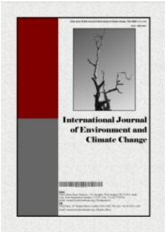

International Journal of Environment and Climate Change

12(11): 3778-3784, 2022; Article no.IJECC.93653
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Spatio-Temporal Analysis of Agricultural Labour Wages Using Vector Error Correction Model: An Integrated Approach to Environment and Climate Change

Rakesh Jammugani [a], B. S. Yashavanth [b*], Supriya Kallakuri [a] and G. P. Sunandini [a]

[a] Professor Jayashankar Telangana State Agriculture University, Hyderabad, India.
[b] ICAR-National Academy of Agricultural Research Management, Hyderabad, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author RJ took part in carrying out statistical analysis and drafting the manuscript. Author BSY designed the study and participated in editing. Authors SK and GPS finalized the manuscript. All the authors participated in final drafting and scrutinizing of the entire study. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i111429

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/93653

Original Research Article

Received 03 September 2022
Accepted 07 November 2022
Published 10 November 2022

ABSTRACT

This study attempted to explore the interactive relations among agricultural labour wage rates in five neighbouring Indian states viz., Andhra Pradesh, Karnataka, Tamilnadu Telangana and Chhattisgarh using monthly time series data of 2005-2020. The objective of this study was to examine the degree of integration among wage rates of agricultural labourers in neighbouring states. Integration with outside markets may partly mitigate the costs of climate change, as individuals respond to warming temperature by migrating to urban areas and internationally in search of employment. We built vector error correction model (VECM) by conducting stationarity test and cointegration test. The Granger Causality test was employed to check whether the wage rates among different states influence each other. For building the VEC Model, the complete data set (180 data points) was split into training (168 data points) and testing (12 data points) data sets. The nonstationarity of the data was established by the Augmented Dickey Fuller test. For the purpose of forecasting, VECM (1) was built and tested for goodness of fit using Mean Absolute

**Corresponding author: E-mail: yashavanthbs@gmail.com;*

Percentage Error (MAPE) which were found to be < 10% for all the states suggesting good fit of the VECM model. A growing body of literature suggests that the economic costs of climate change may be substantial and far-reaching, impacting agriculture, mortality, labour productivity, economic growth, civil conflict and migration.

Keywords: Agriculture; cointegration; labour wage; VECM.

1. INTRODUCTION

Agriculture is one of the major contributor in the development of India's economy. Agriculture and its allied sectors contribute nearly 14% to India's GDP. Agriculture in India is a largely labour-intensive activity. Presently, agriculture employs 41.49% of the workforce in India. Agricultural work force includes cultivators and agricultural labour. Labour is one of the major components of crop production and livestock products. Due to the labour-intensive nature of agricultural operations, labour cost makes up 40% of the total production cost [1]. The majority of labourers in India work on farms, and they rely on agricultural wages to support their families. Cultivators and agricultural labourers are the two main categories of the agricultural workforce. A person is categorised as a cultivator if they cultivate land that is either owned or held by the government, or held by private individuals or institutions, in exchange for payment in cash, kind, or share. A person is considered an agricultural labourer if they work on someone else's property for pay in cash, kind, or a share of the profits. Over the years, the proportion of agricultural labourers has increased compared to the cultivators [2]. The costs of climate change are expected to be particularly acute in developing countries, where households do not have access to the portfolio of adaptation strategies or avoidance behaviours available in more developed countries [3].

Farm wages have undergone large fluctuations during late 2000s and early 2010s. These wages increased significantly after the inception of MGNREGS (Mahatma Gandhi National Rural Employment Guarantee Scheme) [4,5,6]. The average daily income for an agricultural labourer increased from INR 43.90 to INR 228.36 over the 20 years from 1998-1999 to 2017-18 (6). Several research studies have tried to understand the labour related economics in India. Before the inception of MGNREGS, Barbara and Nandini [7] tried mapping India's unorganized labour sector including agricultural labourers. Yashavanth and Laha [2] studied the spatial disparity in the wages of agricultural labours using interval-valued time series analysis. Vector Error Correction Model (VECM) is one of multivariate time series model which is a vector form of Vector Autoregressive Boundary (VAR) for non-stationary time series data and has a cointegration relationship. The purpose of this study is to identify the VECM model in analyzing the relationship between energy use, environmental quality (CO2), and economic growth (GDP) [8].

Market integration is a word used to describe how related marketplaces for products and services exhibit comparable trends in terms of rising or falling commodity prices [9]. Like any other commodity, price of labour i.e., wage is also determined by market forces of supply and demand. Besides, market imperfections, as in any other market, make it deviate from the norms. Due to these factors, there is wide variations in wage rates among various states. Besides MGNREGS, non-farm wages and farm mechanization are also significantly affecting the agricultural labour wages in India. Since 2004, employment has transitioned at a slightly faster pace, reducing the share of employment in agriculture to about half the labour force in 2011–12. Due to this transition, there created the shortage of labour which lead to a rise in agriculture wages. Even though the wage rates of agricultural labour have increased in all the states of India, there exists huge difference in wages paid in different states. The VEC models have been successfully employed to study market integration with regard to agricultural commodities [10,11,12,13]. However, there are no attempts made towards studying the spatial cointegration of agricultural labour wages among different states in India using Vector Error Correction models. The objective of this study is to understand the influence of agricultural labour wages in one state on the other neighbouring states by employing time series cointegration analysis.

2. MATERIALS AND METHODS

2.1 The Data

The study was undertaken covering five states: Telangana, Karnataka, Andhra Pradesh, Tamilnadu and Chhattisgarh. The monthly data of daily agricultural labour wages over the past 15 years i.e., from June 2005 to May 2020 was used. The data was sourced from various reports and publications of the Directorate of Economics and Statistics, Govt. of India. The complete data was split into training (14 years) and testing (1 year) data sets for building and validating the Vector Error Correction model.

2.2 Statistical Analysis

The Sen's slope estimator was used to find the magnitude of the change in agricultural labour wage rates over the study period. Sen's slope estimator is a nonparametric measure which can be used to discover trends in univariate times series [14]. The first step before testing for cointegration is to determine the stationarity of the variables under consideration. Most of the time series analysis techniques are applicable to stationary data. A time series, say y_t, is said to be stationary if its mean, variance and autocorrelation structure do not change over time. Several unit root tests are available which can be used to check if a time series is stationary or not. In this study, we used Augmented Dickey-Fuller (ADF) test which tests the null hypothesis of non-stationarity. The ADF test is augmenting a random walk with drift around a stochastic trend by adding the lagged values of the dependent variable Δy_t [15]. The test will be based on following model:

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \alpha_i \sum_{i=1}^{m} y_{t-i} + \varepsilon_t$$

Where β_1 and β_2 are parameters, t is the time or trend variable, δ represents drift, ε_t is a pure white noise error term.

For testing the presence of long-term correlation, we used the Johansen Cointegration test. Johansen's test is a way to determine if the time series variables are cointegrated and useful in finding the number of cointegrating relationships. If the results from the Johansen's test indicate the presence of long-term equilibrium, one can proceed for the VEC model. If there is no evidence of long-term equilibrium, the Vector Autoregressive (VAR) model can be used.

Assuming $Y_t = (y_{1t}, y_{2t}, \ldots, y_{kt})$ as k-dimensional stochastic time series (t=1,2,…,T) and y_t is integrated of order 1, the VAR model can be established as follow:

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \varepsilon_t$$

With the cointegration transformation, we can rewrite he above equation as:

$$\Delta Y_t = \prod Y_{t-1} + \sum_{i=1}^{p-1} \tau_i \Delta Y_{t-i} + \varepsilon_t$$

where $\prod = \sum_{i=1}^{p} A_i - I$ and $\tau_i = -\sum_{j=i+1}^{p} A_j$. If Y_t has cointegration relationship, then the above equation takes the form

$$\Delta Y_t = \alpha \beta' Y_{t-1} + \sum_{i=1}^{p-1} \tau_i \Delta Y_{t-i} + \varepsilon_t$$

where $\beta' Y_{t-1} = ecm_{t-1}$ is the error correction term. This error correction term reflects the long term equilibrium between the variables.

3. RESULTS AND DISCUSSION

3.1 Spatial Variations for Trend in Labour Wages

Summary statistics of the labour wage data of different states were computed and are reported in Table 1. The highest average labour wages were reported in Tamilnadu closely followed by Andhra Pradesh, Telangana and Karnataka. In addition, these states reported high variations in the labour wages compared to Chhattisgarh which reported least average labour wage as well as variation. The highest wage rate was recorded in Telangana (Rs. 445) during 2020-21. The visual observation of Fig. 1 indicates that the agricultural labour wages have continuously increased for all the states under study. According to the Sen's slope estimators given in Table 2, the highest average monthly increase in the agricultural labour wages was found in Tamilnadu (Rs. 2.143 per month) followed by Andhra Pradesh, Karnataka and Telangana. The least average increase was reported in Chhattisgarh (Rs. 1.12 per month). The graphical analysis (Fig. 1) shows that, the wage rates are not constant over time with variations for all the states indicating non-stationarity of the data. However, the differenced series appear to be stationarity. The results from ADF test (Table 3) revealed that all the original time series are non-stationary at 1% level of significance. Subsequently, the time series variables were tested for presence of cointegrating relationship using Johansen Cointegration test.

Table 1. Descriptive statistics of monthly agricultural labour wages

State	Mean	SD	Kurtosis	Skewness	Min	Max	CV%
Andhra Pradesh	216.51	107.15	-1.38	-0.01	56.25	395	49.49
Chhattisgarh	136.52	60.37	-1.33	0.18	49.29	264	44.22
Karnataka	209.00	111.03	-1.39	0.25	60.00	418	53.13
Tamilnadu	226.12	113.44	-1.50	-0.04	65.00	404	50.17
Telangana	211.40	103.49	-1.15	0.07	56.25	445	48.95

Table 2. Sen's slope estimators

State	Sen's slope estimate	Statistic (z)	p-value
Andhra Pradesh	2.045	18.977	<0.01
Chhattisgarh	1.124	16.789	<0.01
Karnataka	2.028	17.955	<0.01
Tamilnadu	2.143	17.963	<0.01
Telangana	1.961	18.511	<0.01

Table 3. Results of Augmented Dickey Fuller (ADF) test

State	Original series		Differenced series	
	Test Statistic	p-value	Test Statistic	p-value
Andhra Pradesh	-3.42	0.05	-7.68	0.01
Chhattisgarh	-3.23	0.09	-8.15	0.01
Karnataka	-2.53	0.36	-5.74	0.01
Tamil Nadu	-2.86	0.22	-6.66	0.01
Telangana	-4.45	0.02	-6.48	0.01

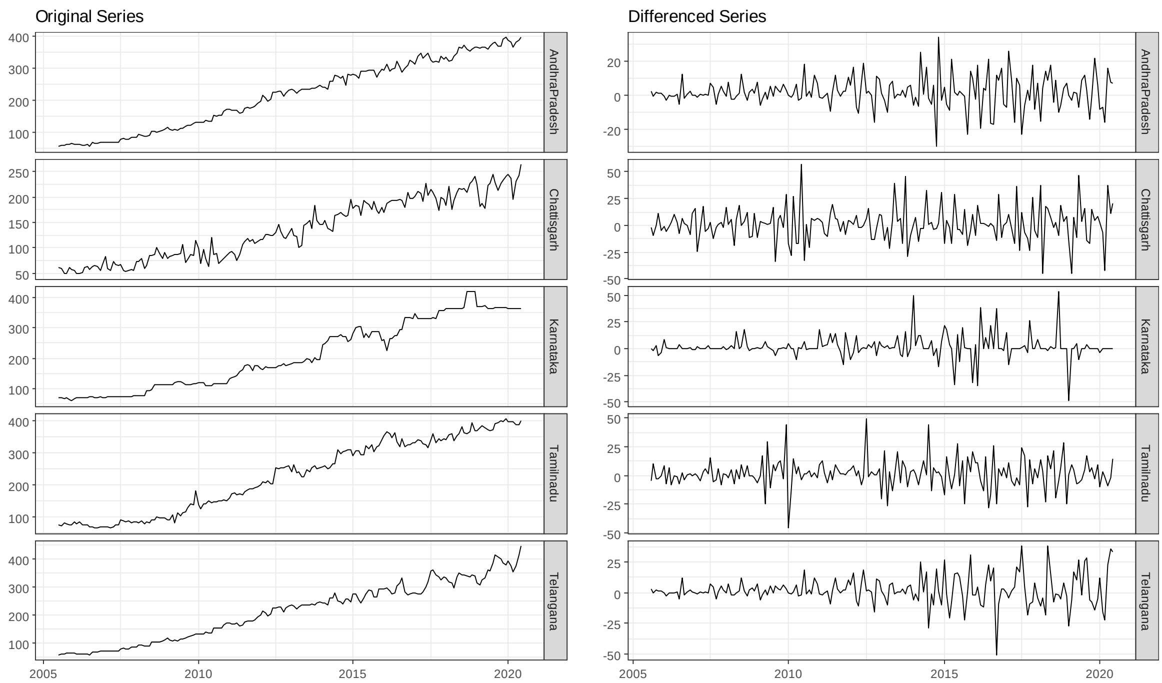

Fig. 1. Time plot of the original and differenced series

Besides getting influenced by its own past values, a time series variable may also get influenced by the past values of other variables. In such cases, it becomes imperative to find out whether there is any such causal relationship between variables. This can be carried out by employing the Granger Causality test. If two labour markets are integrated, then wage in one market would commonly found to Granger cause the wages in other market and/or vice versa. The results of the Granger causality between the five states under study are given in Table 4. The results indicated that, wage rates in Andhra Pradesh were found influencing wage rates in Chhattisgarh, Tamilnadu and Telangana. Similarly, wage rates in Karnataka were found influencing wage rates in Andhra Pradesh, Chhattisgarh and Tamilnadu; wage rates in Telangana found influencing wage rates in Andhra Pradesh, Chhattisgarh and Tamilnadu. Wage rates in Chhattisgarh found influencing wage rates in Tamilnadu, whereas wage rates in Tamilnadu did not influence wage rates in any state. The results suggest that wage rates in one state influence or get influenced by wage rates in one or the other neighbouring state.

3.2 Cointegration Analysis

The Johansen Cointegration test can be carried out using two approaches, viz., trace and the maximum eigenvalue methods. The null hypothesis of the test is that there are at most 'r' number of cointegrating relationships among the time series under the consideration (r > 0). A perusal of the results (Table 5) indicate that the null hypothesis could not be rejected for r = 4, indicating that there are 4 cointegrating relationships. The presence of cointegrating vector indicates that there exists long run relationship between labour markets. Since these markets are cointegrated among themselves, there is an information flow among them.

3.3 Vector Error Correction Model

The existence of cointegration among the variables and their fundamentals necessitated the specification of VECM for this study. So, we fitted the VECM for Agricultural labour wages in five states with one lag and four cointegration relationships. The number of lag terms was decided based on the Bayesian information criterion. The estimates of the VECM are presented in Table 6. Further to the long-term relationships among the variables, the coefficients capturing the short-term dynamics of table are shown in the table along with *t*-values in parentheses. ECT means the error correction term indicating the speed of adjustment at which the wage rates come to equilibrium in case of any disequilibrium. The VEC models suggest that the wage rates in Chhattisgarh and Telangana are influenced by wage rates in Karnataka and Andhra Pradesh, respectively. Besides, the significant error correction terms indicate that the wage rates in many of the states are in long-term equilibrium with each other.

For analysing the performance of the model, we calculated Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) for VEC model of both training and testing data sets. The results (Table 7) showed that the MAPE values are below 10 % for all the states indicating good fit of the VEC model.

Table 4. Results from Granger's Causality test (F values along with significance)

Causing State	Responding State				
	Andhra Pradesh	**Chhattisgarh**	**Karnataka**	**Tamilnadu**	**Telangana**
Andhra Pradesh	-	3.81**	1.47	4.60**	7.45**
Chhattisgarh	1.19	-	0.87	2.30*	1.11
Karnataka	3.41**	3.30**	-	2.47*	0.95
Tamil Nadu	1.91	2.16	0.88	-	1.06
Telangana	4.25**	3.00**	1.66	4.84**	-

**significant at 5%; **significant at 10%*

Table 5. Results of Johansen cointegration test

No. of integrating equations	Eigen value method		Trace method	
	Test Statistic	**5% Critical Value**	**Test Statistic**	**5% Critical Value**
At most 4	12.15	15.67	15.61	19.96
At most 3	20.57	22.00	36.17	34.91
At most 2	47.00	28.14	83.17	53.12
At most 1	51.56	34.40	134.73	76.04
None	64.51	40.30	199.24	102.14

Table 6. Vector error correction model parameter estimates

Parameter	Andhra Pradesh (AP)	Chhattisgarh (CH)	Karnataka (KA)	Tamilnadu (TN)	Telangana (TS)
ECT1	-0.239 (0.073)**	0.194 (0.109).	0.076 (0.095)	0.194 (0.0987)	0.459 (0.086)***
ECT2	-0.102 (0.060)	-0.590 (0.089)***	0.099 (0.078)	-0.045 (0.081)	-0.116 (0.071)
ECT3	0.104 (0.031)***	0.125 (0.045)**	-0.136 (0.040)***	0.012 (0.041)	-0.034 (0.036)
ECT4	0.148 (0.048)**	0.070 (0.071)	-0.099 (0.062)	-0.274 (0.064)***	-0.020 (0.056)
Intercept	5.948 (1.723)***	13.588 (2.561)***	-3.991 (2.237)	1.240 (2.329)	7.130 (2.036)***
AP_{t-1}	-0.115 (0.087)	0.225 (0.130)	-0.019 (0.113)	-0.059 (0.118)	-0.314 (0.103)**
CH_{t-1}	0.090 (0.052)	-0.063 (0.077)	-0.030 (0.067)	0.075 (0.070)	0.099 (0.061)
KN_{t-1}	-0.025 (0.064)	0.287 (0.094)**	-0.095 (0.083)	-0.146 (0.086)	-0.003 (0.075)
TN_{t-1}	-0.006 (0.056)	0.089 (0.084)	0.021 (0.073)	-0.283 (0.076)***	-0.054 (0.066)
TS_{t-1}	0.072 (0.068)	0.147 (0.101)	-0.0876 (0.089)	0.050 (0.092)	0.194 (0.081)*

Table 7. Evaluation of forecasts generated by VECM

State	Training Data		Testing Data	
	RMSE	**MAPE (%)**	**RMSE**	**MAPE ((%))**
Andhra Pradesh	8.24	3.7	13.34	2.9
Chhattisgarh	12.96	8.6	19.39	7.3
Karnataka	10.70	3.8	17.47	4.5
Tamil Nadu	9.96	4.2	9.83	2.1
Telangana	12.94	4.4	45.41	9.8

4. CONCLUSION

In the present study, spatial and temporal relationships in agricultural labour wages among five states viz., Andhra Pradesh, Chhattisgarh, Karnataka, Tamil Nadu and Telangana was studied using time series data of July 2005 to June 2020. The stationarity of the time series data was tested using Augmented Dickey Fuller test which established the nonstationarity of the data. Subsequently, results from the Johansen Cointegration test suggested that there is a long-term equilibrium between the wages in different states. The Vector Error Correction Models were built for the wage rates which indicated that the wage rates in Chhattisgarh and Telangana are influenced by the wage rates in neighbouring states. The VEC models were found to be good fit as established by the Mean Absolute Percentage Error values which were found to be lesser than 10% for all the states. The results of this study establishes that the agricultural labour wages in states are influenced by the wage rates in the neighbouring states and are at long term equilibrium. Thus, the migration of agricultural labourers from one states to other states is imminent if better wage rates are paid in neighbouring states.

ACKNOWLEDGEMENTS

The authors are grateful to anonymous reviewers for their suggestions in improving the manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kumar S, Anwer ME, Immanuelraj TK, Kumar S, Singh HP, Mishra SN, Sarkar SK. Wages in India: trends and

determinants. Agricultural Economics Research Review. 2020;33(1):71-79.
2. Yashavanth BS, Laha AK. Disparity in the wages of agricultural labourers in India: An interval-valued data analysis. Indian Journal of Agricultural Sciences. 2018; 88(6):916-923.
3. Gujarati D. Basic Econometrics. 2003, 4th ed., United States Military Academy, West Point. Jessoe K, Manning DT, Taylor JE. Climate change and labour allocation in rural Mexico: Evidence from annual fluctuations in weather. The Economic Journal. 2018 Feb 1;128(608):230-61.
4. Akhtar SMJ, Azeez NPA. Rural employment guarantee programme and migration. Kurukshetra. 2012;60(4):11–5.
5. Berg E, Bhattacharyya S, Rajasekhar D, Manjula R. Can rural public works affect agricultural wages? Evidence from India. 2012, CSAE working paper.
6. Bhattarai M, Kumar R, Sandhya S, Bantilan C. Whether MGNREGS has affected agricultural wage rate in Andhra Pradesh? A panel modeling across 23 districts from 2000 to 2011. Socioeconomics discussion paper. 2014, ICRISAT, Patancheru.
7. Saini S, Gulati A, Braun J. Kornher L. Indian Farm Wages: Trends, growth drivers and linkages with food prices, ZEF Discussion Papers on Development Policy No. 301, Center for Development Research, Bonn. 2020;42.
8. Fahria I, Sulistiana I. Vector error correction model to analyze energy uses, environmental quality and economic growth during Covid-19 Pandemic. InIOP Conference Series: Earth and Environmental Science. IOP Publishing. 2021;926(1):012066.
9. Barbara HW, Nandini G. Mapping India's world of unorganised labour. Socialist Register. 2001;89–118.
10. Bhardwaj SP, Paul RK, Kumar A. Future Trading in Soybean–An Econometric Analysis. J. Ind. Soc. Agric. Statist. 2015;69:11-17.
11. Paul RK, Karak T. Asymmetric Price Transmission: A Case of Wheat in India. Agriculture. 2002;12:410
12. Sekhar CSC. Agricultural market integration in India: An analysis of select commodities. Food Policy. 2012;37(3):309-322.
13. Wani MH, Sekhar H, Paul RK, Kuruvila A, Hussain I. Supply Response of Horticultural Crops: A Case of Apple and Pear in Jammu and Kashmir, India. Agr. Eco. Res. Review. 2015;28(1):83-89
14. Paul RK, Sinha K. Spatial Market Integration among Major Coffee Markets in India. J. Ind. Soc. Agric. Statist. 2015; 69(3):281-287.
15. Sen PK. Estimates of the regression coefficient based on Kendall's tau. J. Am. Stat. Assoc. 1968;63:1379-1389.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/93653