information set) measure of employment expectations. Unbiased measure of production expectations may be also be built. Final decision depends, however, on significance level selected, which

---

**Table 6. Results of orthogonality test**

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>$\tilde{\alpha}_0$</th>
<th>$\tilde{\alpha}_1$</th>
<th>$\tilde{\alpha}_2$</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tilde{e}_{t}^{IPS}$</td>
<td>0.022</td>
<td>-0.222</td>
<td>-0.058</td>
<td>7.326</td>
</tr>
<tr>
<td></td>
<td>(1.808)</td>
<td>(-3.101)</td>
<td>(-0.854)</td>
<td></td>
</tr>
<tr>
<td>$\tilde{e}_{t}^{IPS}$</td>
<td>0.008</td>
<td>0.003</td>
<td>0.088</td>
<td>535.529</td>
</tr>
<tr>
<td></td>
<td>(21.975)</td>
<td>(2.014)</td>
<td>(1.874)</td>
<td></td>
</tr>
<tr>
<td>$\tilde{e}_{t}^{CP3}$</td>
<td>0.001</td>
<td>0.005</td>
<td>0.412</td>
<td>12.816</td>
</tr>
<tr>
<td></td>
<td>(0.423)</td>
<td>(0.406)</td>
<td>(4.339)</td>
<td></td>
</tr>
<tr>
<td>$\tilde{e}_{t}^{CP3}$</td>
<td>-0.004</td>
<td>-0.002</td>
<td>0.483</td>
<td>36.921</td>
</tr>
<tr>
<td></td>
<td>(-8.041)</td>
<td>(-1.394)</td>
<td>(4.753)</td>
<td></td>
</tr>
<tr>
<td>$\tilde{e}_{t}^{ZP3}$</td>
<td>0.007</td>
<td>0.035</td>
<td>0.025</td>
<td>3.480</td>
</tr>
<tr>
<td></td>
<td>(1.588)</td>
<td>(2.098)</td>
<td>(0.222)</td>
<td></td>
</tr>
<tr>
<td>$\tilde{e}_{t}^{ZPS}$</td>
<td>0.002</td>
<td>-0.003</td>
<td>0.665</td>
<td>57.463</td>
</tr>
<tr>
<td></td>
<td>(4.452)</td>
<td>(-1.503)</td>
<td>(6.621)</td>
<td></td>
</tr>
</tbody>
</table>
makes the results inconclusive. Price changes expectations are generally irrational – both biased and inefficient in regard to selected information set.

Results of rationality tests do not differ significantly from results obtained earlier on the basis of shorter sample (see Tomczyk (2001, 2004)). It may be inferred that employment changes are relatively easy to forecast rationally, contrary to production and price changes. Difficulty in predicting prices may be partly attributed to the fact that production and employment are for most enterprises endogenous while prices are usually market-driven and therefore more difficult to forecast. Irrationality of consumer inflation forecasts in Poland has also been confirmed (see Łyziak (2003)).

Apart from such reasons as measurement errors, small sample problems, and limitations in quantification methods used, more substantial causes of irrationality of expectations of Polish industrial enterprises may be pointed out. One of them is system transformation. In this paper, expectations starting in 1997 are analyzed when economic processes have probably exhibited relative stability in comparison to the early nineties. When compared to time period in which economic agents on American and Western European markets observe their – quite stable in comparison to Central European standards – environment, it is difficult to conclude that it is a sufficient length of time for formation and dissemination of methods of rational forecasting. Failing to meet standards of rationality may result from very extensive learning processes.

Results of an effort to build quantitative measures of expectations may be deemed satisfactory. Time series obtained as a result of quantification processes favorably compare with balance statistics and may be employed in other analyses of properties of expectation formation processes of Polish industrial enterprises. Comparison of expectations series with observed changes in variables suggests, however, that there are differences in subjective and objective – or at least official – evaluation of economic processes. Changes in levels of variables noted in official statistical reporting are generally overestimated, and their variation is generally underestimated by survey respondents.

Efforts to limit measurement errors in expectations series are one of the possible directions of continuation of analysis of expectations formation processes of Polish entrepreneurs. Analyzing individual firm-level data may prove useful to estimate the direction and size of aggregation bias. Differentiation of analysis by ownership, sector, region and size of enterprise also seems promising and may prove to be especially important for results of quantification procedures (for example, a 5% increase may be interpreted differently by a small and a big enterprise.) More complex quantification
methods should be also introduced, including nonlinear models and corrections including asymmetric reaction of expectations for increase and decrease of a given variable.

Results of quantification procedures present a valuable source of information for an economist interested in degree of precision of expectations of Polish enterprises in relation to different quantification models and selection of a dependent variable. Results of unbiasedness and orthogonality tests not only describe current properties of expectations formation processes but also form basis for their forecasting and further interpretation. It is important to note that while our results do not undermine the usefulness of survey expectations in predicting business conditions, the implicit assumption of rationality of these expectations is clearly not justified.

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