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Forecasting in Small Business Management

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Abstract: This work aims to verify an authorial forecasting method from a system of interdependent equations, which is based on empirical equations of the structural form and is mainly intended for econometric micromodels. The prediction procedure will be analogous to the so-called chain prediction that is used for recursive models. The difference—compared with the prediction from a recursive model—entails the necessity of using one of the reduced-form empirical equations to begin the procedure of constructing a sequence of forecasts from successive structural-form empirical equations. The research results presented above indicate that the above-proposed iterative forecasting method from structural-form equations of a system of interdependent equations guarantees synchronization of forecasts as part of a closed cycle of relations. A different number of iterations is required to obtain convergent forecasts. It can be noticed that the further ahead the forecasted period is, the more iterations should be carried out to obtain convergent forecasts. Small business management with the use of forecasting can be done remotely. Rapid updates of statistical information will require cloud-based communication. Completion of data in a cloud will allow, on one hand, accurate assessment of expired forecasts and, on the other, to update the predictor equations. This can be carried out at any place with Internet access.

Keywords: econometric micromodel; econometric forecasting; small industrial enterprise; small business management; synchronization of forecasts

JEL Classification: C30; C32; D24

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1. Introduction

Forecasting from systems of interdependent equations is not one of the issues often discussed in econometric literature. In the past, the interest in econometric macromodels caused prediction from systems of interdependent equations to be treated as a mentionable topic rather than one to be elaborated in the literature on the subject. The systems of interdependent equations presented in the literature are mainly models of national economies of different countries.

Macromodels are mostly based on data in the form of annual time series, which are characterized by "smooth" iteration. Econometric macromodels built based on quarterly data are an exception. In such cases, the description accuracy of each equation is usually high, for the convergence coefficient R^2 at a level above 0.95 dominates in micromodel equations, often reaching the value of 0.99 (Wiśniewski 2011). In such a situation, the issue of possible discrepancies in the forecasts obtained from the reduced form, after their confrontation with the results of predictions from the structural-form equations of the model, is not noticed.

This work aims to verify an authorial method of forecasting from a system of interdependent equations, which is based on empirical equations of the structural form and is mainly intended for econometric micromodels. The prediction procedure will be analogous to the so-called chain prediction that is used for recursive models. The difference—compared with the prediction from a recursive model—entails the necessity of using one of the reduced-form empirical equations to begin the procedure of constructing a sequence of forecasts from successive structural-form empirical equations. The issue of whether it matters which of the reduced-form equations will be used for the construction of forecasts or not needs to be clarified. Thus, a procedure of prediction from a system of interdependent equations, which can be described as a reduced-chain prediction procedure (Wiśniewski 2016a, pp. 43–45; 2016b, 2017; Wiśniewski 2018a, 2018b) or an iterative prediction procedure, is consequential to this (Wiśniewski 2020). It also is a contribution to the theory of constructing econometric forecasts under the circumstances indicated below. The econometric forecasting procedure proposed in this work will be illustrated using an empirical example based on real data from an existing small-sized enterprise with a closed-cycle system of relations, which the author was the owner of in 1991–2011.

Availability of forecasts of the components making up each enterprise's system reduces the risk of faulty business decisions. Good information constitutes the foundation for rational decisions, although it does not eliminate the risk of a decision error.

2. Literature

Before 1960, little empirical research on prognostic methods had been carried out. Since then, the research literature has been gradually expanded, particularly in the area of forecasting. New findings have led to a significant increase in the ability to predict and thus help people use forecasts. The scientific research on forecasting from the mid-twenties of the last century entails, e.g., Yule (1927). Kolmogorov's and Wiener's contribution to the forecasting theory is also well-known and acknowledged. The turning point in the theory, methodology and forecasting was marked by a great book by Box and Jenkins (1970), which has been re-published several times. To this day, it has been the primary method of forecasting, even though it gets quite complex when used in full generality. A very general and elementary (almost without the use of mathematics) overview of forecasting methods is contained within books edited by Makridakis and Wheelwright (1983) and Armstrong and Green (2017), Armstrong and Brodie (1999) as well as in a well-known book by Armstrong (1984)). An overview of advanced, classic (fully formal) methods of time-series forecasting is contained within a collective work edited by Makridakis and Wheelwright (1979), Graefe et al. (2015), Hawkins (2015). A book by Pankratz (1983) contains an essential introduction to the Box–Jenkins method. An important, contemporary work by West and Harrison (1997) introduces the Bayesian approach to forecasting theory. A book by Harvey (1989) is similar in its degree of advancement, but it does not stress the Bayesian methods. Both these works use the so-called state–space methods and an algorithm (of estimation and sequential forecast) called the Kalman filter.

Forecasters should validate any method they put forward, comparing it with the evidence-based methods. An ideal way to avoid bias is to obtain experimental evidence for multiple reasonable hypotheses. Such an approach has a long tradition in science, as described by Chamberlin [1890] (Chamberlin [1890] 1965). Simple methods may turn out to be reasonable ones. According to the evidence summarized by Armstrong (1984), simple models of extrapolation (such as the naive model that "things will not change") often turn out to be accurate. Schnaars (1984), for example, used extrapolation methods to produce annual forecasts for 98 annual series representing the sales of consumer products for five years ahead; the naive forecast was as accurate as any of the other five extrapolation methods he used.

Forecasting methods can be categorized in various ways, for example, depending on the application or on the forecast horizon. An important division of the popular methods entails those designed for mass forecasts (PDPM methods), which are largely related to statistics and often automated, and those designed for sporadic forecasts (PDPS methods), which may (but need not) be expensive and time-consuming, for example, requiring the establishment of expert commissions or teams. Division based on the degree of formalization of the method is even more important. Apart from the history of ancient prophecies, it is believed (e.g., Makridakis and Wheelwright 1983) that the history of formal forecasting methods begins with and involves the use of statistical methods to forecast future values in large sets (Beveridge 1921). Statisticians have treated the issue of forecasting very seriously and non-opportunistically: as Dawid (1984, p. 287) writes, "one of the major purposes of statistical analysis is to make forecasts for the future". A decisive impact on the theory of the forecast, however, was made by Kolmogoroff (1941) and Wiener (1949).

3. Methodology and Data

Prediction from a system of interdependent equations can be carried out in two ways. In the first method, structural-form equations of the model are used, whereas, in the second method, inference into the future is based on reduced-form equations. These methods are not interchangeable, especially when the system of equations is ambiguously identifiable.

Reduced-form equations can be used when the existence of mutual causal relations in the stochastic interdependent variables is omitted and when the objective is to estimate the effect of the one-sided dependence of these variables exclusively. Particularly, such conduct is justified in the case of econometric macromodels built based on annual time series. The procedure is then similar to that used for simple equations. The values of the exogenous variables that in the equations play the role of the explanatory ones are determined for T forecasting periods, using such methods as those applied to exogenous variables. It should be noted that normally equations of the reduced form, each of which contains all the predetermined variables, are characterized by the occurrence of statistically insignificant explanatory variables. This usually results in large average prediction errors, calculated from the reduced form. Therefore, the average prediction errors for forecasts from the systems of interdependent equations obtained from the reduced-form equations ought to be determined from the matrix of variance and covariance of the assessments of the structural parameters obtained from the structural-form equations (Wiśniewski 2017).

The procedure used in this work will consist of the "breaking" of a closed cycle (Wiśniewski 2017). The use of the forecasts from a selected reduced-form equation allows the determination of forecasts from the structural-form equation immediately following that equation. Knowledge of the forecasts from the structural-form equation allows the construction of further forecasts, following the mechanism of the cycle's relations. The same goes for the structural-form equation that was earlier replaced by the reduced-form equation to determine the first forecast. It is then possible to compare the forecast obtained from the structural-form equation with the forecast obtained from the equation of the reduced form. The differences between these forecasts usually are significant. It is, therefore, necessary to continue the recurrent proceedings to determine forecasts from the successive structural-form equations, following the direction in the cycle. The proceedings are continued until the forecasts converge. As such, the procedure ends when, after the next iteration, identical forecasts are obtained, as in the previous iteration for any of the forecasted variables. In this situation, the next iteration repeats the previous forecasts for each of the other forecasted variables.

Below is the current closed cycle of relations between five interdependent variables from an econometric model of a small industrial enterprise. The below-presented mechanism of relations is similar to a recursive one. It, however, differs from recursiveness in the fact that there is neither a beginning nor an end. The following closed cycle of relations between five endogenous variables in a small enterprise will be considered:

The following variables occur in the above-presented Figure 1:

CASH—the amount of cash inflows in period t, in thousands PLN;
SBRUT—the gross sales revenues in period t, in thousands PLN;
PROD—the value of ready-made production (in sales prices) in period t, in thousands PLN;
EMP—the number of employees, in full-time equivalents, in period t (number of persons);
APAY—the average net wage in the enterprise, paid to employees for work in period t, in PLN.

Figure 1. Closed cycle of relations between five endogenous variables in a small enterprise.

The essence of the iterative forecasting method proposed lies in the endogeneity of the variables making up a closed cycle of interrelations or feedback. To date, this issue has not been discussed in the literature. The exogeneity of the variables appearing around the system has a significant impact on its dynamics. The inclusion of exogenous variables allows conscious control of the system, reducing the risk of faulty business decisions.

Individual empirical equations of the econometric model also contain delayed endogenous variables (including an autoregression) and monthly dummy variables, which allow isolation of periodic variations of individual variables forming the cycle. The dummy variables were marked with symbols dm1, dm2, … , dm12. In the equation describing production (PROD), an exogenous variable (MACH) appears, with relevant statistically significant delays, which provides information about the initial value of machinery and equipment (in thousands PLN). The empirical equations describing the variables in the cycle can be found in Appendix A (Tables A1–A5).

4. Empirical Results

4.1. Forecasts from Structural-Form Equations, in a Stable Enterprise System

In the empirical equation describing ready-made production (Table A2), an explanatory variable MACH occurs, with delays of 2, 3, 4, 5 and 12 months. The variable MACH is treated as a decision-making instrument, the size of which is determined by the company's manager. The response to a change in the initial value of machinery and equipment within the dimension of ready-made production takes place with a delay calculated in months, as indicated above. The first variant of forecasting from a closed cycle of relations assumes that in the next months of 2009, the value of machinery and equipment will remain at the current level, i.e., $\mathrm{MACH}_{2008,\mathrm{I}} = \mathrm{MACH}_{2008,\mathrm{II}} = \ldots = \mathrm{MACH}_{2008,\mathrm{XII}} = 405.9$ thousand PLN.

The existing research shows that forecasting from an econometric micromodel with a closed cycle of relations can be started with any equation, without the need to use any forecasts from the reduced-form equations. As such, it is assumed that in the following months of 2009, employment volume ($\mathrm{EMP}^{(s)}_{\mathrm{Tp}}$) will reach the size of 20 full-time positions. Table 1 presents these values in row EMP.it.0.

Having the $\mathrm{EMP}^{(s)}_{\mathrm{Tp}}$ values assumed enables the performance of the first iteration and calculation of the $\mathrm{PROD}^{(s)}_{\mathrm{Tp}}$ forecasts, the acquisition of which allows determination of the $\mathrm{SBRUT}^{(s)}_{\mathrm{Tp}}$ forecasts. On the other hand, having the $\mathrm{SBRUT}^{(s)}_{\mathrm{Tp}}$ forecast enables the determination of the $\mathrm{CASH}^{(s)}_{\mathrm{Tp}}$ forecasts. In this way, we have four forecasts from the structural-form equations, i.e., $\mathrm{PROD}^{(s)}_{\mathrm{Tp}}$, $\mathrm{SBRUT}^{(s)}_{\mathrm{Tp}}$, $\mathrm{CASH}^{(s)}_{\mathrm{Tp}}$, $\mathrm{APAY}^{(s)}_{\mathrm{Tp}}$. As such, the $\mathrm{EMP}^{(s)}_{\mathrm{Tp}}$ forecasts can be calculated using the $\mathrm{APAY}^{(s)}_{\mathrm{Tp}}$ forecasts from the structural-form empirical equation. If all $\mathrm{EMP}^{(s)}_{\mathrm{Tp}}$ forecasts from the first iteration are identical to the employment figures assumed, the procedure should be terminated. The values presented in row EMP.it.1 differ from those in row EMP.it.0. This results in the necessity to perform another forecasting of $\mathrm{PROD}^{(s)}_{\mathrm{Tp}}$, $\mathrm{SBRUT}^{(s)}_{\mathrm{Tp}}$, $\mathrm{CASH}^{(s)}_{\mathrm{Tp}}$, $\mathrm{APAY}^{(s)}_{\mathrm{Tp}}$ in a second iteration, reaching the forecasts presented in row EMP.it.2 (Table 1). Due to the differences in the forecasts from the first and the second iterations—the procedure should be continued to determine forecasts in the following iterations, using the forecasts from a previous iteration. Repetition of the forecast values in a given iteration ends the proceedings. The forecasts obtained in the last iteration become definitive, guaranteeing their synchronization within the closed cycle.

Table 1. Forecasts from the structural-form system of interdependent equations—the path to convergent forecasts, under the conditions of the stabilized initial value of machinery and equipment.

Equation	**2008.I**	**2008.II**	**2008.III**	**2008.IV**	**2008.V**	**2008.VI**
$MACH_{Tp}$	405.9	405.9	405.9	405.9	405.9	405.9
PROD.it.1	110.409	94.8325	96.0643	80.6571	74.8738	87.8515
PROD.it.2	93.3367	102.157	100.285	64.161	68.9945	82.237
PROD.it.3	93.4261	102.106	***100.297***	64.2639	69.0156	82.3362
PROD.it.4	***93.4252***	***102.107***	***100.297***	***64.2627***	***69.0154***	***82.3351***
PROD.it.5	93.4252	102.107	100.297	64.2627	69.0154	82.3351
SBRUT.it.1	177.8	112.649	100.186	56.9856	57.0119	83.1602
SBRUT.it.2	172.007	114.233	98.421	52.5911	55.185	77.6438
SBRUT.it.3	***172.037***	***114.221***	98.4411	52.6189	55.1989	77.7004
SBRUT.it.4	***172.037***	***114.221***	***98.441***	***52.6187***	***55.1988***	***77.6998***
SBRUT.it.5	172.037	114.221	98.441	52.6187	55.1988	77.6998
CASH.it.1	161.672	141.708	149.108	100.97	79.5387	73.4275
CASH.it.2	159.436	141.188	148.736	98.9295	77.9757	70.9417
CASH.it.3	***159.447***	***141.189***	***148.742***	98.9442	77.9865	70.9663
CASH.it.4	***159.447***	***141.189***	***148.742***	***98.9441***	***77.9864***	***70.9661***
CASH.it.5	159.447	141.189	148.742	98.9441	77.9864	70.9661
APAY.it.1	1281.11	1203.54	1243.85	1220.03	1172.06	1126.98
APAY.it.2	1278.22	1201.62	1241.04	1215.83	1167.98	1120.64
APAY.it.3	***1278.24***	***1201.63***	***1241.06***	***1215.86***	***1168.01***	***1120.69***
APAY.it.4	1278.24	1201.63	1241.06	1215.86	1168.01	1120.69
APAY.it.5	1278.24	1201.63	1241.06	1215.86	1168.01	1120.69
EMP.it.0	20	20	20	20	20	20
EMP.it.1	16.2182	16.7653	16.7805	15.7093	16.1792	16.8273
EMP.it.2	16.238	16.7795	16.8013	15.7405	16.2108	16.8706
EMP.it.3	***16.2378***	***16.7794***	***16.8012***	***15.7403***	***16.2106***	***16.8702***
EMP.it.4	16.2378	16.7794	16.8012	15.7403	16.2106	16.8702
Equation	**2008.VII**	**2008.VIII**	**2008.IX**	**2008.X**	**2008.XI**	**2008.XII**
$MACH_{Tp}$	405.9	405.9	405.9	405.9	405.9	405.9
PROD.it.1	107.122	90.232	164.406	162.291	114.32	117.549
PROD.it.2	93.6612	79.1525	159.211	151.03	98.6509	99.0386
PROD.it.3	93.9084	79.2407	159.21	151.462	98.9368	99.3524
PROD.it.4	***93.9063***	***79.2405***	***159.209***	***151.457***	***98.9338***	***99.3472***
PROD.it.5	93.9063	79.2405	159.209	151.457	98.9338	99.3472
SBRUT.it.1	87.8517	165.25	204.767	159.38	142.272	137.414
SBRUT.it.2	79.0447	160.068	200.514	150.357	133.723	127.36
SBRUT.it.3	79.1532	***160.127***	200.572	150.545	133.851	127.583
SBRUT.it.4	***79.1522***	***160.127***	***200.571***	***150.543***	***133.849***	***127.58***
SBRUT.it.5	79.1522	160.127	200.571	150.543	133.849	127.58
CASH.it.1	61.9467	102.761	130.137	130.354	113.385	158.007
CASH.it.2	58.153	98.8548	127.692	125.421	108.85	152.76

Table 1. *Cont.*

CASH.it.3	58.2024	98.9002	127.724	125.507	108.932	152.869
CASH.it.4	***58.2019***	***98.9***	***127.723***	***125.506***	***108.931***	***152.867***
CASH.it.5	58.2019	98.9	127.723	125.506	108.931	152.867
APAY.it.1	1114.92	1104.59	1160.77	1162.62	1099.85	1128.53
APAY.it.2	1103.49	1091.46	1149.03	1145.17	1082.18	1107.44
APAY.it.3	***1103.60***	***1091.58***	1149.17	***1145.39***	***1082.42***	1107.78
APAY.it.4	***1103.60***	***1091.58***	***1149.16***	***1145.39***	***1082.42***	***1107.77***
APAY.it.5	***1103.60***	***1091.58***	***1149.16***	***1145.39***	***1082.42***	***1107.77***
EMP.it.0	20	20	20	20	20	20
EMP.it.1	16.9126	17.1149	17.1232	17.0767	17.4241	17.3069
EMP.it.2	16.9941	17.2099	17.2099	17.2055	17.5565	17.4577
EMP.it.3	***16.9933***	***17.209***	***17.2089***	***17.2039***	***17.5547***	17.4552
EMP.it.4	***16.9933***	***17.209***	***17.209***	***17.2039***	***17.5547***	***17.4553***

Source: own calculations, using the GRETL package. Explanation: Bold and italic—hese are the final results and should be highlighted.

Full synchronization of the forecasts for all forecasted periods occurred after four iterations. Iteration five was necessary to confirm the forecasts obtained in the fourth iteration. The synchronized forecasts are presented in Table 1, in bold italics. It turns out that the more distant the forecast period is, the more iterations are necessary to obtain convergence of forecasts. Some forecasts converged after just three iterations (the variables APAY, EMP for the first six months). Full repetition of the forecasts in the fifth iteration occurred for the variable APAY. Therefore, in the fifth iteration, there was no need to make any calculations for the variable EMP.

The synchronized forecasts presented in Table 1 allowed the construction of Table 2 containing the definite forecasts. The last row of Table 2 presents annual forecasts of the variables PROD, SBRUT and CASH, expressed in thousands of PLN. The values of the variables APAY and EMP are the average monthly wages and the number of employees. The significant difference between the annual forecasts of the variables PROD and SBRUT is noteworthy. It should be noted that ready-made production is expressed in a net value. On the other hand, the value of the sales revenues is the amount of the revenues from the net sales plus the tax on goods and services, which, on average, represents about 20% of the net revenues.

4.2. Forecasts from Structural-Form Equations, with Consideration of the Increase in the Value of Machinery and Equipment

In the second variant of forecasting from an econometric micromodel with a closed cycle of relations between interdependent variables, an increase in the value of machinery and equipment will be assumed, successively to the level of $MACH_{2008,I} = MACH_{2008,II} = MACH_{2008,III} = 500$ thousand PLN, $MACH_{2008,IV} = MACH_{2008,V} = MACH_{2008,VI} = 600$ thousand PLN and $MACH_{2008,VII} = MACH_{2008,VIII} = \ldots = MACH_{2008,XII} = 700$ thousand PLN. Additionally—as before—it was assumed that the volume of employment ($EMP^{(s)}_{Tp}$), in the following months of 2009, will amount to 20 full-time positions. The forecasting procedure starts with equations of ready-made production (PROD) through SBRUT, CASH, APAY and reaching EMP. The calculation results are presented in Table 3, the rows with the values for the first iteration, i.e., PROD.it.1, SBRUT.it.1, CASH.it.1, APAY.it.1 and EMP.it.1. Since the $EMP^{(s)}_{Tp}$ forecasts from the first iteration differ from the assumed values of EMP.it.0, it is necessary to move onto a second iteration, in the order: from the equation of ready-made production (PROD), through SBRUT, CASH, APAY successively, and reaching the EMP. The second iteration did not provide convergent forecasts. This results in a necessity to continue calculations in subsequent iterations. It turns out that synchronized forecasts are obtained by the performance of three to four iterations. The convergent forecasts of a synchronization quality are presented in Table 3 in bold.

Table 2. Monthly synchronized forecasts of the variables forming the cycle under the conditions of a stabilized initial value of machinery and equipment in 2008.

Period	$PROD_{Tp}^{(s)}$	$SBRUT_{Tp}^{(s)}$	$CASH_{Tp}^{(s)}$	$APAY_{Tp}^{(s)}$	$EMP_{Tp}^{(s)}$
2008.I	93.4252	172.037	159.447	1278.24	16.2378
2008.II	102.107	114.221	141.189	1201.63	16.7794
2008.III	100.297	98.441	148.742	1241.06	16.8012
2008.IV	64.2627	52.6187	98.9441	1215.86	15.7403
2008.V	69.0154	55.1988	77.9864	1168.01	16.2106
2008.VI	82.3351	77.6998	70.9661	1120.69	16.8702
2008.VI	93.9063	79.1522	58.2019	1103.6	16.9933
2008.VIII	79.2405	160.127	98.9	1091.58	17.209
2008.IX	159.209	200.571	127.723	1149.16	17.209
2009.X	151.457	150.543	125.506	1145.39	17.2039
2008.XI	98.9338	133.849	108.931	1082.42	17.5547
2008.XII	99.3472	127.58	152.867	1107.77	17.4553
Σ	1193.536	1422.039	1369.404	1158.78	16.8554

Source: Table 1.

Table 3. Forecasts from the structural-form system of interdependent equations—the path to convergent forecasts, with consideration of an increase in the value of machinery and equipment.

Equation	2008.I	2008.II	2008.III	2008.IV	2008.V	2008.VI
$MACH_{Tp}$	500	500	500	600	600	600
PROD.it.1	110.409	94.8325	47.3476	117.738	193.636	24.7459
PROD.it.2	93.3367	102.157	51.8235	101.012	187.244	19.5592
PROD.it.3	93.4261	102.106	51.8337	101.117	187.267	19.655
PROD.it.4	***93.4252***	***102.107***	***51.8334***	***101.116***	***187.267***	***19.6541***
SBRUT.it.1	177.8	112.649	83.6555	66.9979	89.0404	74.2058
SBRUT.it.2	172.007	114.233	81.9772	62.5389	87.081	68.7677
SBRUT.it.3	***172.037***	***114.221***	81.9967	62.5673	87.0953	68.8236
SBRUT.it.4	172.037	114.221	***81.9965***	***62.5671***	***87.0952***	***68.823***
CASH.it.1	161.672	141.708	142.728	101.607	93.8551	76.2245
CASH.it.2	159.436	141.188	142.39	99.5586	92.2283	73.7431
CASH.it.3	***159.447***	***141.189***	***142.395***	99.5733	92.2394	73.7675
CASH.it.4	159.447	141.189	142.395	***99.5732***	***92.2393***	***73.7672***
APAY.it.1	1281.11	1203.54	1235.6	1217.28	1185.12	1136.67
APAY.it.2	1278.22	1201.62	1232.84	1213.09	1180.97	1130.3
APAY.it.3	1278.24	1201.63	1232.86	1213.12	1181	1130.36
APAY.it.4	1278.24	1201.63	1232.86	1213.12	1181	1130.36
EMP.it.0	20	20	20	20	20	20
EMP.it.1	16.2182	16.7653	16.837	15.731	16.0934	16.7596
EMP.it.2	16.238	16.7795	16.8575	15.7622	16.1255	16.8031
EMP.it.3	***16.2378***	***16.7794***	***16.8573***	***15.7619***	***16.1252***	***16.8027***
EMP.it.4	16.2378	16.7794	16.8573	15.7619	16.1252	16.8027

Table 3. *Cont.*

Equation	2008.VII	2008.VIII	2008.IX	2008.X	2008.XI	2008.XII
$MACH_{Tp}$	700	700	700	700	700	700
PROD.it.1	135.193	205.107	89.2554	178.318	229.459	72.7557
PROD.it.2	121.345	193.503	84.8151	166.216	211.81	54.9055
PROD.it.3	121.596	193.594	84.8083	166.657	212.111	55.2138
PROD.it.4	***121.593***	***193.593***	***84.6434***	***166.864***	***212.108***	***55.056***
SBRUT.it.1	119.939	196.489	183.519	189.846	187.456	122.456
SBRUT.it.2	110.909	191.181	179.457	180.431	178.254	112.421
SBRUT.it.3	111.019	191.241	179.514	180.622	178.386	112.644
SBRUT.it.4	***111.018***	***191.24***	***179.457***	***180.683***	***178.362***	***112.628***
CASH.it.1	72.5829	121.082	129.982	136.785	132.999	158.862
CASH.it.2	68.7183	117.084	127.576	131.745	128.152	153.503
CASH.it.3	68.7682	***117.13***	127.608	131.833	128.236	153.612
CASH.it.4	***68.7677***	117.13	***127.585***	***131.845***	***128.239***	***153.601***
APAY.it.1	1142.43	1142.05	1176.08	1188.18	1154.77	1164.12
APAY.it.2	1130.85	1128.73	1164.3	1170.52	1136.55	1142.57
APAY.it.3	***1130.96***	***1128.86***	1164.44	1170.74	1136.79	1142.91
APAY.it.4	1130.96	1128.86	***1164.41***	***1170.75***	***1136.78***	***1142.9***
EMP.it.0	20	20	20	20	20	20
EMP.it.1	16.7196	16.8304	16.9876	16.8949	17.0297	17.0592
EMP.it.2	16.8022	16.9269	17.0748	17.0253	17.1659	17.2133
EMP.it.3	***16.8014***	***16.9259***	17.0737	17.0237	***17.1642***	***17.2109***
EMP.it.4	16.8014	16.9259	***17.074***	***17.0236***	17.1642	17.2109

Source: own calculations, using the GRETL package. Explanation: Bold and italic—these are the final results and should be highlighted.

The forecasts of the variables from the system are identical in the first two months of 2009. This is due to the delay-effect the value of machinery and equipment has on the volume of ready-made production. The first reaction of the variable PROD to the increase in the variable MACH occurs after two months. Subsequent changes in the value of the variable PROD occur after 3, 4, 5 and 12 months. Table 4 presents annual values of the forecasts that take into account the effects of the increase in the value of machinery and equipment. Table 5, in turn, allows a comparison of the annual values of two forecast variants for each of the variables forecasted: at stabilized values of the variable MACH and after increasing their values to the levels indicated in Table 3.

The company's management may consider various variants of the decision's results on the value of the variable $MACH_{Tp}$ in the forecasted periods T. Consequences of its decisions will be visible in the forecasts of the variables that form the closed cycle of relations. The indicated values of machinery and equipment, resultant from the decision on their increase, cause the annual values of the forecasts presented in Table 4. The forecasts without the increase in the value of the variable MACH can thus be compared with the forecast's consequence to the increase in the value of machinery and equipment (Table 5). The delays of the variable MACH in the ready-made production equation cause the first production effects of the increase in machinery and equipment to begin appearing in April 2008. In the final account, it can be expected that as a result of investing in machinery and equipment, the value of ready-made production will increase in 2008 by about 195,000. PLN (Table 5). It is also possible to expect an indirect outcome of investment in the variable MACH: an increase in the sales revenues, approximately by PLN 118,000, and an increase in the cash inflows by over PLN 66,000. At the same time, an effect of past, labor-saving investments can be observed, i.e., a reduction in the demand for work, on average, by 0.125 a month. The ultimate indirect effect of the increase in machinery and equipment may entail a slight increase in the average monthly pay, by PLN 17.21. It is possible to consider other volume variants of the variable MACH. The self-regulation of the system means that the decision-maker does not have the freedom to shape the values of variables remaining in a relation of a closed-cycle-of-relations nature.

Table 4. Monthly forecasts of the variables forming the cycle, with consideration of an increase in the value of machinery and equipment in 2008.

Period	$PROD_{Tp}^{(s)}$	$SBRUT_{Tp}^{(s)}$	$CASH_{Tp}^{(s)}$	$APAY_{Tp}^{(s)}$	$EMP_{Tp}^{(s)}$
2008.I	93.4252	172.037	159.447	1278.24	16.2378
2008.II	102.107	114.221	141.189	1201.63	16.7794
2008.III	51.8334	81.9965	142.395	1232.86	16.8573
2008.IV	101.116	62.5671	99.5732	1213.12	15.7619
2008.V	187.267	87.0952	92.2393	1181	16.1252
2008.VI	19.6541	68.823	73.7672	1130.36	16.8027
2008.VI	121.593	111.018	68.7677	1130.96	16.8014
2008.VIII	193.593	191.24	117.13	1128.86	16.9259
2008.IX	84.6434	179.457	127.585	1164.41	17.074
2008.X	166.864	180.683	131.845	1170.75	17.0236
2008XI	212.108	178.362	128.239	1136.78	17.1642
2008.XII	55.056	112.628	153.601	1142.9	17.2109
Σ	1389.26	1540.128	1435.778	1175.99	16.7304

Source: Table 3.

Table 5. Comparison of the variable forecasts forming the cycle in a 2008 annual system, without a change and after increasing the value of an exogenous variable (MACH).

Variable	Annual Sum of the Forecasts * of Individual Variables without a Change in the Value of MACH	Annual Sum of the Forecasts * of Individual Variables after Increase in the Value of MACH	Difference
$PROD_{Tp}^{(s)}$	1193.536	1389.26	+195.724
$SBRUT_{Tp}^{(s)}$	1422.039	1540.128	+118.089
$CASH_{Tp}^{(s)}$	1369.404	1435.778	+66.374
$APAY_{Tp}^{(s)}$	1158.78	1175.99	+17.21
$EMP_{Tp}^{(s)}$	16.8554	16.7304	−0.125

* The annual value for the variable $APAY_{Tp}^{(s)}$ signifies the average monthly net pay while $EMP_{Tp}^{(s)}$ signifies the arithmetical average of monthly employment volume. Source: Tables 2 and 4.

5. Conclusions

The research results presented above indicate that the above-proposed iterative forecasting method from structural-form equations of a system of interdependent equations guarantees synchronization of forecasts as part of a closed cycle of relations. A different number of iterations is required to obtain convergent forecasts. It can be noticed that the further ahead the forecasted period is, the more iterations should be carried out to obtain convergent forecasts.

Convergent forecasts from the structural form differ significantly from the forecasts from reduced-form equations. These differences are all the greater the lower the value of the coefficient R^2 in the empirical equation. Moreover, forecasts from the reduced form do not have the properties of synchronizing the forecast values as part of a closed cycle of the relations between the variables forecasted, which constitutes a significant disadvantage of the solutions used to date.

To "break" a closed cycle of relations in an iterative procedure, there is no need to use forecasts based on any reduced-form equation. It is enough to assume rational future values of any of the variables forecasted in the cycle. As a result of subsequent iterations, the system is autoregulated, which ultimately leads to convergent forecasts, characterized by adequate autosynchronization in the system. An economic system in the form of a closed cycle of interdependent variables autonomously strives for balance, guaranteeing synchronized forecasts. Therefore, the procedure presented in this work can be effective both in econometric micromodels as well as in macromodels. The first proposal of the forecasting method from the system of interdependent equations entailed a suggestion to begin from the reduced-form with the highest R^2 (Wiśniewski 2016a, pp. 43–45). It was named the snail method. In the course of further research, it turned out that the enterprise's economic system seeks equilibrium, regardless of the choice of the initial equation and the starting values of the forecasts in the initial equation (Wiśniewski 2020, chp. 6).

The use of cloud computing in company management allows acceleration of the decision-making process. It results from the possibility of immediate reaction to new circumstances and statistical information. Regardless of the decision-maker's location—he/she may still have full knowledge of the company situation. This allows for a response adequate to the situation, especially when unexpected cases occur. The systematic flow of statistical data on the variables that make up the cycle enables the control of the forecast accuracy in the system. As such, if necessary, the empirical model can be respecified, thus reducing the risk of inaccurate forecasts.

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Ethical Approval: This article does not contain any studies with human participants performed by any of the authors. I certify that I comply with the applicable ethical principles obligatory for MDPI.

Appendix A

Table A1. Dependent variable: number of employees, in full-time equivalents, in period t (EMP) (observation 2000:07–2007:12 (N = 90)).

Variable	Coefficient	Std. Error	*t*-Statistic	Prob. *p*	
const	3.14014	1.0705	2.9333	0.0043	***
APAY	−0.00684514	0.00153286	−4.4656	<0.0001	***
APAY_1	0.0058283	0.00155833	3.7401	0.0003	***
dm4	−1.24797	0.491222	−2.5405	0.0129	**
EMP_1	0.903308	0.0615207	14.6830	<0.0001	***
EMP_5	−0.249044	0.0935859	−2.6611	0.0093	***
EMP_6	0.234981	0.0835741	2.8116	0.0061	***
const	3.14014	1.0705	2.9333	0.0043	***
Mean dependent var.		19.11111	SD dependent var.		2.687652
Sum squared resid.		118.1950	SE of regression		1.193330
R-squared		0.816150	Adjusted R-squared		0.802860
F(3, 31)		61.40927	Prob (F-statistic)		1.86×10^{-28}
Log-likelihood		−139.9681	Akaike info criterion		293.9363
Schwarz criterion		311.4349	Hannan–Quinn criterion		300.9928
Autocorrel. coeff. (rho1)		−0.028815	Durbin h-statistic		−0.336642

Explanation: ***—statistical significance for $p < 0.01$; **—statistical significance for $0.01 \leq p < 0.05$.

Table A2. Dependent variable: value of ready-made production (in sales prices) in period t (PROD) (observation 2001:01–2007:12 (N = 84)).

Variable	Coefficient	Std. Error	*t*-Statistic	Prob. *p*	
const	−30.4323	30.1963	−1.0078	0.3171	
EMP	4.51437	1.77749	2.5397	0.0133	**
EMP_1	−5.79804	1.90079	−3.0503	0.0032	***
EMP_3	4.17608	1.42888	2.9226	0.0047	***
EMP_10	2.0825	0.987263	2.1094	0.0385	**
MACH_2	−0.517713	0.246821	−2.0975	0.0396	**
MACH_3	0.911772	0.306579	2.9740	0.0040	***
MACH_4	0.868031	0.321655	2.6986	0.0087	***
MACH_5	−1.38254	0.251358	−5.5003	<0.0001	***
MACH_12	0.183259	0.0902438	2.0307	0.0461	**
dm8	−26.2803	10.9694	−2.3958	0.0193	**
dm9	48.8021	9.98067	4.8897	<0.0001	***
dm10	52.375	8.66769	6.0426	<0.0001	***
PROD_8	−0.252661	0.0607184	−4.1612	<0.0001	***
PROD_11	0.392794	0.0861144	4.5613	<0.0001	***
Mean dependent var.		104.0060	SD dependent var.		39.07460
Sum squared resid.		26,233.08	SE of regression		19.49845
R-squared		0.792994	Adjusted R-squared		0.750993
F(3, 31)		18.88032	Prob (F-statistic)		2.72×10^{-18}
Log-likelihood		−360.4371	Akaike info criterion		750.8743
Schwarz criterion		787.3365	Hannan–Quinn criterion		765.5318
Autocorrel. coeff. (rho1)		−0.140929	Durbin h-statistic		2.280957

Explanation: ***—statistical significance for $p < 0.01$; **—statistical significance for $0.01 \leq p < 0.05$.

Table A3. Dependent variable: gross sales revenues in period t (SBRUT) (observation 2001:01–2007:12 (N = 84)).

Variable	Coefficient	Std. Error	*t*-Statistic	Prob. *p*	
const	4.32888	12.8217	0.3376	0.7366	
PROD	0.339317	0.0826794	4.1040	0.0001	***
PROD_2	0.201699	0.0677421	2.9774	0.0040	***
PROD_6	0.180337	0.0805435	2.2390	0.0282	**
PROD_12	0.313787	0.0780841	4.0186	0.0001	***
dm1	54.4481	8.183	6.6538	<0.0001	***
dm4	−47.2574	8.82433	−5.3554	<0.0001	***
dm5	−22.5667	8.84125	−2.5524	0.0128	**
dm8	62.2141	8.90435	6.9869	<0.0001	***
dm9	50.1442	10.2446	4.8947	<0.0001	***
SBRUT_1	0.155464	0.0619913	2.5078	0.0144	**
SBRUT_6	−0.152382	0.0613659	−2.4832	0.0154	**
Mean dependent var.		118.9869	SD dependent var.		56.88350
Sum squared resid.		28,110.54	SE of regression		19.75915
R-squared		0.895331	Adjusted R-squared		0.879340
F(3, 31)		55.98928	Prob (F-statistic)		8.53×10^{-31}
Log-likelihood		−363.3403	Akaike info criterion		750.6807
Schwarz criterion		779.8505	Hannan–Quinn criterion		762.4067
Autocorrel. coeff. (rho1)		−0.049523	Durbin h-statistic		−0.551555

Explanation: ***—statistical significance for $p < 0.01$; **—statistical significance for $0.01 \leq p < 0.05$.

Table A4. Dependent variable: amount of cash inflows in period t (CASH) (observation 2001:01–2007:12 (N = 84)).

Variable	Coefficient	Std. Error	*t*-Statistic	Prob. *p*	
const	50.4052	10.0194	5.0307	<0.0001	***
SBRUT	0.385957	0.0670915	5.7527	<0.0001	***
SBRUT_1	0.195233	0.0624877	3.1243	0.0026	***
SBRUT_6	−0.11779	0.0480459	−2.4516	0.0167	**
SBRUT_9	0.196502	0.0611543	3.2132	0.0020	***
SBRUT_12	0.166486	0.0630426	2.6408	0.0102	**
dm3	33.2137	8.10437	4.0982	0.0001	***
dm5	−29.9424	10.1212	−2.9584	0.0042	***
dm6	−62.6892	12.3368	−5.0815	<0.0001	***
dm7	−64.3534	10.1973	−6.3108	<0.0001	***
dm8	−62.9222	9.37499	−6.7117	<0.0001	***
dm9	−74.7007	8.88617	−8.4064	<0.0001	***
dm10	−74.1246	10.4016	−7.1263	<0.0001	***
Mean dependent var.		114.8274	SD dependent var.		40.71390
Sum squared resid.		15,614.39	SE of regression		14.93528
R-squared		0.886509	Adjusted R-squared		0.865432
F(3, 31)		42.06067	Prob (F-statistic)		7.72×10^{-28}
Log-likelihood		−338.6464	Akaike info criterion		705.2927
Schwarz criterion		739.3242	Hannan–Quinn criterion		718.9731
Autocorrel. coeff. (rho1)		−0.026584	Durbin–Watson statistic		2.045460

Explanation: ***—statistical significance for $p < 0.01$; **—statistical significance for $0.01 \leq p < 0.05$.

Table A5. Dependent variable: average net wage in the enterprise, paid to employees for work in period t (APAY) (observation 2001:01–2007:12 (N = 84)).

Variable	Coefficient	Std. Error	*t*-Statistic	Prob. *p*	
const	−101.487	57.5161	−1.7645	0.0816	*
CASH	1.29239	0.265176	4.8737	<0.0001	***
CASH_2	0.667649	0.27319	2.4439	0.0168	**
CASH_6	1.22519	0.268721	4.5593	<0.0001	***
CASH_7	0.673364	0.299422	2.2489	0.0274	**
CASH_9	0.571513	0.222173	2.5724	0.0120	**
time	4.66942	0.82609	5.6524	<0.0001	***
dm1	122.463	31.1652	3.9295	0.0002	***
APAY_1	0.433048	0.0912593	4.7453	<0.0001	***
APAY_7	−0.230824	0.0972228	−2.3742	0.0201	**
Mean dependent var.		834.5106	SD dependent var.		216.1564
Sum squared resid.		334,083.0	SE of regression		65.86912
R-squared		0.916858	Adjusted R-squared		0.907140
F(3, 31)		94.34752	Prob (F-statistic)		7.14×10^{-38}
Log-likelihood		−482.4634	Akaike info criterion		984.9269
Schwarz criterion		1009.586	Hannan–Quinn criterion		994.8564
Autocorrel. coeff. (rho1)		−0.056694	Durbin h-statistic		−1.007593

Explanation: ***—statistical significance for $p < 0.01$; **—statistical significance for $0.01 \leq p < 0.05$; *—statistical significance for $0.05 \leq p < 0.10$.

Table A6. Statistical information on the model's variables, monthly from January 2000 to December 2007.

Period	SBRUT	APAY	EMP	PROD	CASH	MACH	Period	SBRUT	APAY	EMP	PROD	CASH	MACH
1	99.6	390	10	52.7	142.1	34.4	49	164.8	923.81	21	88.4	163.3	332.5
2	39	390	10	48.7	77.4	34.4	50	112.1	1044.44	18	93.9	150.1	332.5
3	55.2	378.57	14	53.6	71.6	59.2	51	97.4	994.74	19	118.6	158.6	332.5
4	33.9	268.42	19	56.9	61.1	97.2	52	37.8	820.00	20	109.8	72.4	332.5
5	29.8	365.71	17.5	52.5	45.7	144.7	53	55.2	888.89	18	140.7	86	332.5
6	37.6	366.67	15	46.4	32.1	157	54	66.6	850.00	18	50.6	68	332.5
7	69	412.50	16	57.5	42.4	157	55	75.3	922.22	18	123.5	62	332.5
8	103.6	412.50	16	107.9	77.9	157	56	199.5	942.11	19	138	139.9	384.9
9	199.3	570.37	13.5	202.8	88.5	157	57	262.7	1076.47	17	151.3	169.9	394.9
10	184.9	438.89	18	152.5	151.1	157	58	168.6	933.33	18	121.8	152.2	394.9
11	112.9	417.65	17	90.1	143.9	159.3	59	123.7	994.44	18	100.6	126.7	399.4
12	60.9	473.33	15	33.4	139	189.1	60	150.1	1011.11	18	108	170.5	399.4
13	97.7	448.28	14.5	40.2	124.9	189.1	61	204.7	1047.37	19	114.3	177.1	399.4
14	60.3	464.71	17	58.7	84.3	189.1	62	93.5	947.37	19	80.2	122.2	399.4
15	48.1	468.75	16	56	88.8	195.9	63	99	1000	19	78.7	131	399.4
16	45.4	480	15	51.9	88.4	195.9	64	54	805	20	93.6	112.2	399.4
17	19.9	460	15	38.4	42.9	195.9	65	58.9	776.19	21	72.1	70.8	399.4
18	32	476.47	17	31.1	32.6	195.9	66	63.3	820.00	20	68.5	73.8	399.4
19	59	442.11	19	62.9	42.8	236.7	67	103	938.10	21	130.2	60.9	399.4
20	115.1	500	19	100	61.9	236.7	68	165.7	961.90	21	80.4	113.8	399.4
21	157.1	535.14	18.5	116	107.6	236.7	69	216.2	947.62	21	131.6	141.1	399.4
22	179.5	518.18	22	195.5	109.1	236.7	70	156.3	990.48	21	164	126.7	399.4
23	131.2	486.36	22	105.5	118.7	236.7	71	174.2	930.00	20	133.1	101	399.4
24	119	477.27	22	81.2	165.9	236.8	72	117.1	989.47	19	125.1	150.5	399.4
25	136.3	628	25	97.4	145.6	236.8	73	177.1	1111.11	18	111.1	180.1	399.4
26	120.6	604	25	68.3	107.9	236.8	74	86.8	977.78	18	93	134	399.4
27	69.9	708.70	23	83.9	140.6	236.8	75	62.5	1000	18	85.5	122.7	399.4
28	37	622.73	22	79.5	59.2	236.8	76	58.2	1029.41	17	96.9	91.1	399.4
29	44.6	654.55	22	71.4	52.2	236.8	77	63.6	894.12	17	90.6	86.7	399.4
30	61.5	690.48	21	71.7	54	236.8	78	75.1	964.71	17	83.5	76.3	399.4
31	95.1	723.81	21	78.1	69.2	236.8	79	118.5	935.29	17	110.3	70.3	399.4
32	136.9	761.90	21	112.8	107.4	236.8	80	160.1	944.44	18	43	105.5	403.4
33	194.1	732	25	219.6	108.7	236.8	81	195.2	1077.78	18	168.4	153	403.4
34	173.6	629.63	27	148.3	120.5	236.8	82	169.1	1155.56	18	167.4	140.8	403.4
35	153.6	603.85	26	114.8	122.6	236.8	83	158.2	1005.56	18	126.7	115.9	403.4
36	148.3	675.00	24	103.4	144.7	236.8	84	126.9	977.78	18	99.7	143	403.4
37	194.7	752.17	23	98.5	187.7	250.1	85	177.5	1170.59	17	139.2	165.2	403.4
38	88.7	795.45	22	97.2	165.5	250.1	86	92.9	988.24	17	84.4	115.6	403.4
39	159.1	833.33	21	82.6	186.6	256	87	84.6	1011.77	17	94.2	128.4	405.9
40	55	742.11	19	81.1	67.5	256	88	30.4	1043.75	16	110.9	108.5	405.9
41	59.7	720.00	20	63.5	77.2	276	89	73.5	900.00	16	61.2	84	405.9
42	77.7	723.81	21	96	53.9	276	90	78.9	875.00	16	61	63	405.9
43	85.7	905.26	19	80.8	66.2	276	91	107.8	1072.73	16.5	83.9	71.7	405.9
44	218.2	1010.53	19	140.1	124.6	276	92	142.6	977.78	18	117.2	133	405.9
45	267.5	985.71	21	259.9	168.1	276	93	210.2	1083.33	18	143.9	131.7	405.9
46	179.9	1063.16	19	159.4	149.4	276	94	146.3	1164.71	17	140.5	172.4	405.9
47	178.3	940	20	113.5	123.3	276	95	121.5	1100.00	17	116	120.8	405.9
48	155.9	775	24	119.7	214	276	96	101.5	1217.65	17	112.1	146.6	405.9

Source: the company's documentation.

The graphs show forecasts with a 95% confidence interval, which constitutes a computational standard in the widely available, free-of-charge GRETL package. The range boundaries, however, can be changed, depending on the research needs.

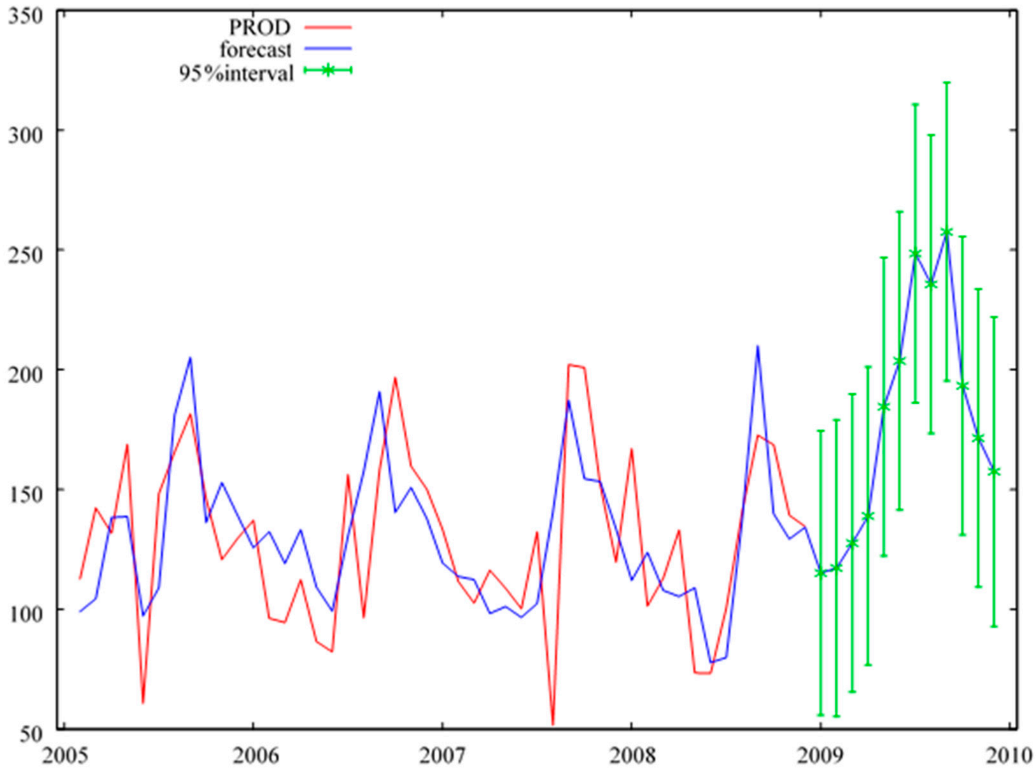

Figure A1. Monthly forecasts of ready-made production $PROD_{Tp}^{(s)}$ for the year 2009, in a system with an increase in the initial value of machinery and equipment. Source: Table 4.

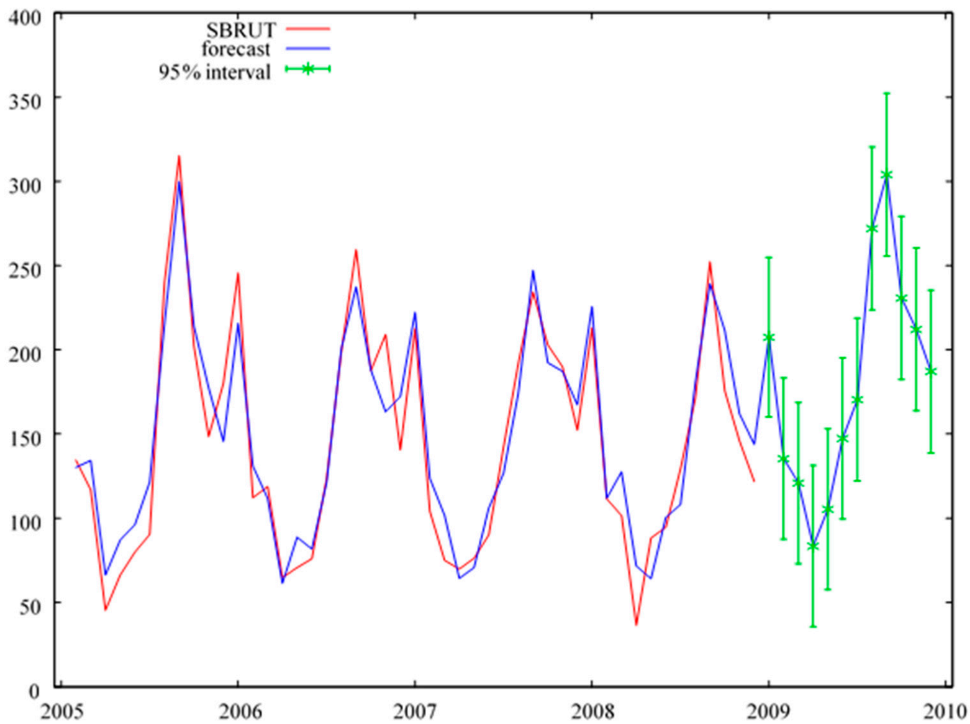

Figure A2. Monthly forecasts of gross sales revenues $SBRUT_{Tp}^{(s)}$ for the year 2009, in a system with an increase in the initial value of machinery and equipment. Source: Table 4.

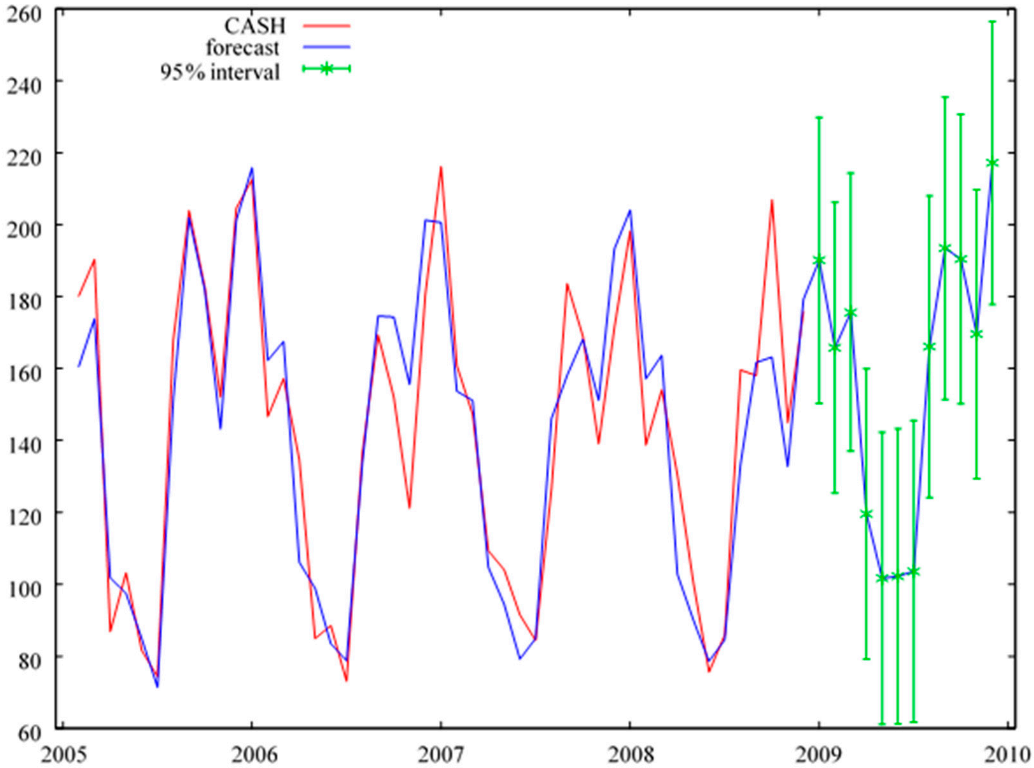

Figure A3. Monthly forecasts of the cash inflows $CASH_{Tp}^{(s)}$ for the year 2009, in a system with an increase in the initial value of machinery and equipment. Source: Table 4.

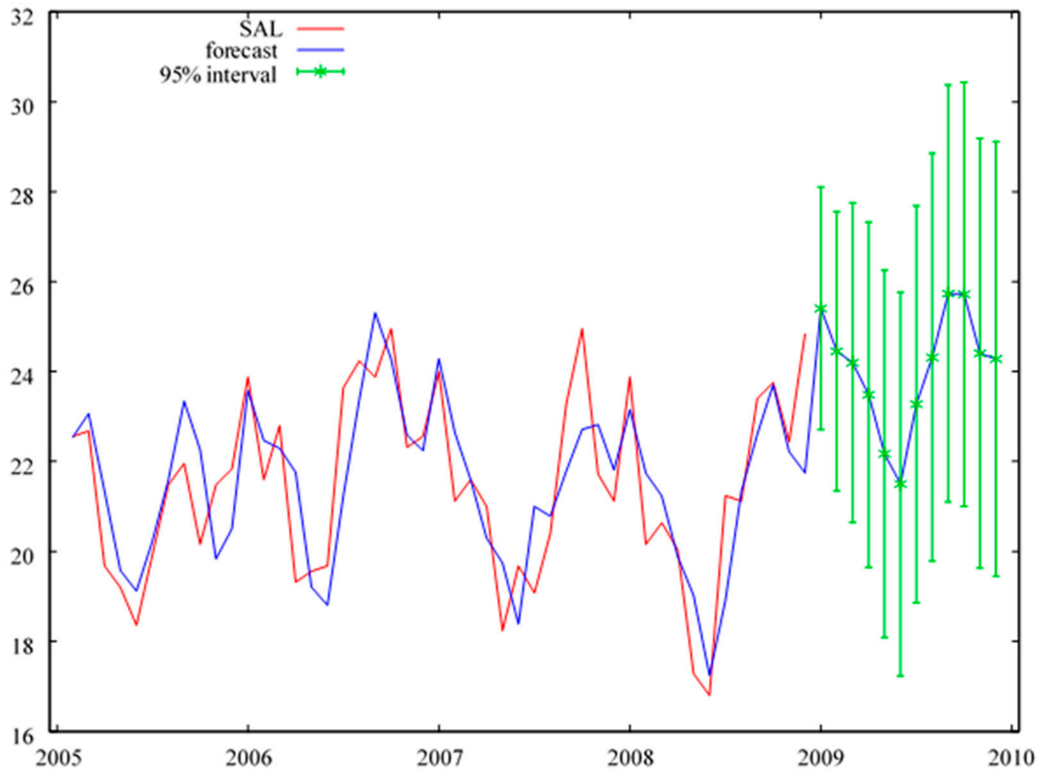

Figure A4. Monthly forecasts of net pay $SAL_{Tp}^{(s)}$ for the year 2009, in a system with an increase in the initial value of machinery and equipment. Source: Table 4.

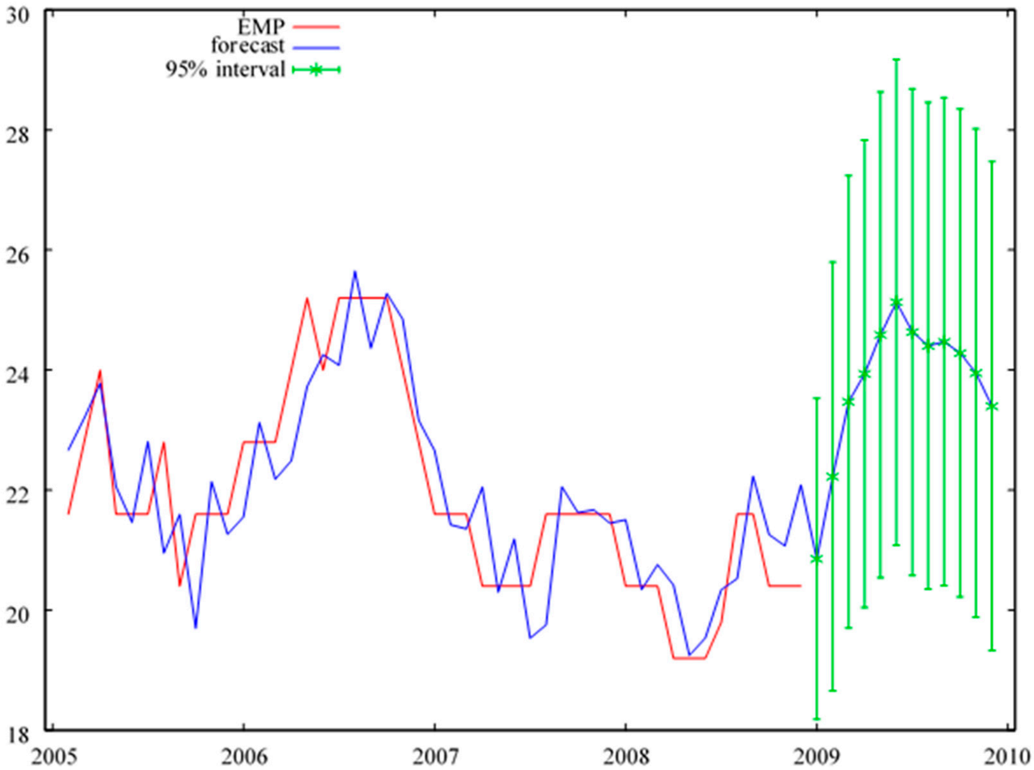

Figure A5. Monthly forecasts of employment volume $EMP_{Tp}^{(s)}$ for the year 2009, in a system with an increase in the initial value of machinery and equipment. Source: Table 4.

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