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Agri. Industrial Structure and its Influence on Energy Efficiency: a Study of Pakistan

[1] Zeeshan Ahmad
[2] Meng Jun
[3] Imran Khan

[1] College of Economics and Management, Northeast Agriculture University, Harbin, China
PhD Scholar
E-mail: zeeshanahmad_83@yahoo.com
[2] Northeast Agriculture University, Harbin, China
Professor at Faculty of Sciences
[3] School of Economy and Management, Harbin Institute of Technology, China
PhD Scholar, Lecturer, Department Of Management Sciences, the Islamia University Of Bahawalpur, Bahawalnagar Campus, Pakistan

Abstract

For last few years Pakistan has been suffering from energy crisis, under these circumstances to encourage efficiency and increase farmer's income is very important and for this proposes the optimization of agricultural industrial structure is an important way. We collected 18years data on agricultural industrial structure measurements, energy efficiency indicators in 4 provinces from 1993-2010, and established regression models to look for the influence of agricultural structure on energy efficiency of Pakistan. We tried to find out the relationship between energy efficiency and agricultural industrial structure. Empirical results have shown that agricultural structure optimization has positive effect on social stability, agricultural economic development and energy efficiency in Pakistan's rural areas. Therefore agriculture industrial structure deserves the attention of researchers as well as government.

Keywords: agricultural industrial structure; energy efficiency; economics growth; optimization; Pakistan; regression model; rural development.

Introduction

Energy has been an elementary input of agriculture since the age of agriculture as bread to butter till now the modern ages. It is a well-known fact, worldwide, that agricultural production is positively correlated with energy inputs (Singh, 1999). Almost 113.16 million (64.3%) of Pakistan's people live in rural areas, the persistent improvement of agricultural productivity and energy efficiency are therefore important challenges for the country's long-term development. Pakistan's agriculture is in a process of modern technology adoption plant cultivation, forestry, and animal husbandry all are going through this technology evolution period. Traditional ways of agriculture are shifting into modern ways of agriculture. In broader perspectives, however, the industrial structure of Pakistan is almost concentrated on grain production. Along with all other factors, war on terror in the

region has also made space for smuggling of livestock from all provinces to war affected areas where it is sold on high prices.

As per the Pakistan Economics survey 2011, the percentage share of agriculture to total output is 21.4 % which shows that agriculture is of vital importance in country's economic development. Furthermore, considering current energy crisis situation, continuously increasing energy costs and international environmental challenges, energy efficiency is considered to be of utmost importance for sustained growth in Pakistan. As per the Hydrocarbon Development Institute of Pakistan 2011, coal, oil, LPG (liquid Petroleum Gas), natural gas and electricity accounted for 10%, 29%, 1%, 44% and 16% respectively of the total energy consumption in Pakistan. Agriculture sector of Pakistan largely depends on electricity and oil but this is mostly associated to low efficiency and the oil usage also results in pollution. As agriculture is the source of bread and butter for rural areas of Pakistan and its economic development, considering the current energy crisis situation and short fall of energy production in the country, energy consumption is a key constraint in the future development.

Hence, modifications in agricultural structure are of key importance for the economic growth of the country. Since 1993 to 2010 in Punjab and Sindh province, plant cultivation was the most important sub-sector in agriculture and accounted for 57% of agricultural output. As agriculture is the main industry in the country, if there are any kinds of structural changes within the agricultural industry then it would be most important factor for increase in incomes and living standards of the people related to this sector in the region. On the contrary, as energy efficiency depends mostly on technology advancement to decrease the energy intake and energy amount in the production process, it might be possible to make agriculture as energy efficient sector by adjusting its industrial structure to best optimized one. Therefore to improve energy and resource efficiency, agricultural industrial structure alteration can be of vital importance.

Although a few studies of energy use patterns in Pakistan have been carried out but these were mostly for a specific area or a specific crop (Khan, 1994; Khan and Singh, 1996; Khan and Singh, 1997). Pakistan is continuously going through technology adoption and for this reason the energy output/input ratio has fluctuated over this period. Therefore it is not rational to consider this only by taking few crops into consideration. Energy use in the Pakistan agriculture has significantly increased over the last several years. This trend will continue in the future. Therefore the policy makers are required to put in order energy use policies which are environment friendly energy and guarantee a sustainable growth of agriculture sector (Mohammad A. K et. al. 2009).

In this research the analysis are conducted initially to study systematic influence of the agriculture industrial structure adjustment on Energy Efficiency of Pakistan's four provinces (Punjab, Sindh, Khyber Pakhtunkhwa (KPK) and Balochistan). In addition, our work distinguishes itself from earlier qualitative studies by conducting quantitative analysis using regression analysis to apprehend the heterogeneity in each sub sector and four provinces, to enhance the energy efficiency of the county's rural areas.

This research initially gives insight to selective literature overview on development and structural adjustment/change, later quantitatively analyzes the relationship between agricultural industrial structure and efficient energy consumption. Finally the research discusses some repercussions and future guidelines in policy making, based on our study, to make sure a sustainable growth in sector by reducing the energy cost of the sector by enhancing energy efficiency.

Literature review

The literature dealing with agriculture industrial structure change/adjustment and its influence on energy efficiency is numerous. But the question here is "what is the influence of agriculture industrial structure adjustment on energy". Agriculture is a key industry for any developing country and for Pakistan it plays the role of backbone of Pakistan's economic progress. Predominantly it is closely linked to people's income growth. Structure adjustments in agriculture sector could expand the sector's efficiency as well as the quality of the environment. This may ultimately play vital role in conserving the size of cultivated land and enhance its production capacity (Bai et al. 2007). The structure and current configuration of the industry which refers to the segments and the inter relationship among sub sectors, directly control the features of growth and whole economic development. It is frequently hypothesized that the introduction of a

production quota slows own structural change and hinders efficient adjustment processes (Colman, 2000).But is this also true if quotas could be tradable (Barichello, 1995)?

Previous research work in this area has studied agricultural industrial structure from other angles. Most of the researches in the area have been carried out since 1990's with a goal to improve the agriculture industrial structure. As energy efficiency relies mainly on technology advancement to reduce the energy intake and energy amount in the production process, it might be possible to make agriculture as energy efficient sector by adjusting its industrial structure to the best optimized one, increasing the proportion of energy saving sub sectors, and reducing the share of energy consuming sub sectors (Zha et. al. 2009). This can also be achieved by looking at the Sector-wise energy conservation potential. The change of both attitudes and of life styles towards the use of energy is needed at the national level to conserve electricity which will help in reducing the present run-way demand. Energy conservation is the only short term measure which can fill the gap between demand and supply (M. S. Khan 2012). Agricultural production system which includes input output ration of the sector is also an important factor to energy efficiency. In recent years Pakistan's Agricultural production systems could not increase the resulting output. Importance of integrated planning in achieving desired outputs while using all the available technologies for improving agricultural production has increased and the planners need to formulate policies which are environmental friendly and sustainable in longer terms (Mohammad A. K. et. al. 2009).

Pakistan is a developing country and is under a process of technology adoption in every area. Agriculture is also taking a modern shape. This means the use of modern technology and the use of more energy. But it is still far behind than the other developing countries in the region like India or China. Although agriculture sector is not using huge energy supplies but still there is huge potential for energy efficiency and through proper implementation Pakistan can save around billions of dollar per annum (F. U. Khan 2011).

The weakness in the previous study works are related to the lack of detailed quantitative data, therefore, some of the conclusions are absent of strong empirical evidences. Several studies have used environmental factors and discussed their impact on agricultural development (Karkacier and Goktolga 2005; Downing et al. 2005). This research aims to address some of the weaknesses by (a) establishing a regression analysis using historical data from four provinces of Pakistan to observe the whole influence of agricultural industrial structure adjustment on energy efficiency, and (b) applying regression analysis to measure the role of different sub sectors of agriculture to energy efficiency.

Data and pre-analysis treatments

The data which is used in this study covers all four provinces of Pakistan namely Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan. We build two models for analysis of the Agri-Industrial Structure Adjustment and its influence on Energy Efficiency.

In underlying study the dependent variable of these two models is output per unit of energy consumption. Higher the energy efficiency the better it is. The independent variable in our study, for both of the models, is Agri-industrial structure. Whereas it is further divided into four sub sectors namely; Plant cultivation, Livestock/animal husbandry, Forestry and Fisheries. The industrial structure is measured in terms of share in GDP of the above mentioned four sub sectors.

For consistency reasons, estimates of GDP are taken at constant factor cost of (1999-2000). We calculate gross output values as the sum of output from plant cultivation, livestock/animal husbandry, forestry, fisheries, and service sector. Province-wise data has been calculated as the average of provincial outputs. For output per unit of energy consumption we first calculated the per acre production of every province then per unit output of energy consumption was calculated by the proportion of each agriculture sector. Data for 4 provinces are obtained from different sources i.e. Pakistan Bureau of Statistics (Agriculture Statistics Section, 1993-2012), Government of Pakistan Ministry of Food, Agriculture and Livestock (Economic Wing) 2006, Pakistan Economic Survey (2005-06, 2012-13), Hydrocarbon Development Institute of Pakistan, Pakistan Energy Yearbooks (2001, 2003, 2006), Provincial Bureau of Statistics , World Bank and Food & Agriculture Organization (FAO).

Data analysis and discussion

Energy efficiency refers to output per unit of energy consumption. Since the start of energy crisis Pakistan suffers from inefficient use of its energy resources. However to increase the energy efficiency has become an important topic in Pakistan for the current and future economic

development. To check the impact of agricultural factors on energy efficiency we use regression analysis. Separate regression models were built for each province because energy supply and efficiency is different in each province. For our analysis we have not taken forestry into consideration and supposed that it has very minimal effect on energy conservation.

To check the energy efficiency of Punjab we develop the following model:

$$E_t = \beta_0 + \beta_1 m_t + \beta_2 n_t + \beta_3 o_t + \varepsilon_{it} \quad \text{(Model-1)}$$

Where E is energy efficiency and m_t, n_t, o_t represents the ratio of the agri. sub sector variables cultivation, livestock and fisheries in the GDP respectively. β 1, β2, β3 are the slopes of the sub sector variables and β0 is intercept. ε is the error term with zero mean and constant variance. t denotes the different time periods. Following are the SPSS output tables:

Table 1

Model No.	**R2**	**R2 – Adj.**	**Std Error of Estimate**	**F (sig)**
1	0.787	0.742	1.383	0.000
2	0.794	0.750	3.17684	0.000

Table 2

	Model No. 1	**TOL**	**VIF**	**Model No.2**	**TOL**	**VIF**
Constant (β_0)	-12.579			63.912		
Cultivation (β_1)	1.141	0.178	5.621	1.222	.621	1.611
Std. error	0.523			0.199		
Sig.	0.047			0.000		
Livestock (β_2)	-0.465	0.205	4.868	2.175	.629	1.591
Std. error	0.270			0.421		
sig	0.106			0.000		
Fisheries (β_3)	1.50	0.648	1.544	-4.191	.905	1.105
Std. error	0.383			1.110		
Sig.	0.002			0.002		

First table shows the model summary, according to R2 the model is fitted good with the value of (0.787) which means that 78.7% of the variation is explained by the model. Significant result of ANOVA also supports that our model is fitted good with significant value of f-test is (0.000). Most of the variation is explained by the model. There is no multi-collinearity in the model as our variance inflation factor (VIF) values are below 10.

Beta coefficients of cultivation, livestock and fisheries are 1.141, -0.465 and 1.50 respectively. Beta coefficient of livestock is insignificant but other two are significant at 0.05 level of significant. Cultivation and fisheries are showing positive impact on energy efficiency of Punjab province.

Government should focus on these sectors by taking serious initiatives to enhance the GDP share of cultivation and fisheries as it has positive relationship with energy efficiency in Punjab province.

Energy efficiency of Sindh province:

Same model is used to measure the energy efficiency of Sindh province

$$E_t = \beta_o + \beta_1 m_t + \beta_2 n_t + \beta_3 o_t + \varepsilon_{it} \quad \text{(Model-2)}$$

The explanation of the parameters are same but in consideration of Sindh province.

This model is also fitted well with the R2 value of (0.794) which means that 79.4% of the variation is explained by the model. Significant value of F-test (0.000) also shows that the model is fitted well. Model doesn't have any violation of the regression assumption as VIF and tolerance (TOL) values are in the acceptable range. Beta coefficients of the variables cultivation, livestock and fisheries are 1.22, 2.175 and -4.191 respectively. Cultivation and livestock shows the positive effect on energy efficiency but fisheries shows negative impact on energy efficiency. This negativity is because most of the fisheries industry of Sindh is associated with sea.

Energy efficiency of KPK province:

To validate the simple model we modify the model by applying the natural logarithm of both independent and dependent variables. So the new model is as under:

$$\ln E_t = \delta_o + \delta_1 \ln m_t + \delta_2 \ln o_t + \delta_3 \ln q_t + \varepsilon_t \quad \text{(Model-3)}$$

δ_o is constant, δ_1, δ_2 and δ_3 are parameters and m, o, q are variables for cultivation, livestock and fisheries respectively. Where t is time period.

Table 3

Model No.	**R2**	**R2 – Adj.**	**Std Error of Estimate**	**F (sig)**
3	0.503	0.397	0.4459	0.018
4	0.357	0.219	0.4722	0.000

Table 4

	Model No. 3	**TOL**	**VIF**	**Model No.4**	**TOL**	**VIF**
Constant (δ_o)	-3.205			9.943		
Cultivation (δ_1)	.349	0. .417	2.399	1.721	0.583	1.715
Std. error	0.413			0.767		
Sig.	0.000			0.041		
Livestock (δ_2)	1.350	0.477	2.095	-2.584	.576	1.738
Std. error	1.431			1.074		
sig	0.000			0.030		
Fisheries (δ_3)	-.537	0. 281	3.560	-1.488	.983	1.017
Std. error	.287			1.815		
Sig.	.082			.426		

As the results show that this model fitted well. Both R^2 and F-value support the argument (0.50 and 0.018 respectively). Model doesn't have any violation of the regression assumption as VIF and TOL values are in the acceptable range. Beta coefficients of all independent variables are significant (Cultivation and livestock are significant at 0.01 and fisheries is significant at 0.10). Beta coefficient of livestock indicates that 1% increase in ratio of livestock in GDP will increase energy efficiency by 1.35%. Beta coefficient of cultivation shows that 1% change of cultivation ratio in GDP will result an increase of 0.35% in energy efficiency. While the fisheries has negative effect on energy efficiency. As results shows that 1% increase in fisheries ratio in GDP will decease energy efficiency by 0.54%. Policy makers have to focus more on livestock and cultivation in KPK province to enhance energy efficiency. KPK is the province with more feasible conditions for livestock as well but previously it was considered that it is only suitable for cultivation. Many of the fruits are being cultivated in KPK. As the empirical results show, Government should support farmers to enhance livestock share in KPK GDP.

Energy efficiency of Balochistan province:

To validate the simple model, we modify the model by applying the natural logarithm of both independent and dependent variables as applied for KPK. So the new model is as under:

$$\ln E_t = \delta_0 + \delta_1 \ln m_t + \delta_2 \ln o_t + \delta_3 \ln q_t + \varepsilon_t \quad \text{(Model-4)}$$

δ_0 is constant, δ_1, δ_2 and δ_3 are parameters and m, o, q are variables for cultivation, livestock and fisheries respectively. Whereas "t" represents the time period.

Goodness of fit of the model is good as F-value is significant (0.000). Models don't have any violation of the regression assumption as VIF and TOL values are in the acceptable range. Beta coefficients of all independent variables are significant except fisheries. Cultivation and livestock is significant at 0.05 level of significant. According to results livestock has negative impact on energy efficiency. One percent increase in ratio of livestock in GDP will result a decline in energy efficiency by 2.58%. It is because that the rural area of Balochistan province is lacking behind in some fundamental agriculture facilities. The Population is very scattered. While cultivation has positive impact on energy efficiency as results indicates that 1% increase in cultivation ratio in GDP will improve energy efficiency by 1.72%. Balochistan is an important fruit producing province in Pakistan. If government focuses more in enhancement of its share in GDP it will increase energy efficiency.

Conclusion

Agriculture sector plays a significant role in Pakistan's economy in diverse ways. Roughly 20% of national income and 43 % of total employment are generated within this sector. Despite the accepted lamentations about the neglection of agriculture in the country, the performance of the sector has been simply exciting. Pakistan is a developing country and is under a process of technology adoption in every area. Agriculture is also taking a modern shape. This means use of modern technology and use of more energy. But it is still far behind than the other developing countries in the region like India or China. Although agriculture sector is not using huge energy supplies but still there is huge potential for energy efficiency and through proper implementation, Pakistan can save around billions of dollar per annum. According to National Energy Conservation Centre (Enercon) Pakistan under these energy crises situation sector-wise energy conservation potential includes 25 per cent for industry, 20 per cent for transport, 20 per cent for agriculture and 30 per cent for buildings. Which means agriculture sector is playing an important role in energy efficiency of the country.

Agri. Structure adjustments have a considerable influence on energy efficiency and demand further attention of the researchers in the area of research. We have examined the adjustments in all 4 sub sectors of agriculture using the best available data. In Punjab province GDP share of plant cultivation and fisheries must be increased as increase in these two sectors has positive impact on energy efficiency. For Sindh province, our empirical results have shown that GDP share of plant cultivation and livestock should be increased as these sectors have positive relationship with energy efficiency. Same is the case with Khyber Pakhtunkhwa where plant cultivation and livestock have positive relationship with energy efficiency. But in Balochistan only plant cultivation has positive impact on energy efficiency. Other sub-sector livestock and fisheries have negative influence.

These adjustments will make a positive impact on farmer's income which makes a room for further research in this area. Based upon our results one can concluded that agriculture sector has potential for energy efficiency and therefore needs further attention of government authorities to make policies in this regard. There is one limitation of this research that we didn't differentiate among different sources of energy like coal, oil, natural gas etc. while modeling the influence of agri. Structural adjustment, since they produce varying levels of pollutions which may influence our results as discharge of pollution also influences energy efficiency.

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