GIM Journal of Management

ume 2, Number 1 January - June 2012

ISSN 0974 - 0708

Guruvayurappan Institute *of* Management

MANAGEMENT FOCUS

MANAGEMENT THRUST

*Applied for registration

Co-integration and Error Correction Models:The Temporal Causality between Wage and Productivity in the Wood and Wood Products Manufacturing sector in Tamilnadu

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ABSTRACT

The present study attempts to analyse the problem at the regional level by concentrating on one particular state namely, Tamil Nadu. Further, there are few studies in the past that have attempted to analyse the productivity and wage relationship at individual industry level. A study of the individual industries at regional level was therefore, attempted to have a better understanding of the problem, so as to delineate the area for remedial action. The reference period of the study was from 1979-80 to 2008-09. In order to clearly understand the links between wages and productivity in selected industries, this study has used a simple econometric analysis namely, step-wise regression model. The wage-productivity relationship that existed in the manufacture of Wood and Wood products in majority of the cases (either insignificant or negative) disproved the hypothesis that wage rate (Lnw) was significantly related to labour productivity (LnGVA/L). This explained the fact that there were factors other than those considered in this model that have influenced the real wage rate (Lnw) in this industry.

A. Introduction

Wood and wood based products are an important part of our day to day life. Wood products include: cases, boxes, hard wood flooring, joinery, wood casks, treated rough wood, pre-fabricated wooden buildings, wood carvings, door frames and other niche items. Most wood in India is used for the manufacture of doors, window frames, wall panels, moldings and furniture. Domestic manufacturing is highly fragmented and unorganized with much of the production, particularly for doors, windows and interiors still done by individual carpenters on site. The appreciation of the need for rational utilization of wood as a raw material has resulted in the increased consumption of these products everywhere.

The share of American woods in the Indian import market Is relatively small, but has grown from 0.4 percent to almost 1 percent ($12.8 million). India's supplies of domestic wood are very limited. Because of this shortage, the import market for raw and semi-processed wood is expected to increase with demand and construction activity over the next few years.Logs account for the largest portion (67 percent) of all wood and wood products imported into India due to relatively lower import tariffs and a local preference for unprocessed wood. Imports of logs have increased by 72 percent to $1.14 billion. India imports logs mostly from Malaysia, Myanmar, Ghana and New Zealand due to a freight advantage and relatively lower prices.

The furniture market is the second largest wood processing segment after logs, making India a fast emerging market for high-end, value-added imported products.The manufacture of pre-fabricated doors and windows is relatively new and the current market is growing at 10% per annum. The total annual market for furniture in India is estimated to be US$ 1.25 billion about 90% of which is for wooden products. The branded (higher quality) wooden furniture industry is growing at 15% annually.

Imports of fiber and particle board, veneer and sawn lumber have also increased over the last decade,

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indicating positive demand in the housing, construction, household products, furniture and packaging sectors.Panel and plywood products are main wood products in India. Product categories include veneer sheets, particle board (composite wood core with plastic laminate finish), panel products (fiber board), plywood made from both hard and softwood (veneered panels and laminated woods), and medium density fiber board. Indian particle board and plywood industry have large producers who accounts for 15% of the total production, producing some 30 million sqm of plywood and blockboards. The Indian market for particle board and plywood is estimated in value terms, at over Rs 17 billion. Of the total market, particle board accounts for over 30% of the market with the rest over 70% accounted by plywood segments. Western India has emerged as the leader in the particle board segment. A relatively new product in the industry is Medium Density Fibre Board (MDF board).Two large companies are major players in this field, one by the Birla group, Mangalam Timber and another by Nuchem Plastics. As in many emerging markets, India is experiencing a rapid phase of urbanization with a change in lifestyles, a growing demand for engineered wood panel products, and a high infrastructure, industry sources expect positive growth for wood products such as plywood, particle board, medium density fiberboard, oriented-strand board and laminated veneer lumber in near future.

In the post-liberalisation phase marked by virtually jobless growth in India and recessionary trends in the global economy, the studies pertaining productivity, changes in productive efficiency and wage productivity relationship has assumed increasing importance and relevance. As there are many studies at the aggregate of manufacturing, the present study attempts to analyse the problem at the regional level by concentrating on one particular state namely, Tamil Nadu. Further, there are few studies in the past that have attempted to analyse the productivity, efficiency and wage relationship at individual industry level. A study of the individual industries at regional level was therefore, attempted to have a better understanding of the problem, so as to delineate the area for remedial action.

These industries refer to the sub-set of manufacturing that process raw materials obtained from agriculture and associated sectors. These industries provide crucial farm-industry linkage which helps to accelerate agricultural development by creating backward linkages (supply of credit, inputs and farm production enhancement services) and forward linkages (processing and marketing) adding value to the farmer's produce, generates employment opportunities and increasing farmer's income. Thus, the development of this industry implies the development of agricultural sector on the one hand and the entire set of industries on the other.

B. Selection of the Variables

1. Gross Value Added (GVA) was taken as output, since trends are not affected significantly by the use of gross value added. Kendrick (1973) based his estimates of factor productivity growth on gross value added. Also ambiguity in the calculation of depreciation can be over come if gross value added is taken as a measure of output.

2. Labour input consisted of both workers directly involved in production and persons other than workers like supervisors, technicians, managers, clerks and similar type of employees.

3. In productivity measurement, the fixed capital was taken into account in calculating capital inputs.

4. Wages included renumeration paid to both workers and non-workers.

C. Data Base of the Study

The basic data source of the study was Annual Survey of Industries (ASI) published by Central Statistical Organisation (CSO), Government of India covering the period from 1979-80 to 2008-09.

Since the time period involved in the study was fairly long (24 years), the need to normalise the data has been recognised. All the referred variables were normalised by applying Net State Domestic Product (NSDP) deflator. The NSDP at current and constant prices were obtained by referring to internet web site w.w.w. tn.govt.in, Economic Survey, published by Government of India, Ministry of Finance and Economic Division, New Delhi, Tamil Nadu - An Economic Appraisal, published by Evaluation and Applied Research Department, Government of Tamil Nadu, India. The data on Consumer Price Index for Industrial Workers (CPIIW) was also drawn from the same source to fit the functional relationship between wage and productivity, since CPIIW was one of the factors influencing productivity changes.

D. Tools of Analysis

a. Augmented Dickey Fuller Test

Econometric and time series models have been based on the assumption that the underlying data processes are stationary. Empirically it has been shown that most of the macro variables are non-stationary in nature. Hence, the analysis of non-stationary series with conventional techniques give rise to a fair possibility of spurious co-movement between the variables. In this context, the co-integration and error correction modeling have been suggested to confront the spurious regression and provide a short-run dynamics of causal relationship.

Before doing any test of co-integration, it is necessary in the first place to ascertain that the concerned series are not I(0) and also the exact order of integration since co-integration between two variables arises only when they are of the same order. Hence, the test for unit-root becomes obvious.

In the present study non-stationarity or the presence of a unit-root was tested using the Augmented Dickey Fuller (1979, 1981) tests. To test if a sequence Yt contains a unit-root, two different regression equations are considered.

$$\Delta Y_t = \alpha + \gamma Y_{t-i} + \theta_t + \Sigma \beta_i \ \Delta Y_{t-i} + \varepsilon_i \text{......................(1)}$$

$$\Delta Y_t = \gamma Y_{t-i} + \Sigma \beta_i \ \Delta Y_{t-i} + \varepsilon_i \text{..............................(2)}$$

The first equation includes both a drift term and a deterministic trend and the the second does not contain an intercept but include the deterministic trend. In both the equations the parameter of interest is g. If g = 0, the Yt sequence has a unit-root. The estimated 't' statistic is compared with the appropriate critical value of Dickey Fuller tables to determine if the null hypothesis is valid. However, if the variables are non-stationary, they are tested for the possibility of a co-integrating relationship.

b. Multi-variate co-integration analysis

The multi-variate co-integration technique developed by Johansen (1998) and Johansen and Juselius (1990) was used to test for the number of co-integrating vectors (co-integration rank) in the system. This test enables the estimation of more than one co-integrating relationship and also permits testing for the validity of any restrictions on co-integrating relationships implied by economic theory. This procedure has a further advantage when testing for co-integration. When there are 'n' series and (n-1) potential co-integrating relationships, it first test the null hypothesis of zero co-integrating relationship and proceeds in step-wise fashion to test the null of higher number of such relationship upto (n-1).

The general form of the model for a higher order autoregressive process is :

$$\Delta \chi_\tau = \Sigma\ \pi_1 \Delta_{\tau-1} + \pi \chi_{\tau-m} + \varepsilon\tau \quad \text{.............................. (3)}$$

where c_t is the (n x 1) vector of variables, e_t is an independently and identically distributed 'n' dimensional vector with zero mean and variance matrix SÎP is a (n x 1) matrix and its rank is equal to the number of independent co-integration vectors.

The rank of a matrix is equal to the number of its characteristic roots that differs from zero. Thus, the number of independent co-integrating vectors in the system can be determined by checking the significance of the characteristic roots of π (estimated matrix). The test of the number of co-integration vector can be conducted using the following test statistics :

$$_{trace}(r) = -T\Sigma \quad \ln(1 - l_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$_{max}(r, r+1) = -T \ln(1 - l_{r+1}) \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where li are the estimated values of the characteristic roots or eigen values obtained from the estimated p matrix and T is the number of usable observation. The trace test (equation 4) is the test statistic that tests for the null hypothesis that the number of co-integrating vector is less than or equal to 'r' against a general alternative. The maximum eigen value test (equation 5) is the test statistic that test the number of co-integrating vectors 'r' against the alternative of (r + 1) co-integrating vectors. Critical values for both tests are tabulated in Osterwald-Lenum (1992).

c. Vector Error Correction Model (VECM)

The purpose of the VECM is to focus on the short run dynamics while making them consistent with the long run solution. If a number of variables are found to be co-integrated with at least one co-integrating vector, then there always exists a corresponding error correction representation which implies that the changes in the dependent variable can be formulated as a function of the level of disequilibrium in the co-integration relationship and fluctuations in other explanatory variables. In other words, the error correction term in the VECM provides additional channel for the detection of Granger causality. In fact if Xt and Yt are co-integrated, the first difference of Xt and Yt can be modeled using vector autoregression on VAR augmented by including Yt-1 – θXt-1 as an additional regressor :

$$\Delta \;\;_t = \beta_{10} + \beta_{11}\Delta Y_{t-1} + \ldots + \beta_{1p}\Delta Y_{t-p} + \gamma_{11}\Delta x_{t-1} + \ldots\ldots +$$
$$\gamma_{1p}\Delta X_{t-p} + \alpha_1(Y_{t-1} - \theta X_{t-1}) + U_{1t} \ldots (6)$$

$$\Delta Y_t = \beta_{20} + \beta_{21}\Delta Y_{t-1} + \ldots + \beta_{2p}\Delta Y_{t-p} + \gamma_{21}\Delta x_{t-1} + \ldots\ldots +$$
$$\gamma_{2p}\Delta X_{t-p} + \alpha_2(Y_{t-1} - \theta X_{t-1}) + U_{2t} \ldots (7)$$

where the β's and the γ's are unknown coefficients and u1t and u2t are error terms.

The term Yt- θXt is called error correction term. The combined model in equations (6) and (7) is called a vector error correction model (VECM). In a VECM, past values of Yt - θXt help to predict future values of △Yt and / or △Xt (Stock and Watson, 2004).

The Granger causality can be detected through the statistical significance of t-test for the lagged error-correction term and/or the F-test applied to the joint significance of the sum of lags of each explanatory variable. The non-significance both the t-test and F-test in the system indicates econometric exogenity of the dependent variable. In addition to indicating the direction of causality among variables, the VECM also allows us to discriminate the short run and long run Granger causality. The F-test of the explanatory variables (in their first differences) indicates the "short run" casual effects, whereas the "long run" causal relationship is implied through the significance of the t-test of the error correction term, since it contains long run co-integration information between the variables.

d. Step-wise Regression Model

In order to clearly understand the links between wages and productivity in selected industries, this study has used a simple econometric analysis namely, step-wise regression model (used by Laxmi Narayan, 2003). In the first place, different econometric models, depending upon the number of variables in the exercise were selected, so as to give us relation between wages and productivity. As various measures of productivity may affect wages differently, the models were so designed to include one or more measures of productivity. The analysis was based on the wage rate (W) as the dependent variable and labour productivity (GVA/L), capital intensity (FC/L), consumer price index for industrial workers (CPIIW), gross value added (GVA), total factor productivity index of Kendrick (TFPK) and trend variable (T) as explanatory variables.

The variables included and the models estimated for the analysis are given below.

Model I : W = A eu (GVA/L)α

Model II : W = A eλtu (GVA/L)α

Model III : W = A eλt+u (GVA/L)α (GVA)β

Model IV : W = A eλt+u (GVA/L)α (GVA)β (FC/L δ

Model V : W = A eλt+u (GVA/L)α (GVA)β (FC L)δ(CPIIW)λ

Model VI : W = A $e^{\lambda t+u}$ $(GVA/L)^{\alpha}$ $(TFPK)^{\beta}(FC/L)^{\delta}(CPIIW)^{\lambda}$

Model VII : W = A e^{u} $(GVA/L)^{\alpha}$ $(GVA)^{\beta}$

Model VIII : W = A e^{u} $(GVA/L)^{\alpha}$ $(GVA)^{\beta}$ $(FC/L)^{\delta}$

Model IX : W = A e^{u} $(GVA/L)^{\alpha}$ $(TFPK)^{\beta}$ $(FC/L)^{\delta}$

E. Manufacture of Wood and Wood Products

The results of Augmented Dickey Fuller test for first difference for the manufacture of Wood and Wood Products is presented in table 1.

Table -1 : Augmented Dickey Fuller (Adf) Test for First Difference - Manufacture of Wood and Wood Products

Variable	ADF Value
Wage rate (W)	– 5.5987*
Labour Productivity (LnGVA/L)	– 4.5721*
Gross Value Added (GVA)	– 5.6908*
Capital Intensity (FC/L)	– 6.5820*
Consumer Price Index for Industrial workers (CPIIW)	– 4.0008*
Total Factor Productivity Index (TFPK)	– 2.1497

Source : Estimation based on ASI data.

Note : * Significant at 5% level

The above results indicated that the null hypothesis of a unit-root process could be rejected for all the variables in their first difference at five per cent level indicating that the series were stationary for the manufacture of Wood and Wood Products. However, it was not rejected for Kendrick total factor productivity index (TFPK). This implied that the variable showed the presence of unit-root.

Having established that the variable TFPK was non-stationary, it was tested whether the linear combination of the series was stationary i.e. whether they were co-Integrated by applying the maximum eigen value and trace test.The results are presented in tables 2 and3

Table- 2 : Co-Integration Likelihood Ratio Test Based on the Maximum Eigen Value of the Stochatic Matrix - Manufacture of Wood and Wood Products

Model	Ho	Alternative	Statistics	Critical value (95%)	Eigen value
VI	r = 0	r = 1	14.7264	11.0300	0.5393
	r <= 1	r = 2	0.0139	4.1600	0.7314
IX	r = 0	r = 1	8.5360	11.0300	0.3619
	r <=1	r = 2	0.1317	4.1600	0.6930

Source : Estimation based on ASI data.

Table -3 : Co-Integration Likelihood Ratio Test Based on the Trace of the Stochastic Matrix - Manufacture of Wood and Wood Products

Model	Ho	Alternative	Statistics	Critical value (95%)
VI	r = 0	r >= 1	14.7403	12.3600
	r <= 1	r = 2	0.0139	4.1600
IX	r = 0	r >= 1	8.5360	12.3600
	r <=1	r = 2	0.1317	4.1600

Source : Estimation based on ASI data.

The analysis confirmed the presence of one co-integrating vector for model VI and IX which has TFPK has the explanatory variable. Based on the significance of test statistic, the hypothesis r ≥ 1 was accepted for the model VI and IX.

Table -4 explains the relationship between wage rate and related variables with details regarding VAR model for model VI and IX.

The results of regression analysis for functions explaining wage- productivity relationship in the manufacture of Wood and Wood Products showed that, when real wage rate (Lnw) was regressed on labour productivity (LnGVA/L) in Model I, the relationship was positive and statistically significant with very low elasticity for labour productivity (LnGVA/L) and very low R2 (0.0583). Introduction of time variable (LnT) in model II significantly improved explanatory power, but reduced the value of labour productivity (LnGVA/L) co-efficient in the model. Introduction of gross value added (LnGVA) in model III improved greatly the value of R2 and co-efficient of labour productivity (LnGVA/L) turned significant at 10 per cent level, but co-efficient of newly introduced variable was negative and significant at one per cent level. Introduction of capital intensity (LnFC/L) in model IV turned the sign

TABLE - 4 : WAGE-PRODUCTIVITY RELATIONSHIP - MANUFACTURE OF WOOD AND WOOD PRODUCTS

Model No.	Constant	LnGVA/L	LnGVA	LnFC/L	LnCPIIW	LnTFPK	LnT	Ecm1	R2	DW statistic	F - ratio
I	3.790*** (1.927)	0.393 (1.056)	-	-	-	-	-	-	0.0583	0.613	1.115
II	3.185** (2.334)	0.305 (1.55)	-	-	-	-	0.501* (4.367)	-	0.5562	1.243	10.653
III	6.891* (5.676)	0.369*** (2.074)	-0.826* (4.655)	-	-	-	0.078 (1.570)	-	08282	1.425	18.704
IV	5.978* (4.221)	-0.096 (0.226)	-0.893* (4.865)	0.713** (1.207)	-	-	0.078 (0.613	-	0.8282	1.425	18.704
V	6.084* (4.115)	-0.060 (0.136)	-0.963* (3.811)	0.628 (0.981)	0.091 (0.421)	-	0.064 (0.477)	-	0.8303	1.443	13.701
VI	34.994*** (1.407)	0.029 (0.503)	-	0.554 (0.583)	-0.412*** (1.7264)	-	0330* (3.182)	-1.4312* (3.6868)	0.5182	1.8691	3.765
VII	7.851* (7.184)	0.399** (2.167)	-1.016 (7.523)	-	-	-	-	-	0.7825	1.437	30.573
VIII	6.015/* (4.337)	-0.221 (0.610)	-0.972* (7.630)	0.921*** (1.940)	-	-	-	-	0.8239	1.448	24.947
IX	16.410 (0.444)	-0.075 (0.130)	-	0.357 (0.607)	-	-	-	-1.1795** (2.7429)	0.3244	0.713	1.266

Source : Estimation based on ASI data

Notes : (i) Figures in parantheses are 't' values of the estimates; (ii) * Significant at 1% level; (iii) ** Significant at 5% level; (iv) *** Significant at 10% level.

of labour productivity (LnGVA/L) co-efficient to be negative and statistically insignificant.

The error correction term of the VAR model

Model	Error Correction Term
VI	Ecm1 - 0.6177* Lnw - 0.5352* LnTFPK
IX	Ecm1 - 0.4062* Lnw - 0.2506* LnTFPK

Introduction of consumer price index for industrial workers (LnCPIIW) in model V showed that co-efficient of LnCPIIW took positive sign but was statistically insignificant, whereas the co-efficient of labour productivity (LnGVA/L) was negative, indicating that increase in consumer price had reduced the real earnings of workers. Exclusion of gross value added (LnGVA) in model VI did not bring any significant change in the labour productivity (LnGVA/L) co-efficient, but it turned the trend co-efficient (LnT) significant and positive. The examination of models without trend co-efficient (LnT) i.e model VII, VIII and IX brought out mixed association (positive and negative) between wage rate (Lnw) and related variables. In model VI and model IX, Ecm1 emerged to be significant at one per cent and five per cent level respectively.

The model that seems to best describe the relationship between real wage rate (Lnw) and explanatory variables In terms of R2 was as follows:

$$Lnw = 6.891 + 0.369\ LnGVA/L - 0.826\ LnGVA + 0.166\ LnT$$

$$(5.676) \quad (2.074) \quad (4.655) \quad (1.576)$$

$R^2 = 0.8115$ DW-statistic = 1.494 F-ratio = 22.959

Though the model did not have highest explanatory power but had expected positive sign for labour productivity (LnGVA/L). However, the co-efficient of (LnGVA) was negative and significant at one percent level. The negative sign should not be construed as negative association between gross value added (LnGVA) and wage rate (Lnw). The institutional factors measured in terms of trend variable (LnT) had a positive effect on real wage rate (Lnw) and was significant at 10 per cent level.

Conclusion

The wage-productivity relationship that existed in the manufacture of Wood and Wood products in majority of the cases (either insignificant or negative) disproved the hypothesis that wage rate (Lnw) was significantly related to labour productivity (LnGVA/L). This explained the fact that there were factors other than those considered in this model that have influenced the real wage rate (Lnw) in this industry.

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