CAUSALITY ANALYSIS OF ECONOMIC GROWTH, ELECTRICITY CONSUMPTION AND EMPLOYMENT IN MANUFACTURING INDUSTRY: EXAMPLES OF TURKEY

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ABSTRACT

In this study, we investigate casual relationship between GNP, electricity consumption and employment in manufacturing industry. To investigate the stationarity nature of the time series Augmented Dickey Fuller and Dickey Fuller – GLS unit root test to see are conducted. To examine relationship between variables Toda – Yamamoto and Dolado – Lüktepohl causality tests are used. The results of Lee – Strazicich unit root test showed that there are structural breaks in 90's for each variables. However, the causality analysis of Dolado – Lüktepohl and Toda – Yamamoto imply that there has been a causality running from employment in manufacturing industry to gross national product and from gross national product to electricity consumption in manufacturing industry.

Keywords: Causality Analysis, Energy Consumption, Manufacturing Industry.

JEL Classification: Q43, C32.

Ekonomik Büyüme ile İmalat Sanayi İstihdam ve Elektrik Tüketimi Arasında Nedensellik Analizi: Türkiye Örneği

ÖZET

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Bu çalışmada GSMH ile imalat sektörü elektrik tüketimi ve istihdam arasındaki nedensellik ilişkisi incelenmiştir. Zaman serilerinin durağanlık şartlarına uyum gösterip göstermediği Augmented Dickey Fuller ve Dickey Fuller – GLS birim kök testleri ile analiz edilmiştir. Toda – Yamamoto ve Dolado – Lütkepohl nedensellik testleri değişkenler arasındaki ilişkiyi analiz etmek için kullanılmıştır. Lee – Strazicich birim kök testleri sonucunda her bir değişken için 90'lı yıllara ait yapısal kırılmalar olduğu elde edilmiştir. Bununla birlikte, nedensellik testleri imalat sektörü istihdam seviyesinden GSMH'ye doğru ve GSMH'den imalat sanayi elektrik tüketimine doğru bir nedensellik ilişksinin olduğu sonucu elde edilmiştir.

Anahtar Kelimeler: Nedensellik Analizi, Enerji tüketimi, İmalat Endüstrisi.

1. INTRODUCTION

Libanio (2006) reports that improvement of manufacturing industry is seen as the driving force of economic development and it is among the subjects that countries give prior importance in their economic and politic programmes. Because the basic principle for economic development of a country is the rational and effective use of available resources and opportunities within the country and to achieve this, improvement of manufacturing industry is the first condition to optimal usage of resources and achieving full employment targets. Development of manufacturing industry has crucial function in all industry branches and this is another reason explains importance level of manufacturing industry.

Energy consumption in manufacturing industry is another important issue to discuss. Because alternative economic policies have been worked in order to attempt to practice energy conservation without keeping in view on economic growth. In addition to save energy there are some other reason for energy conservation policies, such as reducing dependence on foreign energy sources (Bowden and Payne, 2008: 181). So, it is important to know relationship between energy consumption and manufacturing industry to practice exact and efficient energy policies to save energy and to achieve maximum economical growth.

The relationship between energy consumption of manufacturing industry, employment level of manufacturing industry and economic growth have been the subject of intense research over the past two decades. Oh and Lee (2004), Masih and Masih (1998), Asafu-Adjaye (2000) and Kayhan et al. (2010) examined the relationship between the variables and found different results about causality.

Recently alternative studies have investigated the causal relationship between these variables by applying the time series analysis, especially in the context of Dolado-Lütkepohl (1996) causality, Granger (1974) causality and Toda-Yamamoto causality tests (Lee and Oh, 2004: 974).

Studies carried out in literature focus on causal relationship between electricity consumption and income. The studies about Turkey showed that causal relationship was found running from electricity consumption to income (Murry and Nan, 1996; Sarı, 2001; Altınay and Karagöl, 2005; Nisancı, 2005). On the other hand, Nazlıoğlu et al. (2010) found that there is no relationship between total electricity consumption and GDP for Turkey. Also Altinay and Karagol (2004), Jobert and Karanfil (2007) and Aktas and Yilmaz (2008) found the same results supporting neutrality hypothesis. In another group of studies casual relationship was found running from GDP to energy consumption. Halicioglu (2007), Lise and Monfort (2007) and Karanfil (2008) are some of them.

There are litreally studies about relationship energy consumption and economic growth also. Stern (2000) found causal relationship running from electricity consumption to income for U.S.A. by using data between 1948–1994. Shiu and Lam (2004) found the same results for China by using data between 1971–2000, Asafu-Adjaye (2000) found this causality for India, Indonesia, Philippines and Thailand by using data between 1971 – 2000. In alternative studies, Engsted and Bentzen (1993) investigated relationship between energy consumption, energy prices and real GNP by using data between years 1948 – 1990 in Denmark. As a result, they did not find any structural break in series belonging variables. Besides, Narayan and Smyth (2005) used energy consumption per person, employment rate in manufacturing industry and real GNP by using data between 1966 – 1999 in Australia. They found causal relationship running from real GNP towards electricity consumption. As can be seen in international and Turkey literature there are mixed results. Results depend on data and methodology used in analysis and so differences for same countries would occur.

2. DATA AND METHODOLOGY

Data used in this study is annual basis and collected through the Statistics Yearbook published by the Turkish Statistics Institution and covers 1960 – 2005 period. Period between 2005 and 2009 was not included into analysis because of restricted data in the Turkish Statistics Institution. E-Views 6.0 and Gauss 8.0 were used in order to practice econometrical analysis. Series of electricity consumption of manufacturing industry in Turkey (MEC), GNP (Million TL), employment in manufacturing industry (MEM) are used. Following the studies of (Chang, 2001, Fatai, 2001) all variables are transformed into natural logharitms, because this helps to induce stationarity in the variance–covariance matrix. Finally as we distrust temporal aggeration monthly data into annual data may weaken causal relationships between variables.

2.1. Unit Root Tests

Time series have to include fixed variance and average. Otherwise, the results of analysis will be misleading. For this reason, first of all series are exposed to unit-root test. In this phase, Lee-Strazicich unit root test that takes double-interior breaking structural is utilized. Lee – Strazicich (2003) tests trend stability in alternative hypothesis. Stated in other words Lee – Strazicich (2003, 2004) allows for breaks under both the null and the alternative hypothesis in a consistent manner. There are two different versions such as Model A and Model C in Lee – Strazicich test. Lee and Strazicich used unit – root test that helps double – interior breaking that is based on Lagrange Multiplier (LM). Model A is used in structural breaking, Model C is used in static and trendy breaking for unit – root test (Temurlenk and Oltulular, 2007: 4).

Model A

$$\Delta y_t = K + \phi y_{t-1} + \beta t + \theta_1 DU1_t + \theta_1 DT2_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \quad (1)$$

Model C

$$\Delta y_t = K + \phi y_{t-1} + \beta t + \theta_1 DU1_t + \theta_2 DT1_t + \theta_2 DU2_t + \theta_1 DT2_t + \gamma_1 DT_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \quad (2)$$

Here, Δ is the first difference operator, ε_t is a white noise disturbance term with variance σ^2; and t=1,….T is an index of time. The Δy_{t-j} terms placed on the right-hand side of eqs. (1) and (2) allow for serial correlation and ensure that the disturbance term is white noise. DUt is an indicator dummy variable for a mean shift occuring at time TB and DTt is the corresponding trend shift variable (Narayan and Smyth, 2005: 1109 – 1116) ;

$$DU_t = \begin{cases} 1 & t > TB \\ 0 & other \end{cases}$$

and (3)

$$\mathrm{DT_t} = \begin{cases} t - TB & t > TB \\ 0 & other \end{cases}$$

Table 1. Lee-Strazicich test for unit roots in the presence of double structural

	Model A			Model C		
	Min. t stat.	**Break 1**	**Break 2**	**Min. t stat**	**Break 1**	**Break 2**
MEC	-16.009	1983 (8)* [-2.0856]**	1991 (8)* [-2.0534]**	-4.6418	1979 (3)* [3.2512]**	1994 (3)* [4.7595]**
MEM	-3.5247	1991 (1)* [-2.9711]**	1998 (1)* [0.5163]**	-5.3586	1975 (2)* [3.2327]**	1991 (2)* [-3.0625]**
GNP	-3.6071	1994 (7)* [-0.4807]**	1999 (7)* [-9.42719]**	-58.2313	1985 (7)* [-0.8255]**	1995 (7)* [46.2955]**

Not:* Figures in parenthesis below the lag lengths are selected using the Akaike Information criterion.

** Critical value of the Lee-Strazicich (2003) test is -4.54 for Model A in % 1 significance level, -5.82 for Model C, is -3,842 for Model A in % 5 significance level and is -5,74 for Model C.

According to model A, in series of electricity consumption in manufacturing industry, structural breaks have occured in 1938 and 1991 and according to model C, there are structural breaks in 1979 and 1994. There are structural breaks in manufacturing industry employment indicator in 1991 and 1998 according to model A. According to model C, they are in 1975 and 1991. Finally we found structural breaks in 1994 and 1999 according to result of employing model A and also in 1985 and 1995 as result of model C in gross national product serie. After the applicaiton of Lee-Strazicich test and the results of model A, it has seen that a structural break that has occured in electricity consumption of manufacturing industry can affect the employment of manufacturing industry in 7 – 8 years. But when we take into consideration the model C for the same variables, it is clear that a structural break has occured in employment of manufacturing industry can affect the electricity consumption of manufacturing industry in 3 – 4 years.

Results of Augmented Dickey Fuller (ADF) test composed by Dickey and Fuller (1979) are presented in the following table. According to the results employment and electricity consumption series in manufacturing industry have unit root at level. But both series are stationary in their first differences.

GNP serie has unit root at 1% significance level at its level and also first difference. For this reason we test stationarity of GNP at its second difference and we obtained that GNP serie has no unit root in its second difference at 1% significance level. Results are shown in table 2.

Table 2: Results of Augmented Dickey Fuller Unit Root Test

	GNP			**MEC**			**MEM**			**Critical Values**
	***I*(0)**	***I*(1)**	***I*(2)**	***I*(0)**	***I*(1)**	***I*(2)**	***I*(0)**	***I*(1)**	***I*(2)**	
1	1.53	-3.37	-10.4	-3.98	-5.36	-8.47	-1.81	-5.78	-10.6	0.01= -3.63 0.05= -2.95 0.10= -2.61
2	-2.30	-4.02	-10.5	-1.08	-7.38	-8.37	-1.57	-5.88	-10.5	0.01= -4.25 0.05= -3.54 0.10= -3.20

[1] Intercept (c) term; [2] Trend (t) and intercept (c) term.

Note: MacKinnon (1996) critical values was used. All variables was made ADF test according to Schwarz information criterion.

Dickey Fuller – GLS unit root is another unit root test we practice to obtain stationarity of series. Results of Dickey Fuller – GLS unit root test developed by Elliot, Rothenberg and Stock (1996) are shown in Table 3.

Table 3: Results of Dickey Fuller – GLS Unit Root Test

	GNP			MEC			MEM			Critical Values
	I(0)	*I*(1)	*I*(2)	*I(0)*	*I(1)*	*I(2)*	*I(0)*	*I(1)*	*I(2)*	
1	-0.77	-1.60	-10.0	0.32	-5.16	-8.68	0.78	-5.36	-8.54	0.01= -2.61 0.05= -1.94 0.10= -1.61
2	-1.11	-4.09	-10.6	-0.51	-6.61	-8.19	-1.20	-5.98	-10.2	0.01= -3.77 0.05= -3.19 0.10= -2.89

[1] Intercept (c) term; [2] Trend (t) and intercept (c) term.

Note: MacKinnon (1996) critical values was used.

Results of Dickey Fuller – GLS unit root test are similar with ADF test results. So MEC and MEM are stationary at their first difference while GNP is stationary at second difference of serie.

2.2. Dolado-Lütkepoh Causality Test

To analyse causal relationship between variables, modified Wald (MWALD) test developed by Dolado-Lütkepohl (1996) is used. In order to apply causality analysis, series should be I(1). The most important advantage of this type causality test is that the unit root analysis is not important since the estimated model is robust to the type of integration and cointegration properties exhibited by data (Booth and Ciner, 2005). Causality test requires carrying out zero restrictions on VAR coefficients using familiar $\chi 2$ or F-tests based on the Wald principle.

The presence of I(1) variables in the VAR model may cause non-standard asymptotic distribution of these statistics. Especially, Wald tests for Granger causality may result in nonstandard limiting distributions based on the cointegration properties of the system and possibly on nuisance parameters. These nonstandard asymptotic properties of the test of the zero restriction on cointegrated VAR processes are due to the singularity of the asymptotic distributions of the estimators (Lütkepohl and Kratzig, 2004). The Dolado-Lütkepohl causality test overcomes this singularity problem by adding an additional lag to the true order of the VAR model. The testing procedure involves two steps. Firstly, a VAR (p) is determined by a model selection criterion such as Schwarz Bayesian Criterion (SBC). Secondly, a VAR (p +1) is estimated and then the standard Wald test is applied on the first p lags.

The first step of the Dolado-Lütkepohl testing is to select the optimal lag length since results of causality test are sensitive to the lag imposed. We use Akaike Information Criterion and find that the optimum lag is equal to 2. Therefore we estimate the following VAR (3) model by OLS,

$$\begin{bmatrix} \ln MEC_t \\ \ln GNP_t \\ \ln MEM_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} + \begin{bmatrix} \beta_{11,1}\beta_{12,1}\beta_{13,1} \\ \beta_{21,1}\beta_{22,1}\beta_{23,1} \\ \beta_{31,1}\beta_{32,1}\beta_{33,1} \end{bmatrix} \begin{bmatrix} \ln MEC_{t-1} \\ \ln GNP_{t-1} \\ \ln MEM_{t-1} \end{bmatrix} + \begin{bmatrix} \beta_{11,2}\beta_{12,2}\beta_{13,2} \\ \beta_{21,2}\beta_{22,2}\beta_{23,2} \\ \beta_{31,2}\beta_{32,2}\beta_{33,2} \end{bmatrix} \begin{bmatrix} \ln MEC_{t-2} \\ \ln GNP_{t-2} \\ \ln MEM_{t-2} \end{bmatrix} + \begin{bmatrix} \beta_{11,3}\beta_{12,3}\beta_{13,3} \\ \beta_{21,3}\beta_{22,3}\beta_{23,3} \\ \beta_{31,3}\beta_{32,3}\beta_{33,3} \end{bmatrix} \begin{bmatrix} \ln MEC_{t-3} \\ \ln GNP_{t-3} \\ \ln MEM_{t-3} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}$$

(4)

The hypothesis that GNP does not cause electricity consumption can be constructed as; H_0 : $\beta_{11,1}$ = 0; and the hypothesis that electricity consumption does not cause GNP can be constructed as; H_0 : $\beta_{12,1}$ =0□.

Table 4. Results of Dolado-Lütkepohl Causality F-tests

Hypothesis	p-value	Causal
mem→gnp	0.0135	Yes
gnp→mem	0.2459	No
mec→gnp	0.0071	Yes
gnp→mec	0.0029	Yes
mec→mem	0.1763	No
mem→mec	0.5381	No

According to Dolado-Lütkepol Granger causality test results, there is a causal relationship between the variables and the direction of relationship is from employment in manufacturing industry and electricity consumption in manufacturing industry towards GNP and from GNP towards only electricity consumption in manufacturing industry. According to the results there is no causal relationship between employment and electricity consumption in manufacturing industry.

2.3. Toda Yamamoto Causality Test

Toda and Yamamoto (1995) represents an improvement over the standard Granger causality test by ensuring that the latter's test statistic follows a standard asympthotic distribution (Squalli, 2007). This technique has advantage that is applicable irrespective of the integration and cointegration properties of the system. In this approach, VAR $(k + d_{max})$ has to be estimated to use the modified Wald test for linear restrictions on the parameters of a VAR (k) which has an asymptotic distribution. All we need is to determine the maximal order of integration $d_{\max}$ which we suspect might occur in the model and then to over-fit intentionally a level VAR with additional lags (Toda and Yamamoto, 1995). In the first step of Toda and Yamamoto causality test, the lag length of the variables (k) can be set according to Akaike Information criterion (AIC) and then to identify integration of variables ($d_{\max}$) stationary tests.

In the last step of test a modified Wald test is employed to estimate following VAR system where the null hypothesis of no causality is not rejected when $\beta_{1i} = 0$, $\lambda_{1j} = 0$ and $\delta_{1j} = 0$.

$$mec_t = a_0 + \sum_{i=1}^{k} a_{1i} E_{t-i} + \sum_{j=k+1}^{d} a_{2j} E_{t-j} + \sum_{i=1}^{k} \beta_{1i} gnp_{t-i} + \sum_{j=k+1}^{d} \beta_{2j} gnp_{t-j} + \sum_{i=1}^{k} \beta_{1i} mem_{t-i} + \sum_{j=k+1}^{d} \beta_{2j} mem_{t-j} + \varepsilon_{1t} \quad (5)$$

$$gnp_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} mem_{t-i} + \sum_{j=k+1}^{d} \gamma_{2j} mem_{t-j} + \sum_{i=1}^{k} \gamma_{1i} mec_{t-i} + \sum_{j=k+1}^{d} \gamma_{2j} mec_{t-j} + \sum_{i=1}^{k} \lambda_{1i} E_{t-i} + \sum_{j=k+1}^{d} \lambda_{2j} E_{t-j} + \varepsilon_{2t} \quad (6)$$

$$mem_t = \delta_0 + \sum_{i=1}^{k} \delta_{1i} gnp_{t-i} + \sum_{j=k+1}^{d} \delta_{2j} gnp_{t-j} + \sum_{i=1}^{k} \delta_{1i} mec_{t-i} + \sum_{j=k+1}^{d} \delta_{2j} mec_{t-j} + \sum_{i=1}^{k} \delta_{1i} E_{t-i} + \sum_{j=k+1}^{d} \delta_{2j} E_{t-j} + \varepsilon_{2t} \quad (7)$$

According to unit root test results maximum integration number of series is two and lag length of reduced VAR methodolgy is two. For this reason we employee VAR (4) process and we use MWALD test to examine causality between variables.

According to results, there is a casual relationship between employment in manufacturing industry and GNP running from employment to GNP. This result is consistent with findings of Dolado – Lütkepohl test results. Relationship between electricity consumption in manufacturing industry and GNP runs from GNP to electricity consumption. This result is inconsistent with Dolado – Lütkepohl test results. Causality test results between electricity consumption and employment show that there is no relationship between variables.

Table 4. Results of Toda Yamamoto Causality F-tests

Hypothesis	p-value	Causal
mem→gnp	0.0151	Yes
gnp→mem	0.3909	No
mec→gnp	0.1709	No
gnp→mec	0.0003	Yes
mec→mem	0.9864	No
mem→mec	0.7868	No

3. CONCLUSION

In this study, we examined relationship between GNP, electricity consumption and empolyment in manufacturing industry in Turkey between 1960–2005. To this end, we employee two different causality test and Lee – Strazicich strucutral break test. According to unit root test used in the analysis, manufacturing industry employment and electricity consumption series were found to be static in the first difference, GNP serie was found to be static in the second difference. In Lee-Strazicich double-interior breaking unit root test that was conducted for each three variables, it was seen that breaking became denser in 1990s.

We obtained results that causal relationship running from employment in manufacturing industry towards GNP was found by using both results. Dolado Lütkepohl test results imply that there is casual relationship between electricity consumption and GNP running from electricity consumption to GNP. But there is no relationship between these variables according to results of Toda Yamamoto test. Another important finding is that there is a casual relationship between electricity consumption in manufacturing industry and GNP running from GNP to electricity consumption. Finally results show that there is no casual relationship between electricity consumption and employment in manufacturing industry.

We conclude that employment in manufacturing industry is one of the main source of economic growth. Although there are mixed results in our analysis and also in the literature, electricity consumption has crucial role for economic growth in Turkey. It is clear that there is no relationship between electricity consumotion and employment in manufacturing industry. Another finding is about casuality running from GNP to electricity consumption. Economic growth increases electricity consumption in manufacturing industry. It might be cause of structural change in manufacturing industry by economic growth. So development in manufacturing technology increases dependency to electricity power. But it has to be investigated firmly and this is left for future research.

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