Energy Perspective of Sugar Industries in Pakistan: Determinants and Paradigm Shift

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Abstract

The aim of this study is to empirically explore micro and macroeconomic factors affecting the Pakistani sugar industries and searching the energy potential of this industry, through the survey of literature. The empirical part has been explored by employing Vector Autoregression (VAR), Granger Causality tests and simultaneous equation models through quarterly data for the period of 1991q2-2008q4. The study also aims to devise policies for the development of sugar industries and identify its growing importance for the energy sector of Pakistan.

Empirical tests applied on the domestic prices of sugar, domestic interest rates, and exchange rate, productive capacities of sugar mills, per capita income, world sugar prices on cultivable area and sugar production reveal very useful results. Results reveal an improvement of productive capacity of the sugar mills of Pakistan on account of increasing crushing capacity of this sector. Negative effect of rising wholesale prices on the harvesting area was also observed. Profit earnings of the sugar mills significantly increase with the rise of sugar prices but the system does not exist for the farming community to share the rising prices of sugar. The models indicate positive and significant effect of local prices of sugar on its volume of import. Another of the findings of this study positively relates the local sugar markets with the international prices of sugar.

Additionally, the causality tests results reveal exchange rate, harvesting area and overall output of sugarcane to have significant effects on the local prices of sugar. Similarly, import of sugar, interest rate, per capita consumption of sugar, per capita national income and the international prices of sugar also significantly affect currency exchange rate of Pakistani rupee in terms of US$. The study also finds sugar as an essential and basic necessity of the Pakistani consumers. That is why there are no significant income and price effects on the per capita consumption of sugar in Pakistan. All the empirical methods reiterate the relationship of variables. Economic policy makers are recommended to improve governance and management in the production, stock taking, internal and external trading and distribution of sugar in Pakistan using bumper crop policies. Macroeconomic variables such as interest rate, exchange rate per capita income and consumption are closely connected with the production and distribution of sugar in Pakistan.

The cartelized role of the sugar industries should also be examined by further studies. There is need to further explore sugar sector of Pakistan with the perspective of energy generation through this sector; cartelized sugar markets in Pakistan and many more other dimensions of this sector. Exact appraisal of sugar industries for energy generation can be done appropriately by the experts from applied sciences.

Keywords: sugar industries, Pakistan, Energy, Dual role of sugarcane.

1. Introduction

Sugar industry is the second largest industry of Pakistan after the textile sector and the country ranks sixth in terms of harvested area of sugarcane out of 16 major cane producing countries(www.isosugar.org). It has valuable significance in the economy of Pakistan and contributes significant share to the national income balance. For the last so many years, yield per hectare of sugarcane in Pakistan has been on the lower side as compared to the developed economies. Macroeconomic policies have been observed affecting the yield of white sugar and sugarcane (Keethipala, 2002).

Pakistanis endowed with 83 functional sugar mills. Of which 45 are in Punjab, 31 in Sindh and 7 in the Khyber Pukhtunkha. With the total crushing capacity of six hundred thousand tons per day, sugar mills are exploiting only 60% to 70% of their actual capacity. Capacity utilization of these mills depends upon the production of sugarcane every year. Thus, production of sugarcane can never be determined with certainty. Output of sugar declined from 4.7 million tons in 2007-08, to 3.19 million tons in 2008-09. Yet further decline was observed in the year 2009-10 to an amount of 3.1 million tons on account of relatively less cropping area in the year 2009-10. On the demand side with estimated per capita consumption of 25 kilogram and population of 175 million, total domestic requirement of sugar is around 4.375 million tons. Around 67 percent of this huge consumption accrues to the commercial purpose in Pakistan.[1] The na-

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1) National Sugar Policy 2009-2010; a draft prepared by the ministry of industries, Pakistan.

tion can easily meet its domestic requirements from its own sources with appropriate management. Uncertain output of sugar in the country necessitates the policy of managing buffer stocks which will also reduce burden on national exchequer by reducing the quantity of imported sugar.

Pakistani sugar mills are engaged only in the production of edible sugar. Many developing countries like India, are trying to link sugar industries with their potential energy needs. Smouse et al. (1998) projected India's rising demand for power exceeding 300,000 M We for the next 25 years for which India is striving to enhance its capacity for energy generation in order to avoid any untoward economic crisis. United States Department of Energy, Pittsburgh Energy Technology Center has already experienced a pilot and highlighted biomass as a source of fuel to generate around 3,500 M We which will be on the increase at the later stages, provided that the sugar industries are brought in the production cycle. Pakistanis also experiencing worst energy shortfall these days. We can benefit from similar projects by involving USAID in the energy sector of Pakistan. Many more studies(Higgins et al., 2003 Sen and Chandra, 2007 Magdy and Daifullah, 1998 Zamarreño and Vega, 1997 Paez-Osuna, et al.,1998 Chiad amrong and Kawtummachai, 2008) have covered energy generating aspect of the sugar industries in various countries. Despite well established sugar mills in Pakistan, researchers in the field of applied sciences have not appropriately focused on energy potential of Pakistani sugar industries.

This study addresses energy and food perspectives of Pakistani sugar industries. Objective of the study is to identify policies not only for the development of sugar sector with the pursuit of prudential macroeconomic policies but also to recognize growing significance of this sector in meeting energy needs of the country in the event of unwieldy power generation system of Pakistan. Purpose of the study is to identify dynamic role of sugar industries in the economy of Pakistan beyond meeting the consumption need of the country. Studies with the perspective of energy generation from the sugar industries of Pakistan are invited from the field of applied sciences, the technicalities of which are beyond the expertise of the writers of this study.

In this connection, our paper is perhaps the first to present an extended review of literature inspiring policy makers to engage applied scientists for the preparation of comprehensive energy plan associated with sugar industries of Pakistan. Additionally, this paper empirically examines micro and macroeconomic factors related to the sugar sector with the perspective of designing comprehensive policies for the development of second largest sector of the Economy of Pakistan. The study empirically explores the effect of domestic prices of sugar, domestic interest rates, and exchange rates in terms of US dollar coupled with productive capacities of sugar mills, per capita income, world sugar prices on cultivable area and sugar production. Main objective of this study is to identify policies for not only the development of sugar sector but also to single out its growing importance for the energy sector of the country.

Following the introduction, further organization of the study includes literature survey, models, and estimation of models, results and their analysis, detailed discussion and conclusions and also some of the limitations.

2. Theoretical Foundation from Literature

2.1. Sugarcane as Blessing for Food

Sugar is one of the most important items in the consumption bundle of Pakistani community. With more than 50 percent of the population below poverty line (Mankiw, 2007); most of the Pakistanis consider sugar as the rich source of calories for human body. Invaluable contribution of sugar industry can be analyzed in two ways. Firstly, this industry produces sugar which is very essential consumer good. Secondly, sugar industry can supplement economy with power generation in Pakistan where energy shortfall is around 3000-5000 MW per day.[2] The energy-oriented aspect of the sugar industries is concealed and it needs to be explored by Pakistani academia, researchers and policy makers alike. Focus of this study is on the energy-orientation. That is why one entire subsection of the review of literature discusses energy orientation of the sugar industries. Demand for sugar generally depends on consumer tastes, availability of substituting factors of sugar, income of the consumer, consumption habits and nature of markets. At the same time role of macroeconomic factors representing economic policies is of significant importance for the sugar sector of Pakistan. Interest rates, exchange rate; imports, world prices, sugar mill capacities, domestic prices of sugar are the macroeconomic factors singled out from the previous studies.

Prominence of this paper arouses in terms energy-dimension of the Pakistani sugar industries in addition to the policy analysis of macroeconomic factors. Though there are many studies on the policy variables related to the sugar industries but economic theory does not unequivocally explains causal relationship of these variables (Titus, 2005). Bordo (1980) examined relationship between money supply and agriculture prices in the short run. Chambers and Just (1982) explored positive effect of expansionary monetary policy on agriculture and negative effect of contractionary monetary policy on the agricultural output. Studies also find dependency of sugarcane yield on pricing of raw sugar set for the farmers, quality of fertilizer, water supply and role of intermediaries (Yaseen, et al., 2005). They employed univariate time series data of sugarcane yield from 1947-2002. Low productivity of sugarcane is also due to some indirect factors of macroeconomic policy. Main weakness of this study is its using of a-the-

2) The statement is from amongst the reasons for load-shedding of electricity given by Minister of Water and Power, Pakistan in one of his interviews to the media persons in July 2010.

oretic models which are highly sensitive to the lag length. Naseer (2005) hints at low productivity faced by the Pakistani sugar industry. The study finds out yield of sugarcane between 39-47 tons per hectare for the last ten years and claims that productivity can be raised to 90-110 tons per hectare. According to the study, recovery of sugarcane could be raised from 8.7% to 11%. One of the reasons for growing low quality sugarcane is the uniform price paid to the sugarcane farmers (Naseer, 2005). This study is based on data from Pakistan Rural Household survey-2004 and found a strong negative impact of sugarcane quality on the productivity of the domestic sugar industry.

Studies(Samdani, 2009) also attribute sugar crisis in Pakistan to cartels of sugar mills and hoarding of sugar stock to the tune of 200, 000 tons of refined sugar by Trading Corporation of Pakistan. Samdani (2009) terms late payment to the growers by the mill owners as one of the sugar crisis in the country.

In many Asian developing economies, the indirect impacts of trade and macroeconomic policies have caused overvaluation of the real exchange rate, which in turn has decreased the effective agricultural prices (Bautista, 1990). According to this study gradual appreciation of currencies in the Asian Economies during 1990s resulted from slashing interest rate in these countries during the period of 1980s. That appreciation of currencies once again penalized agriculture and other trad able sectors. In Philippines, overvaluation of the macroeconomic policies arising from the protection of domestic industry reduced agricultural prices by 30 percent during the 1980s (David, 1990). On the similar pattern of policies in Pakistan, Sri Lanka, and Thailand spurred overvaluation of the real exchange rate by 15–25 percent during the period of 1980s (Bautista, 1990).

Studies also address the effects of counter protectionism policy for the agricultural products in Asia and South East Asia on the prices of local agro-based products. David (1990) particularly studies rising trend of prices of agro-based items on account of counter protectionism policy in the Asian Economies in the mid-1980s.

Faruqee (1998) emphasizes on restricting government intervention in the markets of agro-based products in order to ensure acceptable level of agricultural growth. According to the study, free sugar market in the absence of government intervention and protection against the foreign competition will lead to productive use of constrained land and water resources in the country. The study also recommends the establishment of private sector in order to ensure competition and prevent possible monopolies of sugar mills.

Ferrantino and Ferrier (1995) used stochastic production frontier method to examine technical efficiency among Indian vacuum-pan sugar factories over a five-year period. The study finds most of the factories close to Indian best practice in terms of technical efficiency. Smaller firms and firms with access to sweeter cane are likely to be more efficient than other firms, while publicly owned firms are less efficient. There are transitory positive effects of a long crushing season on technical efficiency.

From this literature survey it is revealed that macroeconomic factors do have an impact on sugar production, sugar prices and also raw material production related to the sugar. Some administrative issues also affect sugar industry but mostly the impact is due to macroeconomic factors that are being controlled by the policy architects. Macroeconomic factors highlighted in the literature are trade-related factors such as imports, interest rates, input prices, taxes, world prices of sugar and production yield or capacity.

2.2. Sugarcane as Blessing for Energy Sector

Studies have suggested cost effective processes for sugar and starch industries by getting values out of the by-products. Lutin et al. (2002) propose the production of by-products out of the liquid and solid wastes of sugar industries in order to achieve cost efficiency which also controls environmental degradation. Based on their learning from the experience of European mills, they have proposed replacement of technologies such as Clarification of diffusion juices by cross-flow micro-filtration with Scepter membranes, Demineralization and purification by conventional electro-dialysis (ED) and separation of sugars from non-sugars by the Improved Simulated Moving Bed (ISMB) process. Pakistan can greatly benefit from these three techniques by developing good trade relations with European Union and China.

Developing countries like India, are trying to link sugar industries with their potential energy needs. Smouse et al. (1998) projected India’s power demand over the next 25 years to be over 300,000 MWe for which new generating capacity must be installed in order to avoid any untoward economic crisis. The study recommends cogeneration, the combined generation of steam and electricity, as an efficient and cost-effective means to save energy which also helps reduce pollution. According to this study, United States Department of Energy's Pittsburgh Energy Technology Center has already experienced a pilot and highlighted biomass as a source of fuel to generate around 3,500 MWe which will be on the increase later stages provided that sugar industries are brought in the picture. Pakistan is also experiencing worst energy shortfall these days. We can benefit from similar projects by involving USAID in the energy sector of Pakistan.

Higgins et al. (2003) recommends integration of growing, harvesting, transport, milling, and marketing sectors of the Australian Sugar Industries for the efficient production and better supply of sugar. According to this study, integration of all the stakeholders of sugar industries shall improve supply side, help retain international competitiveness and protect consumers’ interest in terms of low price by reducing average cost of supply of sugar in the markets.

Only consumption side of sugar is deemed as important in Pakistanwhile ignoring the use of chemicals of utmost importance. Sen and Chandra (2007) investigated molecular structure of humic acid (HA) in the processing of sugar and its wastes. The study has singled out a number of minerals of great use. Pakistani agricultural scientists should take serious notice of the findings of this study. Similar study was also conducted by Magdy, and Daifullah (1998) on the sugar industry mud. According to another study(Vinod et al., 2003), as much as 90% removal of cadmium and nickel is possible in about 60 and 80min, respectively, under the batch test conditions from the waste water of sugar industry. This study further illustrates

".......effect of various operating variables, viz., solution pH, adsorbent dose, adsorbate concentration, temperature, particle size, etc., on the removal of cadmium and nickel... Maximum adsorption of cadmium and nickel occurred at a concentration of 14 and 12－1and at a pH value of 6.0 and 6.5, respectively. A dose of 10－1 of adsorbent was sufficient for the optimum removal of both the metal Ions. The adsorption of both the metal Ions increased with increasing temperature indicating endothermic nature of the adsorption process. Isotherms have been used to determine thermodynamic parameters of the process, viz., free energy change, enthalpy change and entropy change" (Gupta et al, p. 4040).

Zamarreño and Vega(1997) uses State Space Model on the sugar industry of Spain and prove good performance of the neural predictive control in the processing. Paez-Osuna, et al. (1998) identified significant amount of useful organic matter in the sugarcane. Given the potential output of sugarcane around 240 million tons, Walter and Over end (1999) claimed 2–4 GW production of power at competitive basis and up to 2–3 times more if financial and environmental incentives are given. The study recommends Biomass Integrated Gasifier-Combined Cycles (BIG-CC) technology for this purpose. Proportionally, Pakistan can produce significant amount of power from its sugarcane output.

There are studies(Urbaniec, 2004 Urbaniec et al., 2000) which suggest multistage evaporating retrospect in the sugar industry in order to optimize cost and benefit out of energy associated with this very industry.

The issues related to Pakistan Sugar Industry are more prone to supply chain mismanagement. Chiadamrong and Kawtummachai (2008) in their recently published paper on sugar supply management have focused on Thai market. In this paper they have recommended management of sugar warehouses, distribution route to the targeted markets and seaport. This way the study does not emphasize upon the cost minimization approach as has been the convention of other studies. Piewthongngam et al. (2009) addressed the timings for cultivation in Thai sugar industry. The writers used simulation for the purpose of supply chain management and proved 23 percent increase in the supply of sugar in the Thai Economy. Distribution management of sugar is of significant concern in Pakistan.

Cogenerating systems provide a wide range of heat to power ratios from 0 to as high as 100. The energy productivity of sugar plants differ vastly because of variations in equipment efficiency, system configuration and operating steam conditions (Bhatt and Rajkumar, 2001). This study suggests improvements in the systems by the use of advanced designs of steam turbines and introduction of information technologies and associated supervision control and data acquisition, energy management system, multi-media interaction in order to achieve maximum exportable electrical power from a sugar mill after meeting the internal requirement is around 146 kW h/t of cane. The maximum exportable of steam, as per study is around 0.65 t/t of cane.

Similar study was conducted in Vietnam by Bhattacharyya and Thang (2004) in order to address acute shortage of energy generation on account of high demand for energy inn the growing sectors of the economy. The study emphasizes on the significant potential of energy generation from the sugar industry. The study finds generation of energy from the sugar industry at relatively low cost and financially viable option for medium and large size sugar plants. The study conducts sensitivity analysis and indicates that cogeneration plants would be vulnerable to changes in buy-back rates and investment costs. The internal rate of return is more sensitive to changes in buy-back rates than those in investment costs. Medium and large sized plants would be in a better position to withstand such changes in the business environment.

Bogliolo, et al. (1997) conducted very important study related to the sugar industries from the perspective different from the energy generation. The study explores feasibility of treating press water by reverse osmosis(RO) in order to obtain a clean water stream (the permeate) to be recycled for the sugar extraction and a concentrate stream to be sent to the low grade sugar crystallisation. A suitable purification system of press water for membrane fouling control and the use of high RO process temperatures for preventing microbiological activity are examined in this study. The study also presents amodel to interpret the results of RO experiments in very impressive elaboration. In terms of its possible benefits through the use of the RO.

Drummond (1996) re-interrogates key aspects of social theory—realist and regulationist approaches—in order to develop a conceptual framework within which thinking on sustainable development can be progressed. A modified realist approach and insights from regulation theory are used to consider how the development of the Australian sugar industry has been conditioned in ways which make unsustainable outcomes the norm and how this conditioning might be reversed.

Grabowski, et al. (2001) reveal significance of sugar industries as the producers of sugar and energy. Hernández, et al. (1998) investigated the role of sugar industries from the perspective of their significance in the chemical industries which can produce many tonics as by-products of sugar industries. Higa, et al (2009) not only examined the production of sugar and its determinants but also suggested certain equations to relate operations of sugar industries with energy generation process.

3. Models, Estimation and Results

3.1. Vector Autoregression (VAR)

Simultaneous equation models are very commonly applied to the variables which have multi-directional causation. Macroeconomic factors associated with sugar industries also represent similar behavior of mutual causation. This study distinguishes from the previous studies by using the Vector Auto Regressive (VAR) methodology.

The VAR is very popular in forecasting the financial time series which are closely related. In the present study all the macroeconomic variables such as price of sugar, GDP, per capita consumption of sugar, exchange rate, world prices of sugar, harvested area of sugar, interest rate in their quarterly formats have been employed. These variables are not only time series in nature, but also closely related to each other. The VAR is also appropriate to explore the dynamic impact of random error terms on the group of variables. Contrary to the VAR, the simultaneous equation models, at the very outset, require researchers to identify exogenous and endogenous variables. In the process of identification, most of the time researchers may encounter the problem of over identification. On the contrary, the VAR model can be presented as follows:

$$Y_t = \sum_{i=1}^{p} \alpha_i Y_{t-i} + \beta X_t + \mu_t$$

Where Yt is vector of endogenous variables and Xt is the vector of exogenous variables; while α and β are the coefficient matrices. In the mathematical expression, μis vector of innovations (the error term). The error term might be contemporaneously correlated but without simultaneity. That is why the model produces consistent estimates.

Another reason to consider VAR is its non structural nature for which researchers do not need to probe into the standard economic theory related to the dynamic relationships of the variables. The model is fit where the relationships fail to determine distinct direction of causality.

Determinant of the variance-covariance matrix of the error terms can be calculated according to the following formula (adjusted for degree of freedom):

$$\left|\hat{\Omega}\right| = \det\left(\frac{1}{N-p}\sum_t \hat{e}_t \hat{e}_t'\right)$$

Where p is the number of parameters estimated in each equation of the VAR and the other symbols have their usual meanings.

Assuming multi variate normal Gaussian distribution, the log likelihood ratio can be calculated by the following formula:

$$L = -\frac{N}{2}\{k(1+\log 2\pi) + \log\left|\hat{\Omega}\right|\}$$

For the selection of parsimonious model, this study considers the following two information criteria:

$$AIC = -\frac{2L}{N} + \frac{2n}{N}$$

$$SC = -\frac{2L}{N} + \frac{n \log N}{N}$$

Where n = k(d + pk) is the total number of estimated parameters of the VAR model.

3.1.1. Diagnostic Tests Related to the VAR

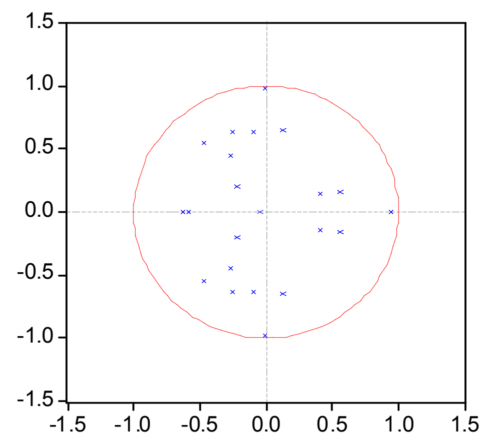
In the class of VAR, the diagnostic tests can be in terms of Lag Structure and Residual Tests in addition to the other statistical criteria.

3.1.2. The Lag Structure Tests

These tests include:

- AR Roots
- Pair-wise Granger Causality Tests
- Lag Exclusion Tests
- Lag Length Criteria

For stable estimates of the VAR, the absolute values of AR roots must be less than one for which they must lie inside the unit circle.



<Figure 1> Inverse Roots of AR Characteristic Polynomial Two Period Lag

It is quite obvious from the figure that most of the roots fall inside the circle. Thus, VAR satisfy stability condition almost on the margin for the data set considered in this study.

The results presented in the table 1 are based on first difference of the endogenous variables.

<Table 1> Roots of Characteristic Polynomial

Roots	Modulus
No root lies outside the unit circle. VAR satisfies the stability condition.	

3.2. Pair-wise Granger Causality Tests

In the VARmodels another of the strongest diagnostic tests is the category of Granger Causality/Block Exogeneity Wald Tests. For each equation of the VAR, the value of chi-squared determines significance of all other lagged endogenous variables of the equation. As per this test in terms of all the equations of VAR, the results are not identical. VAR in this paper was tested in two stages. At the first stage it was tested with four period lag and at the second stage two period lag was considered. The exclusion test in case of four period lag strongly rejects equations given below and strongly approves significance of the variables included in each equation. The variables with asterisk are individually significant for their respective models.

1. L_CAPTY = f(L_CRUSH**, L_ER*, L_HARVEST*, L_IMPORT*, L_INT, L_PCC**, L_PGNP*, L_PRO, L_WORLDP*, L_WSPRICE*)
2. L_CRUSH = f(L_CAPTY, L_ER, L_HARVEST**, L_IMPORT, L_INT, L_PCC, L_PGNP, L_PRO, L_WORLDP, L_WSPRICE)
3. L_ER = f(L_CAPTY, L_CRUSH, L_HARVEST, L_IMPORT**, L_INT*, L_PCC*, L_PGNP*, L_PRO, L_WORLDP*, L_WSPRICE)
4. L_INT = f(L_CAPTY**, L_CRUSH, L_ER*, L_HARVEST, L_IMPORT, L_PCC, L_PGNP, L_PRO, L_WORLDP, L_WSPRICE)
5. L_PCC = f(L_CAPTY, L_CRUSH, L_ER, L_HARVEST, L_IMPORT*, L_INT, L_PGNP, L_PRO, L_WORLDP, L_WSPRICE)
6. L_WORLDP = f(L_CAPTY, L_CRUSH, L_ER, L_HARVEST, L_IMPORT, L_INT*, L_PCC, L_PGNP**, L_PRO, L_WSPRICE)
7. L_WSPRICE = f(L_CAPTY, L_CRUSH, L_ER**, L_HARVEST*, L_IMPORT, L_INT, L_PCC, L_PGNP, L_PRO**, L_WORLDP)

On the similar pattern, the exclusion test in case of two period lag approves the significance of the variables in each equation. The variables with asterisk are individually significant for their respective models.

1. L_CRUSH = f(L_CAPTY*, L_ER, L_HARVEST, L_IMPORT, L_INT, L_PCC, L_PGNP, L_PRO*, L_WORLDP, L_WSPRICE)
2. L_ER = f(L_CAPTY, L_CRUSH, L_HARVEST, L_IMPORT, L_INT*, L_PCC, L_PGNP, L_PRO, L_WORLDP, L_WSPRICE)
3. L_INT = f(L_CAPTY, L_CRUSH, L_ER**, L_HARVEST, L_IMPORT, L_PCC, L_PGNP, L_PRO, L_WORLDP, L_WSPRICE*)
4. L_PCC = f(L_CAPTY*, L_CRUSH, L_ER, L_HARVEST, L_IMPORT*, L_INT, L_PGNP, L_PRO, L_WORLDP, L_WSPRICE)
5. L_PRO = f(L_CAPTY, L_CRUSH*, L_ER, L_HARVEST, L_IMPORT, L_INT, L_PCC, L_PGNP, L_WORLDP, L_WSPRICE)
6. L_WSPRICE = f(L_CAPTY, L_CRUSH, L_ER, L_HARVEST, L_IMPORT**, L_INT, L_PCC*, L_PGNP, L_PRO, L_WORLDP)

3.2.1. LagLength Criteria

In the unrestricted VAR model, we have to have appropriate lag length. This study considers all the variables as endogenous. Hence, the lag starts with 1 instead of zero. Among the criteria of Final Prediction Error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan-Quinn information criterion (HQ), the model with 4 lag comes only up to the AIC criterion. The two period lag models meet the criteria of AIC and SC for this study.

In this section, we have estimated multi-variable Granger Causality models with the lags of 2, 4, 6 and 8 for the endogenous variables included in the model. Lag structure and residual tests were used as diagnostic tests for stability of the roots.

The results have been presented in the Table 1. Causality results identify relationship of variables explained in the following paragraphs. Crushing and production capacity in the economy are related, value of rupee in terms of US dollar is related with capacity of the mills, imports and local capacity are related, wholesale price and production capacity are linked, world prices of sugar and local crushing are correlated, harvested area of sugarcane is related with interest rate, production of sugar, local prices of sugar and volume of imported sugar. The wholesale prices of sugar, consumption and real interest are also correlated. Please refer to the Table 2 for further details.

3.3. Estimation of the Simultaneous Equation Models

During the Granger Causality tests, many of the variablesincluded in the study were found mutually interactive. Looking at this trend relationship of the variables it was decided to consider simultaneous equation models. Following simultaneous equations were employed in order to account for relationship of the variables.

L_CAPTY = c(11) + c(12)@trend + c(13)*L_CRUSH + [ar(1)=c(14)]* .... (1)

L_CRUSH = c(21) + c(22)@trend + c(23)*L_HARVEST + [ar(1)=c(24)]* ..... (2)

L_HARVEST = c(31) + c(32)@trend + c(33)*L_WSPRICE + c(34)*RINT + c(35)* L_CAPTY + [ar(1)=c(36)]* .... (3)

L_IMPORT = c(41) + c(42)@trend + c(43)*L_WSPRICE + [ar(1)=c(44)]* ..... (4)

L_PCC = c(51) + c(52)@trend + c(53)*L_WSPRICE + c(54)* L_PGNP + [ar(1)=c(55)]* ..... (5)

L_WSPRICE = c(61) + c(62)@trend + c(63)*L_ER +*

c(64)*L_WORLDP + [ar(1)=c(65)] ..... (6)

The results are given in the Table 3. Values of the R2 for all the six equations are 94%, 0.7%, 77%, 61%, 21% and 82% respectively. Starting from the equation (1), capacity of the sugar mills in Pakistan seems to have improved over time with rising crushing activities. Crushing is supported by rising harvesting areas but the relationship is not so significant, as the values of R2 and t-test do not statistically support the relationship. However, harvesting area is negatively affected by the wholesale price of sugar. That inverse relationship can be attributed to the Pakistani sugar mafia which does not let the benefit of rising prices of sugar reach the poor sugarcane farmers. This trend can be seen from the results related to the equation (3). Rising price of sugar in the local markets compels policy makers to import sugar from abroad. Sugar being essential part of Pakistani food is widely hoarded which creates artificial shortage. Consequently pushing the market price and thereby opening the opportunity of importing sugar from abroad. Equation (5) notably reveals sugar as being the necessity of Pakistani consumers. There is no significant effect of rising price of sugar and GDP growth on the per capita consumption of sugar in Pakistan. Equation (6) of the system reveals significant positive relationship between prices of sugar in the local and the international markets and this positive link of the two prices has strengthen over the period under discussion.

<Table 2> Granger Causality Test

Causation	Lags 2	Lags 4	Lags 6	Lags 8
Crushing on Capacity	Not Significant	Not Significant	Not Significant	Not Significant
Capacity on Crushing	Not Significant	Significant**	Not Significant	Not Significant
Exchange rate on capacity	Significant**	Not Significant	Not Significant	Not Significant
Capacity on exchange rate	Not Significant	Not Significant	Not Significant	Not Significant
Harvested area on capacity	Not Significant	Significant**	Not Significant	Not Significant
Capacity on Harvested area	Not Significant	Not Significant	Not Significant	Not Significant
Imports on capacity	Not Significant	Significant*	Significant*	Significant*
Capacity on Imports	Not Significant	Not Significant	Not Significant	Not Significant
Per capita Consumption on Capacity	Not Significant	Not Significant	Not Significant	Not Significant
Capacity on per capita consumption	Significant**	Not Significant	Not Significant	Not Significant
Per capita GNP on Capacity	Not Significant	Not Significant	Not Significant	Not Significant
Capacity on Per capita GNP	Not Significant	Not Significant	Not Significant	Not Significant
Sugar production on Capacity	Not Significant	Not Significant	Not Significant	Not Significant
Capacity on Sugar production	Not Significant	Not Significant	Not Significant	Not Significant
World prices on capacity	Not Significant	Not Significant	Not Significant	Not Significant
Capacity on world prices	Not Significant	Not Significant	Not Significant	Not Significant
Wholesale price on capacity	Not Significant	Not Significant	Not Significant	Not Significant
Capacity on wholesale price	Not Significant	Significant**	Not Significant	Not Significant
Real interest rate on Capacity	Not Significant	Significant**	Not Significant	Not Significant
Capacity on real interest rate	Not Significant	Not Significant	Not Significant	Not Significant
Exchange rate on Crushing	Not Significant	Not Significant	Not Significant	Not Significant
Crushing on Exchange rate	Significant*	Significant*	Not Significant	Not Significant
Harvested area on Crushing	Not Significant	Not Significant	Not Significant	Not Significant
Crushing on Harvested area	Not Significant	Not Significant	Not Significant	Not Significant
Import on Crushing	Not Significant	Not Significant	Not Significant	Not Significant
Crushing on Import	Not Significant	Not Significant	Significant*	Not Significant
Per Capita consumption on crushing	Not Significant	Not Significant	Not Significant	Not Significant
Crushing on Per capita consumption	Not Significant	Not Significant	Not Significant	Not Significant
Per capita GNP on crushing	Not Significant	Not Significant	Not Significant	Not Significant
Crushing on per capita GNP	Not Significant	Not Significant	Not Significant	Not Significant
Sugar production on crushing	Significant*	Significant*	Significant*	Significant**
Crushing on sugar production	Significant*	Significant**	Not Significant	Not Significant
World prices on crushing	Significant*	Not Significant	Not Significant	Not Significant
Crushing on world prices	Significant*	Significant*	Significant*	Significant*
Wholesale price on crushing	Not Significant	Not Significant	Not Significant	Not Significant
Crushing on wholesale price	Significant*	Not Significant	Significant**	Significant**
Real interest rate on crushing	Not Significant	Not Significant	Not Significant	Not Significant
Crushing on real interest rate	Not Significant	Not Significant	Not Significant	Not Significant
Harvested area on exchange rate	Not Significant	Not Significant	Not Significant	Not Significant
Exchange rate on Harvested area	Not Significant	Not Significant	Not Significant	Not Significant
Imports on exchange rates	Not Significant	Not Significant	Not Significant	Not Significant
Exchange rates on import	Not Significant	Not Significant	Not Significant	Not Significant
Per capita consumption on exchange rate	Not Significant	Not Significant	Not Significant	Significant*
Exchange rate on per capita consumption	Not Significant	Not Significant	Not Significant	Not Significant
Per capita GNP on exchange rate	Not Significant	Not Significant	Not Significant	Not Significant
Exchange rate on per Capita GNP	Not Significant	Not Significant	Not Significant	Not Significant
Sugar production on exchange rate	Significant*	Significant*	Significant*	Significant*
Exchange rate on sugar production	Not Significant	Not Significant	Not Significant	Not Significant

World prices on exchange rate	Not Significant	Not Significant	Significant**	Not Significant
Exchange rate on world prices	Not Significant	Not Significant	Not Significant	Not Significant
Wholesale price on exchange rate	Not Significant	Not Significant	Not Significant	Not Significant
Exchange rate on wholesale prices	Not Significant	Not Significant	Not Significant	Not Significant
Real interest rate on exchange rate	Significant*	Significant*	Significant*	Significant**
Exchange rate on real interest rate	Not Significant	Significant*	Significant*	Significant*
Imports on harvested area	Significant**	Not Significant	Not Significant	Not Significant
Harvested area on imports	Not Significant	Significant**	Not Significant	Not Significant
Per capita consumption on harvested area	Not Significant	Not Significant	Not Significant	Not Significant
Harvested area on per capita consumption	Not Significant	Not Significant	Not Significant	Not Significant
Per capita GNP on harvested area	Not Significant	Not Significant	Not Significant	Not Significant
Harvested area on per capita GNP	Not Significant	Not Significant	Not Significant	Not Significant
Sugar production on harvested area	Not Significant	Not Significant	Not Significant	Not Significant
Harvested area on sugar production	Significant*	Not Significant	Not Significant	Not Significant
World prices on harvested area	Not Significant	Not Significant	Not Significant	Not Significant
Harvested area on world prices	Not Significant	Not Significant	Not Significant	Not Significant
Wholesale price on harvested area	Significant*	Significant*	Significant*	Not Significant
Harvested area on wholesale price	Not Significant	Not Significant	Significant**	Significant*
Real interest rate on harvested area	Not Significant	Not Significant	Not Significant	Not Significant
Harvested area on real interest rate	Not Significant	Not Significant	Not Significant	Not Significant
Per capita consumption on import	Not Significant	Not Significant	Significant**	Significant**
Import on per capita consumption	Not Significant	Not Significant	Not Significant	Not Significant
Per capita GNP on Imports	Not Significant	Not Significant	Not Significant	Not Significant
Import on per capita GNP	Not Significant	Not Significant	Not Significant	Not Significant
Sugar production on import	Not Significant	Not Significant	Not Significant	Not Significant
Import on sugar production	Not Significant	Not Significant	Not Significant	Not Significant
World prices on imports	Not Significant	Not Significant	Not Significant	Not Significant
Import on world prices	Not Significant	Not Significant	Not Significant	Not Significant
Wholesale prices on imports	Not Significant	Not Significant	Not Significant	Not Significant
Import on wholesale prices	Not Significant	Not Significant	Not Significant	Not Significant
Real interest rate on import	Not Significant	Not Significant	Not Significant	Not Significant
Import on real interest rate	Not Significant	Significant*	Significant*	Significant*
Per capita GNP on per capita consumption	Not Significant	Not Significant	Not Significant	Not Significant
Per capita consumption on per capita GNP	Not Significant	Not Significant	Not Significant	Not Significant
Sugar production on per capita consumption	Not Significant	Not Significant	Not Significant	Not Significant
Per capita consumption on sugar production	Not Significant	Not Significant	Not Significant	Not Significant
World prices on per capita consumption	Not Significant	Not Significant	Not Significant	Not Significant
Per capita consumption on world prices	Not Significant	Not Significant	Not Significant	Not Significant
Whole sale price on per capita consumption	Not Significant	Not Significant	Not Significant	Not Significant
Per capita consumption on whole sale price	Significant*	Not Significant	Not Significant	Not Significant
Real interest rate on per capita consumption	Not Significant	Not Significant	Not Significant	Not Significant
Per capita consumption on real interest rate	Not Significant	Significant**	Significant*	Significant*
Sugar production on per capita GNP	Not Significant	Not Significant	Not Significant	Not Significant
Per capita GNP on sugar production	Not Significant	Not Significant	Not Significant	Not Significant
World prices on per capita GNP	Not Significant	Not Significant	Not Significant	Significant**
Per capita GNP on world prices	Not Significant	Significant*	Significant**	Not Significant
Wholesale price on per capita GNP	Not Significant	Not Significant	Not Significant	Not Significant
Per capita GNP on wholesale price	Not Significant	Not Significant	Not Significant	Not Significant
Real interest rate on per capita GNP	Not Significant	Not Significant	Not Significant	Not Significant
Per capita GNP on real interest rate	Not Significant	Not Significant	Not Significant	Significant*
World prices on sugar production	Not Significant	Not Significant	Not Significant	Not Significant
Sugar production on world prices	Significant*	Significant*	Significant*	Significant**
Wholesale price on sugar production	Not Significant	Not Significant	Not Significant	Not Significant
Sugar production on wholesale price	Significant*	Significant*	Not Significant	Significant**
Real interest rate on sugar production	Not Significant	Not Significant	Not Significant	Not Significant
Sugar production on real interest rate	Not Significant	Not Significant	Not Significant	Not Significant
Wholesale price on world price	Not Significant	Not Significant	Not Significant	Not Significant
World price on wholesale price	Not Significant	Not Significant	Not Significant	Not Significant
Real interest rate on world price	Not Significant	Not Significant	Not Significant	Not Significant
World price on real interest rate	Not Significant	Not Significant	Not Significant	Not Significant
Real interest rate on wholesale price	Not Significant	Not Significant	Not Significant	Not Significant
Wholesale price on real interest rate	Significant**	Significant*	Significant*	Significant**

*at ≤ 5 percent level ** at ≤ 10 percent level

System: SIM_WLS

Estimation Method: Weighted Least Squares

Sample: 1991Q2 2008Q4

Included observations: 72

Total system (balanced) observations 426

Iterate coefficients after one-step weighting matrix

Convergence achieved after: 1 weight matrix, 16 total coef iterations

	Coefficient	Std. Error	t-Statistic	Prob.
C(11)	11.91359	1.590384	7.491013	0.0000
C(12)	0.017620	0.019127	0.921205	0.3575
C(13)	0.000269	0.001273	0.211082	0.8329
C(14)	0.970182	0.048085	20.17651	0.0000
C(21)	10.96787	78.39149	0.139912	0.8888
C(22)	0.012545	0.019914	0.629960	0.5291
C(23)	0.171511	5.698729	0.030096	0.9760
C(24)	0.015422	0.119138	0.129443	0.8971
C(31)	14.66948	1.124337	13.04723	0.0000
C(32)	0.001477	0.001406	1.050308	0.2942
C(33)	-0.097171	0.052100	-1.865081	0.0629
C(34)	0.632333	1.559491	0.405474	0.6853
C(35)	-0.026255	0.092861	-0.282734	0.7775
C(36)	0.781099	0.076972	10.14786	0.0000
C(41)	-15.96398	10.32871	-1.545593	0.1230
C(42)	0.031534	0.023854	1.321979	0.1869
C(43)	3.991455	1.678741	2.377647	0.0179
C(44)	0.721409	0.083414	8.648519	0.0000
C(51)	2.103236	1.012158	2.077971	0.0384
C(52)	0.002558	0.003573	0.716096	0.4744
C(53)	-0.070506	0.083164	-0.847790	0.3971
C(54)	0.001022	0.117159	0.008722	0.9930
C(55)	0.050649	0.115664	0.437898	0.6617
C(61)	4.652927	0.987638	4.711168	0.0000
C(62)	0.002607	0.004170	0.625031	0.5323
C(63)	-0.204229	0.236022	-0.865297	0.3874
C(64)	0.375442	0.088092	4.261928	0.0000
C(65)	0.799620	0.073520	10.87629	0.0000

Determinant residual covariance 1.13E-09

Equation: L_CAPTY = C(11) + C(12)*@TREND + C(13)*L_CRUSH + [AR(1)=C(14)]

Observations: 71

R-squared	0.944704	Mean dependent var	12.72994
Adjusted R-squared	0.942228	S.D. dependent var	0.192586
S.E. of regression	0.046289	Sum squared resid	0.143562
Durbin-Watson stat	2.135704		

Equation: L_CRUSH = C(21) + C(22)*@TREND + C(23)*L_HARVEST + [AR(1)=C(24)]

Observations: 71

R-squared	0.007541	Mean dependent var	13.78813
Adjusted R-squared	-0.036897	S.D. dependent var	3.068454
S.E. of regression	3.124550	Sum squared resid	654.1083
Durbin-Watson stat	1.917798		

Equation: L_HARVEST = C(31) + C(32)*@TREND + C(33) *L_WSPRICE + C(34)*RINT + C(35)*L_CAPTY + [AR(1)=C(36)]

Observations: 71

R-squared	0.778567	Mean dependent var	13.81084
Adjusted R-squared	0.761534	S.D. dependent var	0.072109
S.E. of regression	0.035213	Sum squared resid	0.080596
Durbin-Watson stat	1.989362		

Equation: L_IMPORT = C(41) + C(42)*@TREND + C(43)*L_WSPRICE + [AR(1)=C(44)]

Observations: 71

R-squared	0.613036	Mean dependent var	9.550318
Adjusted R-squared	0.595709	S.D. dependent var	1.853914
S.E. of regression	1.178790	Sum squared resid	93.09965
Durbin-Watson stat	1.866093		

Equation: L_PCC = C(51) + C(52)*@TREND + C(53)*L_WSPRICE + C(54)*L_PGNP + [AR(1)=C(55)]

Observations: 71

R-squared	0.213793	Mean dependent var	1.774980
Adjusted R-squared	0.166144	S.D. dependent var	0.123072
S.E. of regression	0.112384	Sum squared resid	0.833598
Durbin-Watson stat	2.009227		

Equation: L_WSPRICE = C(61) + C(62)*@TREND + C(63)*L_ER + C(64)*L_WORLDP + [AR(1)=C(65)]

Observations: 71

R-squared	0.824524	Mean dependent var	6.093367
Adjusted R-squared	0.813889	S.D. dependent var	0.166234
S.E. of regression	0.071714	Sum squared resid	0.339435
Durbin-Watson stat	1.805170		

4. Conclusions

This study examines significance of sugar industries in the economy of Pakistan. At the first stage it explores micro and macroeconomic factors affecting the production of sugar industries. At the second stage, based on findings from the review of literature, it singles out significance of sugar industries for the production of energy for the economy of Pakistan.

Potential output of the industries has been analyzed using the empirical methods of Vector Autoregression (VAR), Granger Causality Tests and Simultaneous Equation Models by considering the factors such as domestic prices of sugar, domestic interest rates, and exchange rates in terms of US dollar coupled with productive capacities of sugar mills, per capita income, world sugar prices on cultivable area and sugar production for the quarterly data of 1991Q1-2008Q4. Diagnostic tests were also applied in order to ensure reliability of the results.

Results of simultaneous equation models reveal an improvement of productive capacity of the sugar mills in Pakistan on account of increasing crushing capacity of this sector. Negative effect of rising wholesale prices on the harvesting area was also observed. The wholesale prices of sugar are decided by the sugar mills independent of farmers growing sugarcane. Profit earnings of the sugar mills significantly increase with the rise of sugar prices. The farmers get nothing out of it; rather they are discouraged to grow more of sugarcane in the subsequent seasons. Nevertheless, the models indicate positive and significant effect of local prices of sugar on its volume of import. Another of the findings of this study positively relates the local sugar markets with the international prices of sugar. Pakistan is one of the large countries in terms of sugar production. In case of bumper crop and significantly enormous production of sugar, millers hoard and manipulate the local market by creating scarcity of sugar in the local market. This hoarding practice pushes up the price and thereby opens the opportunity of importing sugar from abroad. These relationships are also reiterated by the findings from the other two models such as VAR and Granger Causality tests.

Additionally, the causality tests results reveal exchange rate, harvesting area and overall output of sugarcane to have significant effects on the local prices of sugar. Similarly, import of sugar, interest rate, per capita consumption of sugar, per capita national income and the international prices of sugar also significantly affect currency exchange rate of Pakistani rupee in terms of US$. The study also finds sugar as an essential and basic necessity of the Pakistani consumers. That is why there are no significant income and price effects on the per capita consumption of sugar in Pakistan.

Keeping in view the findings of this study, the policy makers are recommended to improve governance in the production, stock taking, internal and external trading and distribution of sugar in Pakistan. Macroeconomic variables such as interest rate, exchange rate per capita income and consumption are closely connected with the production and distribution of sugar in Pakistan. The millers use their stocks as collateral for the purpose of bank loans. This way, financial sector of the Pakistan Economy can also not remain independent of sugar sector.

There is need to further explore sugar sector of Pakistan with the perspective of energy generation through this sector; cartelized sugar markets in Pakistan and many more other perspectives of this sector. All these areas are significantly important but they were beyond the scope of current study. We could not take up the issue of cartelization and exact potential of energy generation from this sector on account of various constraints.

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