HIDDEN COOPERATION OR COMPETITION AMONG INDUSTRIAL PRODUCTION BRANCHES: SOME RESULTS FOR THE SLOVAK REPUBLIC

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Introduction

The national economy production is organized in the industrial sectors structure. The aim of the paper is to analyze the "hidden" relations among industries that are neither technologically, nor operationally interrelated. We assume the existence of two relation forms. In the cooperation form, the business, legal, tax and financial conditions positively affect the production across the industries. In the competitive relations case, the industries compete for common resources and supply their production in the same consumer market. We assume that this kind of the competition/cooperation relations among the industries define an equilibrium, which can be modeled by the vector error correction model (VECM). Here, the sales indicators of different industrial branches are considered to be endogenous and on the other hand all other variables are exogenous.

The one-equation error correction model (ECM) was firstly applied by Sargan [18] followed by Granger [9], Engle and Granger [6] and others. Johansen and Juselius [13] wrote their seminal paper laying the VECM theoretical background. In this case, the multi-equations system modeling the short-run as well as the long-run equilibrium relations is formulated.

Cointegration, as the central theme of the error correction models, is associated with the theories implying equilibrium relations among time series variables, e.g. permanent income hypothesis (Friedman [7]) or money demand models (Shotar and Barghothi [20]). Another research showed the cointegration between dividends and prices (Campbell and Shiller [2]) or real capital and labor force size (Shotar and Alraymouni [19]). There is empirical evidence of the cointegration relations among the industrial stock prices (Cerchi and Havenner [3]); exchange rates (Komárek and Melecký [14]) or interest rates of different maturities (Engle and Granger [6]).

By modeling the inter-industries relations, Strauss and Wohart [26] investigated the cointegration among prices, wages and labor productivity. The similar analysis considering the cointegration between production and employment was estimated by Upender, Chandramouli and Mendali [29]. Inter-industries labor productivity and wage rates equilibriums were analyzed by Upender and Sujan [30].

In the first section, the investigated data are described. The second and third sections are devoted to the methodology, econometric analysis followed by the results discussion.

1. Data

The investigated monthly time series cover the time period 1998–2007. The selected industrial indicators involve sales, wages and number of employees across the industrial sectors. Variable Sales represents the sales and variable Wages represents the average monthly wage, both expressed in Slovak national currency (SKK). Variable Employees represents the average number of employees working in given industrial branch. We analyzed seven industrial production branches/sectors according to Branch Statistical Classification of the Economic Activities [25]:

- Branch 15 – Manufacture of food products and beverages,
- Branch 20 – Manufacture of wood and of products of wood,
- Branch 30 – Manufacture of office machinery and computers,
- Branch 31 – Manufacture of electrical machinery and apparel,
- Branch 32 – Manufacture of radio, television and communication,

- Branch 33 – Manufacture of medical, precision and optical instruments,
- Branch 34 – Manufacture of motor vehicles, trailers and semi-trailers.

Data were selected from the SLOVSTAT database [21] and Yearbook of the Industry in the Slovak Republic [22], [23], [24]. Nominal currency time series indicators were adjusted to the real values using the harmonized index of consumer prices (HICP). Time series seasonal components were estimated and removed by seasonal moving averages.

All estimations were performed using statistical software Gretl, version 1.7.1. The abbreviations used in the text are presented in Table 1.

2. Cointegration Analysis

Investigating the historical U. S. time series, Nelson and Plosser [17] showed that the majority of economic time series are non-stationary. This conclusion was also assumed in our study. The stationarity tests (using the Augmented Dickey--Fuller (ADF) test and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test) were conducted on the seasonally adjusted time series of Sales, Wages and Employees. To avoid the misidentification of the deterministic and stochastic trends, the performed analysis followed the Dolado, Jenkinson and Sosvilla-Rivero [5] algorithm. To increase the tests power in consequent statistical analysis, the significant deterministic trends were

Tab. 1: Abbreviations

Abbreviations	Interpretation
l_Variable_Number [1)]	logarithmic transformation of the specific variable (for example l_Sales_32 means the logarithmic transformation of the Sales variable recorded in branch 32)
d_l_Variable_Number [2)]	1st difference of the logarithmic transformed variable
d_d_l_Variable_Number	2nd difference of the logarithmic transformed variable
new_Variable_Number	variable logarithmic transformed and detrended by subtraction of the deterministic trend
t	time (current period)
t–i	time lag of i periods

Notes: [1)] The logarithmic transformation was performed to stabilize the variability.
[2)] The difference transformation of the data was performed to satisfy the mean stationarity.

Source: own

Tab. 2: ADF and KPSS unit root tests of modeled time series (Part 1)

Variable	Level of variable (lag order 12) [1)]			First differences of variable (lag order 12)			Likely degree of integration
	Test format [2)]	Test statistics		Test for-mat	Test statistics		
		ADF [3)]	KPSS [4)]		ADF [5)]	KPSS [6)]	
l_Sales_15	C	-0.4006	0.7720	C	-3.0383	0.0954	I(1)
l_Sales_20	C	-1.9511	0.9143	C	-2.3630	0.1096	I(1)
l_Sales_30	C, TT	1.5597	0.1288	C	-1.1275 (-3.4397)	0.1670	I(1) or I(2)

Source: own

Tab. 2: ADF and KPSS unit root tests of modeled time series (Part 2)

Variable	Level of variable (lag order 12) [1]			First differences of variable (lag order 12)			Likely degree of integration
	Test format [2]	Test statistics		Test for-mat	Test statistics		
		ADF [3]	KPSS [4]		ADF [5]	KPSS [6]	
l_Sales_31	C	-0.6938	0.3588	C	-2.1483	0.1046	I(1)
l_Sales_32	C, T	-0.2794	0.1652	C	-2.3096	0.3588	I(1)
l_Sales_33	C, T	-0.8743	0.2211	C	-3.2781	0.0798	I(1)
l_Sales_34	C	-1.7974	0.5364	C	-2.8601	0.0625	I(1)
l_Wages_15	C, TT	-1.3429	0.1320	C	-2.6902 (-5.2430)	0.3144	I(1)
l_Wages_20	C, TT	0.2481	0.1906	C	-2.5102	0.1757	I(1)
l_Wages_30	C	-0.8985	0.7592	C	-1.8797 (-2.4623)	0.1111	I(1)
l_Wages_31	C, TT	-2.7740	0.1243	C	-2.7061 (-3.3247)	0.3325	I(0) or I(1)
l_Wages_32	C	-0.7469	0.6291	C	-4.9018	0.0776	I(1)
l_Wages_33	C	-1.1103	0.6701	C	-2.4874	0.0815	I(1)
l_Wages_34	C	-1.7046	0.7336	C	-2.8095	0.0785	I(1)
l_Empl_15	C, TT	-0.5697	0.2030	C	-1.9028 (-4.1635)	0.2722	I(1) or I(2)
l_Empl_20	C	0.2044	0.8814	C	-1.3171 (-4.8254)	0.1155	I(1) or I(2)
l_Empl_30	C, TT	1.0843	0.1068	C	-1.8222 (-4.1913)	0.2529	I(1) or I(2)
l_Empl_31	C, TT	-1.2910	0.2328	C	-0.9318 (-3.7428)	0.7198 (0.0734)	I(1) or I(2) Rather I(2)
l_Empl_32	C, TT	-1.2516	0.1980	C	-1.2336 (-4.7184)	0.4615	I(1) or I(2)
l_Empl_33	C, TT	-0.8742	0.2136	C	-2.0252 (-3.5340)	0.4965 (0.1007)	I(1) or I(2)
l_Empl_34	C	1.3731	0.9082	C	-1.7471 (-3.7838)	0.2799	I(1) or I(2)

Notes: [1] The number of lags = 12 was determined using the Akaike's information criterion (AIC) in backward regression of the over-identified (full lag) models. Despite the cases where the shorter lags would be more appropriate, we decided to apply 12 lags in all test equations.

[2] Letters C, T and TT indicate involving constant, trend and trend squared in particular ADF test; The statistical significant deterministic trends were removed to increase the test power in consequent analysis.

[3] Critical ADF test values - random walk: -1.95; random walk with drift: -2.89; random walk with drift and deterministic trend: -3.45; (n = 100, 5 % significance - Fuller [8]).

[4] Critical KPSS test values – no trend: 0.347; deterministic trend: 0.119; (10 % significance - Gretl output [4]).

[5] ADF test statistics in parentheses denotes the test results for the 2nd differences.

[6] KPSS test statistics in parentheses denotes the presence of the deterministic trend.

Source: own

removed. This operation increases the possibility to identify the hidden relations but on the other hand, results become more difficult to justify. In other words, in these cases all the interpretations must respect this restriction. Table 2 represents the stationarity test results for all tested variables.

The performed time series stationarity tests did not strictly reject the I(1) hypothesis in any case, so all time series are assumed to be integrated of order 1.

3. Results

The number of cointegrating equations was set by the Johansen test. According to the VECM methodology, we estimated also the short-run equilibrium equations modeling the relations between the endogenous and exogenous variables.

3.1 Long-Run Equilibrium Relations

The statistical procedures followed by the cointegration tests. The cointegration explains here the existence of the long-run equilibrium of different industrial branches sales. The number of cointegrating (equilibrium) vectors was estimated using the Johansen procedure. Table 3 represents eigenvalues, statistics and p-values of the cointegration rank. Since we investigated the sa-

Tab. 3: Johansen tests of the cointegration rank for sales in different industries

Rank	Eigenvalue	Trace test	p-value	λmax test	p-value
0	0.41901	190.95	[0.0000]	58.103	[0.0008]
1	0.36039	132.85	[0.0000]	47.818	[0.0035]
2	0.27226	85.030	[0.0015]	34.005	[0.0445]
3	0.18922	51.025	[0.0228]	22.445	[0.2041]
4	0.16697	28.580	[0.0695]	19.548	[0.0823]
5	0.080690	9.0327	[0.3691]	9.0021	[0.2927]
6	0.00028529	0.030530	[0.8613]	0.030530	[0.8613]

Notes: Number of equations = 7
Lag order = 2 was set according to AIC.
Estimation period: 1999:02 – 2007:12 (107 valid observations)
Unrestricted constant

Source: own

Tab. 4: Cointegrating vectors

l_Sales_15	1.0000 (0.00000)	0.00000 (0.00000)	0.00000 (0.00000)
l_Sales_20	0.00000 (0.00000)	1.0000 (0.00000)	0.00000 (0.00000)
new_Sales_30	0.00000 (0.00000)	0.00000 (0.00000)	1.0000 (0.00000)
l_Sales_31	−7.3055 (1.7136)	4.0645 (1.4610)	39.323 (6.2948)
l_Sales_32	0.56666 (0.17087)	−0.47339 (0.14568)	−3.1470 (0.62767)
new_Sales_33	3.5910 (0.96404)	−3.7253 (0.82192)	−12.748 (3.5414)
l_Sales_34	−1.9050 (0.72156)	−0.023058 (0.61518)	7.1534 (2.6506)

Notes: VECM system, lag order = 2
Maximum likelihood estimates; Estimation period: 1999:02 – 2007:12 (107 valid observations)
Cointegration rank = 3; Unrestricted constant

Log-likelihood = 2463.3846
The determinant of the covariance matrix = 2.3756139e-029
AIC = −42.2502; Bayesian information criterion (BIC) = −37.1793;
Hannan-Quinn criterion (HQC) = −40.1945
The numbers in parentheses are standard errors.

Source: own

les of seven different industrial branches, the maximum possible rank of cointegration matrix is six.

According to the Johansen tests (see Table 3), three cointegrating vectors (Table 4) were identified, which represent three types of the long-run equilibriums.

In all three estimated cointegrating vectors, some corresponding elements pairs have opposite signs *(l_Sales_31 - Manufacture of electrical machinery vs. l_Sales_32 - Manufacture of radio, television and communication and l_Sales_31 - Manufacture of electrical machinery vs. l_Sales_33 - Manufacture of medical, precision and optical instruments).* We interpret this fact as a hidden long-term competition relation between the industrial branches. Nevertheless, some corresponding pairs of the vectors components have identical signs in all three vectors, which is considered to be a form of the "hidden" long-term cooperation relations *(l_Sales_32 - Manufacture of radio, television and communication vs. l_Sales_33 - Manufacture of medical, precision and optical instruments).*

The estimated cointegrating vectors determine the particular Error Correction Components (ECC) that are incorporated as the additional variables into the short-run equilibrium equations. Here, the component ECC1 represents the adjustment to restore the equilibrium of the 1st type, ECC2 to restore the equilibrium of the 2[nd] type, and finally ECC3 represents the return to equilibrium of the 3rd type. The descriptive statistics of ECC1, ECC2, ECC3 are given in Table 5.

The deviations from the long-run equilibrium influence the short-run behaviour of the variable Sales (see Table 6). The reason is that the Sales show the tendency to head toward all three types of the long-run equilibrium. In the next section we present calculations of the short-run equilibrium equations.

Tab. 5: Descriptive statistics of components ECC1, ECC2, ECC3

Descriptive statistics	ECC1	ECC2	ECC3
Mean	−35.5741	2.20979	342.098
Median	−35.6445	2.27784	342.312
Minimum	−36.2214	1.56272	338.575
Maximum	−34.7944	2.70882	344.711
Std. Dev.	0.353152	0.259144	1.55168
C.V.	0.009927	0.117271	0.004535
Skewness	0.435380	−0.577977	−0.497715
Ex. Kurtosis	−0.600598	−0.369119	−0.514418

Notes: Estimation period: 1998:12 – 2007:12 (109 valid observations).

Source: own

3.2 Short-Run Equilibrium Relations

The endogenous variables Sales representing the sales of particular branches were fitted within the reduced form equations system. Since we tried to model the "hidden" form of cooperation or competition among the industrial branches, we did not exclude any kind of the cross relations. It disables to identify the structural form. Therefore, we simplified the interpretation of the cooperation/competition relations to the statistically significant relations between the sales indicators of the particular indu-

Tab. 6: Short-run equilibrium equations for each of modeled industrial branches (in reduced form) [1)]

Exogenous variables	Endogenous variables						
	d_l_Sales_15	d_l_Sales_20	d_new_Sales_30	d_l_Sales_31	d_l_Sales_32	d_new_Sales_33	d_l_Sales_34
const	−0.6979 **	x	x	−1.7109 ***	−9.1813 ***	3.9098 **	3.4119 ***
d_l_Sales_15_(t−1)	−0.1660 *	x	−1.8711 *	x	x	x	x
d_l_Sales_20_(t−1)	0.1219 *	0.5023 ***	1.9369 **	x	1.2473 ***	−1.2505 ***	x
d_new_Sales_30_(t−1)	0.0217 ***	x	0.2500 ***	x	x	x	x
d_l_Sales_31_(t−1)	x	x	x	x	−1.0362 **	1.0425 **	x
d_l_Sales_32_(t−1)	x	x	−0.5409 ***	x	0.3115 ***	x	x
d_new_Sales_33_(t−1)	0.0368 *	0.0419 *	x	0.0575 *	x	x	x
d_l_Sales_34_(t−1)	x	x	x	x	x	x	0.2809 ***
d_new_Wages_15	1.0459 ***	x	x	x	2.0718 **	x	−1.0824 **
d_new_Wages_20	−0.3046 ***	−0.4396 ***	x	−0.3578 **	−1.0175 **	x	x
d_l_Wages_30	x	0.1361 ***	x	x	x	0.3556 **	0.1762 *
d_new_Wages_31	x	x	x	x	x	−1.2147 **	x
d_l_Wages_32	x	x	x	x	x	x	−0.4759 **
d_l_Wages_33	x	0.1399 *	2.8191 ***	0.1892 *	x	x	0.4142 *
d_l_Wages_34	0.1457 *	0.2144 **	x	0.3126**	x	0.9937 **	0.5018 *
d_new_Empl_15	x	x	8.7692 ***	x	x	x	x
d_l_Empl_20	x	0.1945 *	−2.9276 **	x	x	x	x
d_new_Empl_30	−0.1041 ***	x	1.2065 ***	x	x	x	x
d_new_Empl_31	x	0.3134 *	x	x	−2.9462 ***	x	x
d_d_new_Empl_32	−0.3393 **	x	−6.0779 ***	x	x	x	x
d_d_new_Empl_33	x	x	x	x	−1.6283 **	x	x
d_d_l_Empl_34	x	x	x	x	3.7443 **	−3.3450 **	x
ECC1	−0.0080 *	−0.0206 ***	0.1001 *	x	0.1053 ***	x	x
ECC2	x	x	0.1487 **	−0.0261 ***	x	0.1208 ***	x
ECC3	x	−0.0037 **	x	0.0059 ***	0.0382 ***	x	−0.0121 ***
Standard error of residuals	0.00342	0.00413	0.0425	0.0057	0.0201	0.0208	0.0123
Unadjusted R-squared	0.75900	0.80535	0.8198	0.6096	0.8279	0.4494	0.6196
Durbin-Watson statistic	2.06428	2.07692	1.7925	1.9639	2.1008	2.2918	2.1668
First-order autocorrelation coeff.	−0.04249	−0.04221	0.0908	0.0131	−0.0542	−0.1503	−0.0844

Notes and source: see next page

Notes: 1) Mnemonics: d_l_Sales_15_(t–1) means the 1st difference of the logarithmic transformation of variable Sales in branch 15 – Manufacture of food products and beverages (one period time lag); String "_new_" in the variable name means that the original time series was adjusted by removing of the linear or quadratic trend (for example d_new_Sales_30).
*, **, *** denote significance at the 10 %, 5 % or respectively 1 % probability levels; x denotes statistically insignificant variables

Source: own

strial sectors and the lagged sales indicators and other exogenous variables. Variables entering the VECM are as follows: logarithms of the sales indicators of particular industrial branches (as endogenous variables), lagged endogenous variables, exogenous variables and equilibrium errors ECC1, ECC2, ECC3. All the variables besides ECC1, ECC2, ECC3 were difference adjusted to be difference stationary. The estimation of the VECM is given in Table 6. Here, the absolute values of the regression coefficients belonging to ECC characterize the speed of convergence to the equilibrium. The other regression coefficients indicate the relations within the difference form equations.

Analyzing the short run regression results, we conclude the following:

- Although the Sales variable of one industrial branch was positively (or negatively) influenced by the employment of another industrial branch, the opposite relation (e.g. the sales relation of the second researched branch versus employment of the first industrial branch) is not statistically significant in any pair of the investigated branches. We interpret this fact as an absence of the short-run form of the cooperation or competition relations between any pair of the industrial branches.
- The short-run point of view does not confirm the significant long-run competitive or cooperative relations among the industrial branches observed in the long-run model (lagged cross Sales relations).
- Sales of all investigated industrial branches (besides branches 31 and 33) show the short-run persistence pattern (the lagged 1st difference of original Sales variable was in all cases statistically significant).
- The estimated significant regression coefficients modeling the short-run reaction of the sales indicators on the long-run disequilibrium contain the expected sign in most cases. It means that the endogenous variables of the model react on the disequilibrium term by converging to the equilibrium stage.

Conclusion

The main objective of this study was to examine the "hidden" cooperative/competitive relations among the industrial production branches, which are neither technologically nor operationally interconnected. Using the vector error correction model, we identified both the long-run and the short-run equilibrium relationships among the sales indicators and other exogenous variables.

The research showed that even though the industrial branches are not obviously interconnected, the statistical significant relations among them may exist. Using the Slovak monthly time series, we discovered the statistically significant long-term relations among the sales indicators. Here, the industrial branches *Manufacture of electrical machinery and Manufacture of radio, television and communication as well as branches Manufacture of electrical machinery and Manufacture of medical, precision and optical instruments were in the hidden long-term competitive relation and the branches Manufacture of radio, television and communication and Manufacture of medical, precision and optical instruments* were in the hidden long-term cooperative relation. On the other hand, the statistically significant Sales short-term relations to restore the equilibrium were also proved. The short-term relations between the sales indicators on one side and both the cross-sales lagged variables and the exogenous variables on the other side were not statistically significant.

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ABSTRACT

HIDDEN COOPERATION OR COMPETITION AMONG INDUSTRIAL PRODUCTION BRANCHES: SOME RESULTS FOR THE SLOVAK REPUBLIC

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The main objective of this study was to examine the "hidden" cooperative/competitive relations among the industrial production branches, which are neither technologically nor operationally interconnected. We assume the existence of two relation forms. In the cooperation form, the business, legal, tax and financial conditions positively affect the production across the industries. In the competitive relations case, the industries compete for common resources and supply their production in the same consumer market. We assume that this kind of the competition/cooperation relations among the industries define an equilibrium, which can be modeled by vector error correction model. Using the vector error correction model, we identified both the long-run and the short-run equilibrium relationships among the sales indicators and other exogenous variables. We analyzed seven industrial production branches/sectors according to Branch Statistical Classification of the Economic Activities. The selected industrial indicators involve sales, wages and number of employees across the industrial branches. The research showed that even though the industrial branches are not obviously interconnected, the statistical significant relations among them may exist. Using the Slovak monthly time series cover the time period 1998–2007, we discovered the statistically significant long-term relations among the sales indicators. Here, the industrial branches Manufacture of electrical machinery and Manufacture of radio, television and communication as well as branches Manufacture of electrical machinery and Manufacture of medical, precision and optical instruments were in the hidden long-term competitive relation and the branches Manufacture of radio, television and communication and Manufacture of medical, precision and optical instruments were in the hidden long-term cooperative relation. On the other hand, the statistically significant sales short-term relations to restore the equilibrium were also proved. The short-term relations between the sales indicators on one side and both the cross-sales lagged variables and the exogenous variables on the other side were not statistically significant.

Key Words: *industrial production branches, hidden cooperative/competitive relations, long-run/short-run equilibrium, Augmented Dickey-Fuller (ADF) test, Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test, Johansen procedure, Vector error correction model.*

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