Equilibrium Displacement Model for Fertilizer Sector of Pakistan

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Abstract

The current regulatory framework for the fertilizer sector in Pakistan is based upon a huge subsidy on urea processing and use, control on entry through a monopolistic gas supply and tight regulation on distribution, and promotion of urea at the cost of other nutrients. This setting is not sustainable because it has created a huge burden on the exchequer, inefficiency in fertilizer use, un-competitiveness in international markets, and abnormal profits to the industry without much benefit to farmers. This study first explains the existing regulatory framework and quantifies its impact, and then uses an Equilibrium Displacement Model (EDM) to estimate the impact of policy reform on multi-commodities and multi-stakeholder markets. Simulations of several policy options suggests that, under certain scenarios, the abnormal profit of processors can be squeezed, farmers' profit enhanced, and the burden on exchequer can be reduced without much impact on productivity if free trade is allowed.

Keywords: Urea, DAP, fertilizer use, Gas subsidy, distribution subsidy, policy intervention, legal framework, Equilibrium Displacement Model, farmers, processors,

JEL codes: Q13, Q18

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1. Introduction

Public policies designed to promote fertilizer production and its use in Pakistan remain controversial despite many gains attributed to its increased use in agriculture (Ali et. al., 2014). Fertilizer manufacturing was promoted in the country through various fiscal measures, distribution was tightly monitored for any shortage, and its use got popularized among farmers by way of subsidies and several promotional measures. Successive governments have alternated between subsidizing its production, importation and distribution, withdrawing these subsidies in a piecemeal manner, and reverting back when fertilizer prices escalated. However, these policies were highly controversial in terms of their impact on fertilizer-use efficiency, stress on the environment, and burden on the exchequer.

As a result of these policies—alongside a host of other market and institutional factors such as, for example, scale efficiencies in fertilizer processing, lack of institutional capacity to introduce new and more efficient fertilizer products and application methods, and strict regulation for market entry and exit—Pakistan now faces widespread misuse of fertilizer at the farm level, rigid oligopolies in the fertilizer industry, untenable fiscal burdens for the government, and resource degradation in the agricultural sector.

This paper first explains the existing policy environment of the fertilizer sector in Pakistan and its impacts on international competitiveness, distribution of costs and benefits, fertilizer use efficiency and then applies the Equilibrium Displacement Model (EDM) to analyze the multimarket and multi-stakeholder impacts associated with alternative policy interventions.[1] The remainder of this report proceeds as follows. Section 2 synthesizes the related literature while section 3 specifies the EDM in great detail and explains the data used in the model. Next two sections set the stage for the paper by explaining the policy and regulatory environment in the sector in section 4, and explaining the impact of the existing policy environment in section 5. Section 6 describes the simulated results of major government policy interventions. Section 7

[1] The phosphorus fertilizer is not included in the analyses because it has long been free of any government intervention except 2007 and 2008 (Ali et al., 2014).

concludes with recommendations aimed at improving the performance of Pakistan's fertilizer sector and its contribution to future agricultural productivity growth.

2. Literature Review

Most of the studies related to fertilizer in Pakistan are from an agronomic perspective studying its response at the farm-level in various crops (Ayub, Tanveer et al. 1999; Ayub, Nadeem et al. 2002; Shafi, Bakht et al. 2007). Very few studies analyze the policy environment in the sector, which must encompass the whole value chain of processing, marketing, trade, and application to crops. The only exception is the study by CCP, 2010 which describes the policy and regulatory environment of the fertilizer sector in Pakistan. However, the impact of the existing regulatory framework and potential impact of new policy interventions on various players, the main purpose of this study, are not quantified. Moreover, the situation of the fertilizer sector has dramatically changed since 2008, the last year included in CCP 2010.

This study uses an EDM model to quantify the potential impact of new policy interventions, which was originally developed by Richard Muth (Muth 1964). The model links the output of a sector to its various production factors, including qualitative variables such as research, extension, education, advertisement, etc. (Wohlgenant 1993; Piggott *et al*., 1995). It can also link the production outcomes of a sector to its marketing and trade activities (Sumner 1985 and Sumner *et al*., 2005). A sector can be disaggregated to various subsectors and these can also be linked to account for cross-product interactions (say meat, wool, skin, etc. in the sheep industry) to the level researchers wish and the data permits (Piggott *et al*., 1995; Mounter, et al., 2008). The researchers can set some production factors, processing, marketing and trade activities and the outputs of various sectors to be exogenous to the model while others can be endogenous to the system. Harrington and Dubman (2008) have improved the power and flexibility of EDM by combining it with mathematical programming models.

The EDM model has been utilized frequently to examine the impacts of agricultural policies including the impact of new technologies in the Australian beef industry (Zhao, Griffith et al. 2001), Australian sheep and wool industry (Mounter, *et al*., 2008), agriculture research on multiple markets (Piggott 1992), and the impact of environmental regulation on farm income (und Anwendung 1999). Additionally it has been used to assess the effects of U.S. commodity polices on world prices and trade (Sumner 1985), examine water distribution policies (Pritchett, et al.

2010; Alhashim 2013) , analyze the impacts of advertising in Australian beef, lamb, and pork industries in domestic and export markets (Piggott et al. 1995), and very recently to examine the role of fertilizer subsidies in China.(Li, Zhang et al. 2014).

The impacts of policy variables to be studied, assumed to be exogenous, are the price of natural gas used in urea manufacturing (normally called the feed price), the quantity of natural gas supplied for urea manufacturing, the world market urea price, agricultural technology, and the gross sales tax (GST). The impact of these policy variables are analyzed on crop production, prices, trade, profit of farmers, urea production, prices, and its trade, the profit of urea processors, its impact on consumers, the processing and distribution subsidies, and government revenue.

3. Methodology

3.1. Specification of EDM Model

The EDM model works with the premise that an original equilibrium is setup by solving all the endogenous variables in terms of exogenous variables. Then the equilibrium is disturbed by making changes in the variables which are exogenous to the system. These shocks disturb the whole system but the mathematical solution of the model allows new values of the endogenous variables to reach a new equilibrium level thus allowing researchers to examine the impact of exogenous shocks on the variables endogenous to the system.

The model uses parameters derived from demand and supply equations for the input (urea and DAP) and output (i.e. cotton, rice, wheat and other crops) markets[2]. In addition, technology is included as an exogenous variable in all output equations. Both input and output markets are cleared by allowing international trade to balance any deficit or surplus produced in the domestic market. Moreover, marketing margins are assumed to be fixed, i.e., so that changes in consumer and producer prices occurred in the same proportions (See Ali et. al., 2014 for more details). Keeping these assumptions in mind, the following EDM model is specified to estimate the impact of various government policies and their combination on the urea and selected output markets. We first specified the supply and demand for major crops as follows.

$$Q_i^s = f(P_i^f, P_j^f, P_k, T_i)$$

[2] We do not differentiate between the basmati and non-basmati rice varieties in our model mainly because of data constraints. Further, we focused on urea and DAP because these are the most extensively used fertilizer. Moreover, we have a contrasting situation, where urea is heavily subsidized while DAP is not.

$$Q_i^d = h(P_i, P_j, C_i)$$

where Q is the quantity of i^{th} output (i=1,2,3,4 crops, i.e., cotton, rice, wheat, other crops), P_i is i^{th} domestic commodity price at equilibrium where supply and demand curves cross each other, P_j is the price of other commodities, where $j \neq i$, P_k is the domestic price of fertilizer k (k=u, p, i.e., urea, DAP), T is an exogenous technology variable or constant shifter in i^{th} crop production, C_i is the income of the consumer for the i^{th} crop, and the superscript s and d represent domestic production, and domestic demand, respectively.

The output markets are cleared by allowing international trade to balance any deficit or surplus produced in the domestic market as follows.

$$Q_i^d = Q_i^s + I_i$$

$$I_i = l(P_i)$$

$$P_i = P_i^f(1 + t_i)$$

$$P_i^f = P_i^w(1 + z_i)$$

where I_i is quantity of import supply of i^{th} commodity, P_i^f is the factory price of the i^{th} commodity, t_i is the general sales tax (or any other indirect tax imposed) on i^{th} crop. P_i^w is the world price of the ith crop as faced to the traders out of Pakistan (so high P_i^w is an incentive for the outside traders to bring more commodity in the country and vice versa in case of low P_i^w) and z_i is the import duty/tariff/transport cost, which establishes the difference between the world price and domestic price,

Similarly, the urea supply and demand equations are specified as follows:

$$Q_k^s = m(Q_g, P_g, P_k^f, Q_o, P_o)$$

$$Q_k^d = r(P_k, Q_i^s)$$

Where Q_k and P_k are respectively quantity and prices of k^{th} fertilizer , P_k^f is factory price of kth fertilizer, the superscript s, d, w, g, o are respectively for supply, demand, world , natural gas, and phosphate.

The fertilizer market is cleared by allowing international trade to balance any deficit or surplus produced in the domestic market as follows:

$$Q_k^d = Q_k^s + I_k$$

$$I_k = v(P_k)$$

$$P_k = P_k^f(1 + t_k)$$

$$P_k^f = P_k^w(1 + z_k)$$

Where Q_k^d, Q_k^s , is the quantity demanded and supplied of k^{th} fertilizer. I_k is the import of fertilizer, and t_k is the general sales tax on fertilizer. P_k^w is the world price of fertilizer faced by traders out of Pakistan (so a high P_k^w is an incentive for outside traders to bring more fertilizer into the country and vice versa in the case of a low P_k^w), and z_k is import duty/tariff/transport cost and represents the difference between the domestic and world price.

In these supply and demand equations, Q^s, Q^d and P_i , P_k, P_i^w, P_k^w, P^f, I are endogenous variables while *T*, *C*, t, z, Q_g, P_g , Q_o, P_o are assumed to be exogenously determined variables.

These input and output markets are first balanced by substituting the demand equation in the market clearing equation (where demand is equal to supply plus imports). Each equation in this system is then totally differentiated and manipulated so that all variables are converted into proportionate changes and elasticities.[3] The final reduced and transformed equations as follows:

$$EQ_i^s = \eta_i\left(EP_i^f\right) + \sum_{j=1}^{i\neq j, j=3} \sigma_{ij}\left(EP_j^f\right) + \sum_{j=1}^{k=2} \varphi_{ik}(EP_k) + \vartheta_i ET$$

$$EQ_i^s = \gamma_i(EP_i) + \sum_{j=1}^{i\neq j, j=3} \delta_{ij}\left(EP_j\right) + \mu_i EC_i - a_i EI_i$$

$$EI_i = \beta_i \, EP_i$$

$$EP_i^f = EP_i^w + z_i$$

[3] See Appendix 1 for transformation of equations

$$EP_i = EP_i^f + t_i$$

$$EQ_k^s = \upsilon_k EP_k^f + \rho_k EQ_g + \xi_k EP_g + \lambda_k EQ_o + \varsigma_k EP_o$$

$$EQ_k^s = \tau_k EP_k + \sum_{i=1}^{4} \partial_{ki}(EQ_i) - b_k EI_k$$

$$EI_k = \alpha_k \, EP_k$$

$$EP_k^f = EP_k^w + z_k$$

$$EP_k = EP_k^f + t_k$$

Where the operator E applied to any variable is the proportionate change in that variable. For example, EP_k^f, EQ_k^s , EP_k^w, and EI_k are proportionate changes in factory price, domestic supply, world price, and import supply of fertilizer respectively, etc; t_k is the general sales tax on fertilizer; η_i and γ_i are respectively own-price production and demand elasticities, and β_i is the trade elasticities for the i^{th} crop (commodity), μ_i is the demand elasticity of i^{th} crop with respect to the income of domestic consumers, δ_{ij} is the cross price elasticity of demand for the i^{th} crop with respect to the j^{th} crop (j≠i) price and σ_{ij} cross-price production elasticity of i^{th} crop with respect to the price of j^{th} crop (i±j); τ_k is the own price elasticity of demand for k^{th} crop; ∂_{ki} is the elasticity of i^{th} crop production with respect to *k*th fertilizer demand; ϑ_i is the elasticity of crop production with respect to improvement in technology in the i^{th} crop; υ_k is the own price elasticity of supply of *k*th fertilizer; ρ_k, ξ_k, λ_k, and ς_k are respectively processing elasticities of k^{th} fertilizer with respect to its factory price, quantity of natural gas, price of natural gas, available quantity of phosphate and price of phosphate; b_k is the import elasticity of k^{th} fertilizer with respect to its quantity demanded; a_i is the trade elasticity of i^{th} crop with respect to its domestic quantity demanded; $\alpha_k$is the trade elasticity of *k*th crop with respect to its world price.

The above transformed equations are entered in GAMS with their respective elasticities to estimate the impact of exogenous shocks on the endogenous variables.

An important assumption of the model is that the elasticities of the exogenous and endogenous variables being utilized to formulate the equilibrium setup are constant, except for α_k, which takes the value of 1 or 5. The technology of production is assumed to be constant in a given policy scenario although we have also simulated results with an improvement of technology as a result of investment on R&D. The model places no limitations on inputs such as total cropland, or as in the case of this paper, the quantity of natural gas.

3.2. Data and Coefficient Values

The historical data on fertilizer use and its prices, crop production and their prices, gas supplied to the industry and its prices, and international prices fertilizers and crops are obtained from the National Fertilizer Development Center (NFDC), the Ministry of National Food Security and Research (MNFSR), and from various publications referred to in the text. The balance sheets of the industry were used to estimate various fertilizer costs. Personal interviews were also conducted from well informed individuals from the sector. The source and values of different elasticities, marketing margins, and proportions needed to estimate the model are reported in Appendix 2.

All demand elasticities are assumed to be with respect to farmgate prices, supply elasticities with respect to wholesale prices, while trade and import elasticities are with respect to domestic prices in respect to international market prices. The signs of all own price demand elasticities for crops and fertilizers are negative and those of supply elasticities are positive. The sign of the trade elasticity for the i^{th} crop is positive if the commodity is imported in the base year, suggesting that the higher the domestic price relative to the international price, the greater the imports of a commodity oir input, and vice versa if it is exported. For urea and DAP only imported elasticities are assumed because both are always imported. The simulated results for the endogenous variables in percentages are converted into actual quantities and values using 2013-14 as the base year.

4. Policy Environment of Pakistan's Fertilizer Industry

4.1 Processing

Pakistan's emerging domestic fertilizer industry was built on abundant gas supply, which allowed the country to simultaneously increase the national supply of fertilizer and reduce the share of imports, which drew on valuable foreign exchange reserves. Of course, large quantities of certain fertilizer products produced without natural gas (for example, Potassium (K) compounds), and still must be imported in large proportion. Fertilizer use gained momentum as farmers began adopting high-yielding modern wheat and rice varieties in Pakistan's irrigated areas during 1970s (Ali et. al., 2015).

The import substitution policies and introduction of fertilizer responsive varieties led to a sizeable fertilizer industry in Pakistan. Total domestic installed capacity of all types of fertilizer production is currently estimated at 10.0 million metric tonnes, 69 percent of which is for urea and 31 percent for DAP. In recent years, the industry was operating below capacity, at approximately 75 percent in 2013-14, while urea plants were operating at 78 percent of installed capacity. Had there been no underutilization of capacity, installed capacity for urea would have been sufficient to meet all domestic demand (Ali et. al., 2015).

The production capacity and marketing power in the fertilizer industry in Pakistan is concentrated in a relatively few firms. The two big players, Fauji Fertilizer Company (FFC), and Engro Fertilizer Ltd. (EFL), hold more than two-thirds of the total installed urea capacity (MNFSR 2013), and, out of this, about 43 percent is held by FFC and Fauji Fertilizer Bin Qasim Ltd (FFBL).[4] With respect to DAP, FFBL is the market leader with about 54 percent of total demand met by its plant, and with the rest being imported by a large number of smaller firms. As such, there is likely greater competition in the market for DAP, and domestic DAP prices tend to be closely linked to its international price (Ali et. al., 2015).

4.2. Marketing

After privatization of all manufacturing units of the National Fertilizer Corporation (NFC), a public sector fertilizer manufacturing parastatal, over the period 1996 to 2005, domestically produced supply is marketed by private sector processing companies through their registered dealers' networks, while National Fertilizer Marketing Limited, a government subsidiary, is responsible for the distribution of imported urea (Ali et. al., 2014). The marketing of other fertilizer is the responsibility of their respective producers or importers.

4.3. Regulatory Framework

The growth of fertilizer production and use in Pakistan gave rise to a series of policies designed to regulate the industry. First and foremost, from 1954 until the present, the government maintained control of supply and allocation of natural gas to industry. The Provincial Essential Commodity Act (PECA), initially promulgated in 1971 and amended in 1973, placed fertilizer production and marketing under the direct regulatory purview of the federal government. At the provincial level, the Punjab Fertilizer (Control) Order of 1973 further strengthened the power of

[4] FFBL is a subsidiary of FFC, which is controlled by the Fauji Foundation.

federal regulators by rendering provincial management of fertilizer subservient to PECA. Specifically, laws formulated and executed under PECA provide almost complete powers to the Controller[5] in the management of prices, imports and even the size of daily fertilizer transactions. Other policies that have been deployed over the past 40 years include subsidies on fertilizer importation and distribution, and sales tax on its purchases.

The introduction of these policies, alongside the growth of fertilizer production and use, also led to the establishment of several key organizations aimed at promoting fertilizer use. Fertilizer research and development (R&D) was initially undertaken by the Directorate of Soil Fertility in the Research Wing of the Agriculture Department of the Government of West Pakistan, which was converted into provincially separate Soil Fertility Research Institutes (SFRI) in 1971. Issues pertaining to economic policy, for example, concerning production, imports, pricing, subsidies, regulations, and research and development on national issues were addressed by the National Fertilizer Development Centre (NFDC), which was established in 1977 by the Federal Planning and Development Division. At the farm level, the Extension Wing of the Agriculture Department of the Government of West Pakistan was responsible for conveying recommendations for fertilizer use to farmers.

In sum, the development of Pakistan's fertilizer industry has been both a success story and a source of difficulty for farmers, industrialists, and policymakers alike. The success story was driven by a number of key factors: a major technological shift initially in rice and wheat cultivation during the Green Revolution and later in cotton, sugarcane and maize; Pakistan's perceived abundant endowment of natural gas at the time; and the willingness of policymakers and investors to build a domestic fertilizer industry from the ground up. But difficulties in sustaining this success have emerged in the form of unbalanced fertilizer use, poor management practices at the farm-level, poor allocation of public resources for R&D, shortage of gas that induced its rationing, and non-competitive industrial practices. We examine these elements in the sections that follow.

4.4. Fertilizer Use

The total fertilizer offtake increased over fourteen fold between 1970 and 2013 in Pakistan. The 3-year average per hectare N use increased from 20 kilograms per hectare (kg/ha) over 1970-73

[5] For the current management of prices, the controller is at the provincial agriculture department. For imports of urea, the Commerce Ministry through NFML has the responsibility.

to 133 kg/ha during 2011-13, while phosphate fertilizer increased from 2 kg to 33 kg/ha in the corresponding period. The highest increase in per hectare fertilizer use was recorded in 2009-10 when the output-fertilizer price ratio jumped to a record level. During this time, fertilizer application rates increased from 157 kg/ha to 183 kg/ha in just one year. These figures are comparable to those of India (141 kg/ha), but less than those in neighboring Indian Punjab (229 kg/ha).

The balanced use of fertilizer is very important in improving its efficiency. Haerdter and Fairhurst (2003) show that the recovery of N increases from 16 percent within a traditional NP fertilization program to 76 percent in a balanced NPK application. Also, the recovery of P improves with balanced fertilization, namely from 1 percent using NP to 13 percent with NPK, and the recovery of K increases from 22 percent with a nitrogen potassium application to 61 percent with NPK fertilization.

In Pakistan, the recommended ratio of N:P is 2:1, while the optimal level for K is yet to be determined, as its use in the country is very small. However, the average use of P and the N:P proportion is far from optimal. The ratio of N:P was closest to the optimum in 2006-07, at 2.7:1 but decreased afterwards to 3.6:1 in 2013-14. The ratio of N:K reached a minimum in 1985-86 at 28:1 but then decreased over time to 1:0.007 in 2013-14 (Ali et al., 2014). The unbalanced use of fertilizer, which deteriorates the release of all nutrients, including those used in abundance, has not only serious implications for nutrient-use efficiency and agricultural productivity but also for environmental sustainability (Ali et al., 2014) and quality of produce.

4.5. Fertilizer Policy

Fertilizer Policy of 2001 is built around the provision of a gas subsidy for the manufacturing of urea. It states:

> *"It is the intent of this policy to provide investors in new fertilizer plants in Pakistan a gas price that enables them to compete in the domestic market with fertilizer exporters of the Middle East so that indigenous production is able to support the agricultural sector's requirement by fulfilling fertilizer demand."*

Clearly, the policy encourages import substitution to meet all demand from indigenous sources. Although, initially, differential and low rates of gas were offered to new plants to encourage investment, but, lately such differences have been removed. More importantly, the fertilizer policy ignores the distribution, demand and utilization sides of the sector, and particularly, farmers and traders interests are overlooked. Thus, the policy fails to offer incentives to enhance efficiency in fertilizer distribution and application, and to encourage new and more efficient products. The following subsidies are offered to the fertilizer sector.

4.5.1. Gas Subsidy

In line with the fertilizer policy, public subsidies for the production and distribution of fertilizer have also evolved. The most significant subsidy comes through the provision of natural gas to urea producers, as approximately 16 percent of total gas consumed in the country was used by the fertilizer industry (HDIP 2013). The government subsidizes fertilizer manufacturing through a dual gas price policy: one price, similar to the market price in the country, is applicable to the fuelstock for general use, while another price is for gas used in feedstock or fertilizer manufacturing. The feedstock gas prices in Pakistan are substantially lower than the fuelstock prices as well as the USA gas prices, which can be seen as proxy for international prices. The production subsidy, equal to the difference in fuelstock and feed prices in Pakistan, is made available to all urea producers, although issues with access to gas for smaller producers do exist.[6]

We estimated the total value of the production (or gas) subsidy on fertilizer manufacturing in 2013-14 as PKR 48 billion. It has gradually increased from PKR 2.11 billion in 1995-96. While the price of fuelstock increased by over seven times, the growth in the feedstock price was less than four times during the period. The difference in fuel- and feed-stock prices grew by 15 times between 1995-2014 and this, multiplied by a 1.5 times increase in feed gas consumption, has resulted in a 22 times increase in the gas subsidy over the period.

There were clearly two upward shifts in the subsidy trend: one in 2002, when it jumped by 4 times and the other in 2008, when it increased by 1.5 times. The later jump overlapped with the start of an ongoing crisis related to a gas shortage in the country. Although the shortage is not apparent from the gas supply data to the industry, which continuously increased. However, since 2006, the cement sector received 39 percent less gas while the energy sector received 4 percent less of that input. Additionally, the effect of the gas shortage on the fertilizer industry can be

[6] The production subsidy would be much higher if the difference of feedstock prices in domestic market is compared with international prices in USA. However, the subsidy will disappear if the comparison of the gas prices is made with the Middle East price, which itself is highly subsidized.

deduced from the underutilization of an extended capacity, which may alternatively be explained by reasons such as oligopolistic manipulation of the market.[7]

4.5.2 Distribution Subsidy

In addition to domestic production subsidies, the government subsidizes the importation and distribution of fertilizers. Underutilized capacity arose because of gas shortages in 2008, which forced Pakistan to import urea alongside regular imports of DAP. NFML intervenes in the market when the difference in domestic and international prices becomes significant and domestic supply falls short of demand, and it does so by importing higher-priced fertilizer and selling it at the lower domestic price (NFML 2013). Normally, this intervention is limited to imported urea, but for the first time ever in 2007-09, the government intervened in the DAP market through a subsidy on imported DAP.[8] Beginning in 2014, the government allowed the private sector to import urea and sell it at the domestic price, while the NFML covers the price difference including transportation and handling charges.[9] Either way, NFML's intervention in the market is costly for the government (Table 1).

The total production and distribution subsidy in the fertilizer sector during 2013-14 amount to PKR 53 billion, which is about 0.2 percent of the GDP and 4.2 percent of the annual development expenditure of the country.[10] The fertilizer subsidy was 7 times the R&D expenditure in the agriculture sector during 2013-14.

The government also intervenes in the fertilizer market through its tax policies. In 2001, the federal government exempted urea from the general sales tax (GST), but withdrew the exemption in 2011, along with the taxes on other agricultural inputs that had been exempted. We estimate the GST revenue (offtake of urea and DAP multiplied by their respective price and the tax rate) from urea at approximately PKR 50 billion in 2013-14.

[7] Capacity expanded due to new plants of Engro in 2010 and capacity enhancement of FFC in 2009.
[8] The government has also announced a subsidy on DAP sales for 2014-15, but, as of now, no clear distribution mechanism for the subsidy has been defined. (Khan 2014)
[9] However, the SOPs for this mechanism have not been developed.
[10] Estimated using an annual development budget of PKR 1,159 billion, and GDP of PKR 26,001 billion (Economic Survey of Pakistan 2013-14)

5. Impacts of Existing Fertilizer Policies

This section analyzes the impacts of existing fertilizer regulatory and policy environments on sector's competitiveness, distribution of costs and benefits of subsidies, and fertilizer use inefficiency. This will set a stage for a better understanding of the impact of different policy interventions in the next section.

5.1. International Competitiveness

Given the extent of subsidies found in Pakistan's fertilizer industry, it is worth asking whether the industry is actually internationally competitive. One way to evaluate the competitiveness of Pakistan's fertilizer sector is to compare international and domestic prices both with and without subsidies. Although the government provides a relatively small subsidy at the distribution level, we assume that such subsidies stabilize the domestic price and leave them unchanged. Thus direct comparison of domestic prices without the production subsidy and international prices provides an indication of competitiveness in the domestic fertilizer sector.

The domestic price of urea (with the gas subsidy) remained higher than the FOB prices until 2004 with the trend reversing afterwards (Figure 1). Until 2004, fertilizer imports required subsidies because local prices were not high enough to cover shipment, loading/unloading, and in-country transport costs. During 2005-13, the domestic prices were lower; the difference in the two was generally large enough to cover port and other handling charges, thus creating an opportunity for exports of fertilizer, especially to neighboring countries where transportation costs are lower. This opportunity was unlikely to be exploited in the presence of a subsidy, so long as domestic demand remained unmet, and exports existed primarily through informal smuggling channels to Afghanistan.[11] The export of subsidized fertilizers is equivalent to financing importing country farmers.

The trend once again reversed during 2013-14 when domestic prices became higher than international prices, despite the gas subsidy on manufacturing, indicating that the sector has once again become uncompetitive with respect to the international market.[12] Again domestic prices are

[11] The incentive to smuggle urea to India does not exist because of India's higher subsidy rates: India's retail nitrogen prices, with a subsidy, remained far lower than in Pakistan during 1995-2012.

[12] The encouraging fact of this price setting was the absorption of international fertilizer price shocks during 2007 and 2008 without any panic in the domestic market.

not allowed to rise enough to cover the freight, imports, and in country distribution charges as long as imports remained blocked.

So what happens to these same comparisons without the gas subsidies? To examine this, we adjust the domestic price of urea to account for the gas subsidy by adding the per-unit subsidy to the price. Our analysis indicates that the domestic, unsubsidized, price of urea remained higher than the international price during 1996-2004, but afterwards, during 2005-11, it was almost equal to the international price, except for two years (2007-09) when international prices peaked. During 2011-14, the trend reversed again and domestic prices became higher than international prices. This suggests that during 1996-2004, and the last three years, the removal of the gas subsidy would have made urea producers uncompetitive in the international market.[13] During the last twenty years, the fertilizer manufacturing sector without subsidies was competitive with the international market for only six years.

Domestic phosphate prices follow international price trends, but the former remained higher than the latter, with the difference almost equal to transport and shipping costs, except during the peak international price period when government provided a subsidy on phosphate fertilizer (Ali et al., 2014).

5.2. Industry Profit

One logical question from the above discussion is "How has the industry's profit behaved since the increase in the gas subsidy in 2008, accompanied by insufficient gas supply to the industry?" We used the industry balance sheet data which decomposes net sales from fertilizer into various cost items during 2003-2012.[14]

The results depicted in Figure 2 indicate that since 2008, the share of raw material costs increased from 19 percent to 38 percent of total costs, with an almost equal decrease in the share of "other costs of sales." However, these structural changes also were accompanied by an increase in the profit margin from 23 percent in 2003 to 30 percent in 2013, with a peak of 42 percent in 2011.

[13] Our analysis shows that Pakistan is not competitive in the international market, while the CCP (2010) and IRG (2011) studies concluded the reverse. The conclusion in both of these studies is based on 2008 and 2009 international and local price situation, while our conclusion is based on the period 1995-2012. In our study, the normalized prices, after adding back the subsidy in domestic prices, are also lower than international price during 2007, 2008 and 2009.

[14] We completed the series only for FFC and FFBL, which covers over 50 percent of the fertilizer industry. The consistent data over time for Engro firms, another big player in the industry, were not available.

However, it is not clear if this increase in the share of industry profit is due to improvement in the efficiency of the industry, depicted by the decreased costs, or due to the shortage of gas as both phenomena occurred simultaneously since 2008. More analysis is needed to detach the effect of the two on industry profit. Insight in this can be obtained by understanding the performance in an unconstrained market and then taking appropriate steps to distribute the industry profit in an equitable manner. This will be done in one of the following sections.

5.3. Fertilizer Use Efficiency

Fertilizer policies and investments in Pakistan have tended to overlook the promotion of fertilizer efficiency-enhancing practices. For example, fertilizer subsidies have been primarily allocated to the promotion of urea despite the fact that use is close to its optimal level, while other nutrients—namely phosphorus and potassium—are both underutilized by farmers and generally overlooked by subsidy policies. Meanwhile, extension agents tend to place limited emphasis on educating farmers on practices that can improve fertilizer-use efficiency, such as timeliness of application, application methods, and appropriate combinations of different fertilizers.

One impact of this promotion of urea is that its use (119kg per ha), on average, has reached its optimal level (124.7kg per ha) as estimated under farmers' resource-quality and socioeconomic constraints, while the use of phosphorus is far lower than its recommended level. The optimal use of nitrogen fertilizer would have been 16% lower had there been no subsidy of urea (Ali et al., 2014).

Fertilizer use inefficiency (defined as fertilizer nutrient use divided by yield per hectare) has increased in Pakistan for major crops like wheat, rice and cotton, as more fertilizer per unit of yield has been used over time (Figure 3). Possible explanations include increasing resource degradation, such as salinity, water logging, or decreases in organic matter and other nutrient contents in the soil. In very few cases since the Green Revolution have technological changes or changes in soil and water management practices helped to address this problem. An exception is Basmati rice, where a more efficient fertilizer variety was introduced in 1996. This new variety led to a one-time jump in nutrient-use efficiency in rice, indicating the importance of the introduction of new varieties to maintain fertilizer-use efficiency (Figure 3).

Production of 100 kg of wheat in 1980-81 used 4 kg of fertilizer nutrient, but by 2014 to produce the same amount of wheat, 7.9 kg of fertilizer nutrient was applied. Similar trends have been observed in cotton, although fertilizer-use efficiency in rice has remained largely unchanged.

6. Impact of Policy Interventions

After explaining the existing policy and regulatory environment in fertilizer sector and its impact on competitiveness, processors profit, and use efficiency, in this section, we explore the effects of policy changes through different interventions. We use an EDM approach described in the methodology section above to estimate the impact of exogenous policy shocks on the market for urea and DAP and major crops: cotton, rice, wheat and other crops. The analysis not only allows us to understand how the fertilizer market functions in response to various interventions but also identifies winners and losers from each intervention, thereby enabling policymakers to make more informed decisions in the fertilizer sector.

Many simulations can be made using the EDM model, but we consider two most important policy interventions related to this paper: 1) Removing the gas subsidy; 2) Enhancing the crop sector R&D and removing the gas subsidy; 3) Exempting GST on fertilizer; 4) Removing the gas subsidy and GST simultaneously; and 5) removing the gas shortage.

6.1. Policy Scenario 1: Removing the Subsidy on Natural Gas

To completely remove the subsidy on natural gas, the government must exogenously increase the price of the fuel stock by 297 percent. The first important impact from this policy is the rise in the factory cost which shifts the supply curve upward. This increases the factory price of fertilizer and reduces its domestic supply. However, the higher domestic price creates incentives for importers, and thus imports increase based on the import elasticity (which reflects how easy it is to import). In the scenario of a low elasticity for import supply (say of 1), the equilibrium factory price of urea increases by over 10%, while it increases by only 4% in the scenario of a high import elasticity of 5. The price of DAP fertilizer also increases in both scenarios but to a far lesser extent because one unit of DAP requires less than one half the ammonia from natural gas than required for urea. The farm gate prices of urea and DAP (including GST) increase parallel to their factory prices as the difference between the two is a constant wedge. The increased cost of urea and DAP processing reduces domestic supply and increases imports. Higher farm gate prices lower demand (except in the high import elasticity scenario where an increase in imports is more than the decrease in domestic supply).

The changes in the fertilizer market trigger dynamics in the crop markets which produce impacts on government, farmers and manufacturers. The lower demand for fertilizer reduces crop output, depending upon the output supply elasticity with respect to fertilizer price.[15] This creates pressure on output prices. The farmers lose from lower crop production but they benefit from higher output prices and a lower production cost as fertilizer demand declines. In the scenario of a low import elasticity, farmers' overall loss is about PKR 11 billion or 0.5% of the original value of farm production. However, this loss can be turned into a profit of PKR 15 billion if imports are made flexible enough, reflected in the high import elasticity scenario in our model. Although crop outputs still decrease, and output prices increase, both are moderated because of higher imports of fertilizers, and the farmers' loss from lower output drops from PKR 7 billion to PKR 3 billion. On the other hand, expenses on fertilizer are reduced by PKR 19 billion because of the lower increase in fertilizer prices and higher decrease in demand. Thus the moderating effect of a higher import elasticity or facilitation in imports can be used to lower the impact of reduced gas subsidies on farmers.

The government is the biggest net beneficiary, as gas subsidies are reduced by PKR 46 billion. There will be a small change in GST and distribution subsidies, and the net gain to the government would be around PKR 42 billion in the high import elasticity scenario and 46 billion in the low import elasticity scenario.

The decrease in crop production also affects international crop trade. Compared to 2013-14, the generally higher commodity prices provide incentives to international traders to export more commodities to Pakistan or reduce imports from Pakistan. This causes increased imports of cotton and a reduced export of rice, wheat, and other crops creating a total trade deficit by PKR 1 billion. The trade loss can be reduced when the import elasticity of fertilizer is increased.

[15] The crop supply elasticities with respect to fertilizer prices used in our EDM are from Haile, Kalkuh and von Braun (2014). This is an international study and has reported low crop supply elasticities for Pakistan compared to those reported in older Pakistani studies. One reason for the high elasticities in earlier studies may be the low use of fertilizer at the time when these elasticities were estimated. In addition, using high elasticities from the Pakistani literature increases the effects of a policy intervention on crop production to unbelievable levels.

The manufacturers will be the biggest losers in this scenario, as their profit declines by PKR 46 billion in case of the low elasticity and PKR 58 billion in case of a high import elasticity. The cost of gas used in fertilizer processing increases by PKR 38 and 35 billion respectively, while revenue from fertilizer sale decreases by over PKR 8 and 23 billion, respectively. The greater loss of manufacturers in case of liberal import scenario is because more imports are brought into the country.

With the increase in output prices, consumers' demand for agricultural commodities will decrease by PKR 7 billion, although the reduction will be only PKR 2 billion if fertilizer imports are more liberally imported. The society as a whole would lose by about PKR 5 billion in this scenario.[16]

In this simulation, we assumed an elasticity of fertilizer supply with respect to price of natural gas as 0.1 and 0.025 for urea and DAP, respectively. As this elasticity may be argued as low, we also simulated the impacts with an increased elasticity of 0.4% and 0.1, respectively. This further increases the manufacturers' loss, from PKR 46 and 58 billion in the scenarios of low and high import elasticities to PKR 70 and 116 billion, respectively, mainly because of the greater decline in revenue from fertilizer sales.

6.2. Policy Scenario 2: Investment in Crop R&D and Removing Gas Subsidy

There is very little investment in Agricultural R&D in Pakistan. This has reduced the flow of innovations to farmers and, resultantly, productivity-led growth has lagged behind other developing countries, such as China, India, Brazil, and Turkey (Ahmed and Gautam. 2013). IN this scenario, we created a "fiscal space" for the government to increase R&D investment by eliminating the production subsidy in Scenario 1. Here, we assume that 25% of this saving, about PKR 12 billion, goes to R&D in the crop sector, implying a 150% increase in the current R&D budget for agriculture of PKR 8 billion in 2011-12 (ASTI-PARC 2012). We assume this brings about a modest increase in crop productivity across the board of 3%, thereby shifting the supply curves outward. [17]

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[16] The net social gain to society was estimated as change in the value of crop demand + government revenue + farmers benefit + manufacturers benefit.

[17]This productivity increase might come from a variety of sources, such as improved varieties, development and promotion of appropriate input application techniques, improvement in the timely delivery of inputs, such as fertilizer, credit, water and information, development of new crop management models that improve productivity and also reduce post-harvest losses, etc. We assume that the technological innovations are neutral with regard to fertilizer-use

The shift in the crop supply curves induced by R&D expenditures will create growth in the fertilizer sector, while the opposite happened in the earlier scenario. Other important differences are that, unlike in the earlier scenario, the benefits of the policy will spread over several years and there is a significant time lag between the implementation time of the policy and when returns due to enhanced productivity start flowing.[18]

In general, the investment on R&D will shift the supply curve, increase crop production and lower prices. More fertilizer will be required to produce the larger crop production, which will shift the fertilizer demand curve upward. The greater fertilizer demand will increase both farm and factory prices, and induce more fertilizer manufacturing and imports. If domestic manufacturers cannot expand production capacity, importers will fill the gap (especially under the high import elasticity scenario). Although the import bill for fertilizer increases, the expanded crop supply reduces output prices and generates a higher trade surplus, which compensates for the higher import bill of fertilizer. We generated results for five subsequent years after the new technologies start producing results, with 0.5% less productivity enhancement in each year until the value of the technology gets completely exhausted or the technology becomes completely obsolete.

The discounted benefits of the R&D investment to the farmers are PKR 59 billion in the case of a low import elasticity, and PKR 54 billion under the high import scenario. Despite assuming a modest gain of 3% in crop productivity after 150% increase in R&D investment, the gains to farmers, as well as to society, are the highest compared to all other scenarios.

Another advantage of this scenario is that, except for the manufacturers, all stakeholders including government benefit from this intervention. In fact, manufacturers also benefit through an increased fertilizer price and expanded production, and their losses are reduced by 15% compared to the case when only the subsidy on gas is removed. The government benefits from reduced subsidies and increased GST from the enhanced fertilizer demand. Consumers benefit from reduced output prices from the added crop production. International competitiveness improves and generates an

efficiency, thus a general 3% shift in the overall supply curve occurs, rather than an increase in the fertilizer coefficient found in the production function.

[18] We assume here a 5-year lag period between the time the investment on R&D is made and the return (including additional costs on the adoption of new technology) starts flowing in. We also assume a gradual 0.5 point decline in the growth in crop productivity from 3% in the first year to 1.0% in the fifth and last year. With these growth rates in productivity, the model was run for five years. We then discounted the simulated benefit streams at a 15% rate.

improved trade surplus. The additional production likely brings new jobs and businesses in the agriculture sector.

The 25% investment in R&D is capable of reducing all negative impacts of the removal of gas subsidies when both policy scenarios are combined together. The combined interventions reduce urea demand by only 7% (in the case of the low import elasticity) compared to 10% when only gas subsidies are removed. Crop production gains become highly positive, at PKR 52 billion, instead of the decline of PKR 7 billion in the scenario of the gas subsidy removal. Although government revenue declines by PKR 12 billion, farmers gain substantially, as they see a revenue increases to a PKR 36 billion compared to the reduction of PKR 11 billion in the first when only gas subsidy was removed. Similarly international crop trade becomes positive with the combined policy.

6.3. Policy Scenario 3: Removal of General Sales Tax (GST)

Removal of the 17 percent GST on the prices of urea and DAP will immediately reduce its cost to farmers, which will shift their demand functions for fertilizer outward. With this intervention, different reactions occur in all markets and the final outcome again depends upon the import elasticity.[19] In our model, the eventual decline in urea and DAP prices at the farm gate was around 14% and 12%, respectively. This also increases fertilizer demand, which pushes the factory prices of urea and DAP upward by 3% and 5%, respectively, as imports start competing with domestic manufacturers. This increases the domestic supply of urea and DAP by about 2%.[20] The reduction of prices at the farm gate approaches the full reduction in GST if the import elasticity is large. This however will reduce the impact on factory prices, and thus domestic supply declines further as imports are encouraged.

The production of all four crops in our model increases by PKR 11 billion, and the trade surplus increases by PKR 1 billion. Overall the greatest beneficiaries of the removal of the GST would be farmers as they save nearly PKR 37 billion in fertilizer costs, and their revenue from crop production also increases by about PKR 11 billion. Urea and DAP manufacturers also gain PKR 8 billion because of the higher factory prices and greater demand. However, their gains are

[19] Here we first explain the results with low import elasticity of 1, and then generalize the impact of high import elasticity of 5.

[20] Although, the model assumes that any additional input including gas will be freely available to produce equilibrium quantities of fertilizer (as well as crop), One may, however, consider achieving a small increase in fertilizer supply, such as in this scenario, through enhanced efficiency even if additional gas is not available or by encouraging imports.

reduced to PKR 3 billion if high import elasticity is assumed as some of the high fertilizer demand is captured by importers. The government revenue will be affected as it loses tax revenue equal to PKR 50 billion. Another beneficiary of the GST removal from fertilizer is the consumer, as crop demand increases by 0.4%, or PKR 10 billion.

6.4. Policy Scenario 4: Removal of Gas Subsidy and GST Simultaneously

Some policy makers would like to see the fertilizer sector not face any taxes, but also without production subsidies. We analyze the impact of this scenario in this simulation. This means shifting the supply curve of fertilizer outward due to the fact that fertilizer prices are rising, and its demand curve upward because the farmgate price of that input declines, and of course, the net results depend upon supply and demand elasticities. Under the assumed elasticities in our model, the demand for urea decreases despite the decrease in farmgate fertilizer prices because of the removal of the gas subsidy. However, for DAP, the demand quantities and prices move in opposite directions. The factory prices and fertilizer supply both have increased, although the response is relatively low.

The factory price of urea and DAP increases by 13% and 9%, but their farm gate prices decrease by 4% and 7%, respectively as farmers do not have to pay the GST. However, the supply of urea and DAP decline by 12% and 5%, mainly because of an increased manufacturing cost as the gas subsidy is removed. This will also increase the import cost of fertilizer by 24% or PKR 21 billion, in both high and low import elasticities, which can be reduced to some extent by increasing the import elasticity of fertilizer. This change in policy leaves the government with little change in revenue despite its loss of PKR 50 billion from the GST, because it saves PKR 47 billion from the gas subsidy.

The 7% and 3% decrease in the demand of urea and DAP lowers crop production and creates upward pressure on prices, which costs the economy PKR 4 billion without much change in the trade deficit. Farmers gain PKR 33 billion from this scenario from increased output prices and lower fertilizer prices. The farmers' return of the policy, however, can be improved to PKR 70 billion with the higher import elasticity of fertilizer. Manufacturers are the greatest losers in this scenario as gas expenses increase. This is further intensified with the higher import elasticity because the some demand will be captured by importers. The social cost of this reshuffling from the removal of all taxes and subsidies would be PKR 5 billion, which can be turned into a social profit of PKR 20 billion when a higher import elasticity, and therefore a more responsive international sector, is assumed.

6.5. Policy Scenario 5: Removing the Shortage of Gas

The Fertilizer industry as of 2013-14 was operating at around 72% of its installed capacity. One of the key factors impacting the future and viability of the industry will be the availability of natural gas to the sector.[21] In this scenario, we assume that a greater gas supply is available and increase the amount of natural gas supplied to the fertilizer industry by 28%, keeping all other exogenous effects constant.[22]

The policy scenario would shift the supply curve downward and decrease the prices of urea and DAP by 4% and 2%, respectively both at the farm and factory levels, while increasing the equilibrium quantity of domestic supply by about 6% and 4%. As domestic prices decrease, imports become less competitive and are reduced by 4% and 2%, respectively (the decrease in fertilizer prices and imports are higher under the high import elasticity scenario implying more increase in domestic supply as well as demand). The domestic demand increases by 4% and 0.2%, respectively. The quantities of domestically produced wheat, cotton, rice, and other crops increase and put downward pressure on crop prices. Given the base values in 2013-14, the domestic production of all crops increases by about PKR 3 billion, while the trade surplus of these crops increases insignificantly.

Farmers would gain by nearly PKR 6 billion; half of this comes from an increase in the value of crop production (despite a decrease in their prices) and the remaining half from lower fertilizer costs due to lower prices. The urea manufacturers see an increase in revenue by PKR 2 billion but half of this is consumed by an increase in the processing cost. Consumers will also gain by PKR 3 billion. The government subsidy on gas will increase by PKR 2 billion.

Although, the policy of removing the gas shortage benefits all stakeholders, except the government, the extent of benefits are relatively small. Moreover, the policy relies on the utilization of a scarce economic resource in the country. It is estimated that, with the existing rate of utilization, the most extensive recoverable gas reserves available to fertilizer sector, from MARI

[21] The EDM model does not take into account the fast depleting supply of natural gas in Pakistan and the cost to the other sectors if gas was allocated from those sectors to the fertilizer sector.
[22] The model however will only reflect utilization of gas which is needed by the firm to meet equilibrium demand

field, shall be exhausted within 16 years.[23] This suggests that the government should start planning now for a gradual shift of domestic supply to imports, which is inevitable anyway, rather than promoting the speedy utilization of a scarce resource, waiting until it is completely exhausted, and then passing through a stressful transition to imports.

7. Conclusions and Policy Recommendations

The rapid expansion of Pakistan's fertilizer production capacity—alongside increases in fertilizer imports, and the growth of policy, market and institutional infrastructure required to promote fertilizer use—led to significant yield gains in wheat and rice during the 1960s, 1970s, and 1980s, and also introduced new challenges to Pakistan's agricultural sector. First, relatively smaller subsidies for nutrients other than nitrogen led to a long-term pattern of unbalanced fertilizer use. Second, the regulators' strong hand over the fertilizer industry, as set forth in PECA and control of the gas supply, placed significant discretionary powers in the hands of regulators and made entry into the fertilizer industry difficult for those without strong political affiliations. Third, the public sector's extensive investment in the formation and management of Pakistan's fertilizer industry—from the pricing and allocation of natural gas to the distribution of fertilizers to farmers—created interest groups promoting market-oriented reforms difficult.

Another dimension of this problem has been the absence of new product testing and promotion until the first decade of 2000s. During the initial years of fertilizer introduction, provincial extension services played a major role in promoting fertilizer based on recommendations made by SFRI for every crop. However, the emphasis of these demonstrations remained focused on the expansion of fertilizer use, meaning that few more efficient products or application methods were either tested or promoted. Meanwhile, SFRI had little success in formulating and disseminating new fertilizer recommendations—either general or site-specific—based on their R&D activities. These limitations in the research and extension system have exacerbated trends toward unbalanced and inefficient use of fertilizer which promoted resource degradation. Paying attentions to improving fertilizer use efficiency, which is an achievable target, usually have high pay-off in the long-run (Rashid, et. at., 2013).

[23]According to the data from the Ministry of Petroleum and Natural Resources, the balance of the recoverable reserve of gas from MARI fields as of 31st December 2014 was 3,382 billion CF and the utilization rate during 2014 was 211 billion cubic feet, giving the remaining life to the field not more than 16 years. This is also recognized by IRG (2011) in its report on page 17.

Meanwhile, the political economy of fertilizer-related policies to encourage the industry has resulted in a concentration of capacity in few hands (CCP 2010). In addition, the government's effort to manage the deficit supply in urea has almost always exaggerated the crisis.

The current policy environment is not sustainable as it entails a large fiscal cost, creates excess profits to the processors, gives little benefit to farmers, and creates huge inefficiencies in fertilizer application to crops. One of the main problems in reforming the fertilizer sector is the lack of information about alternative policy options and their impact on various stakeholders. This study tries to fill this gap so that informed decisions could be made to reform the sector.

The simulated results through our EDM suggest that removing the gas subsidy results in an increase in government revenue but produces losses to manufacturers, consumers and farmers. Increasing the gas supply results in small benefits to consumers, manufacturers and farmers, but government expenditure increases due to continued gas subsidies on higher base. Removing the GST alone results in similar benefits as observed in increasing the gas supply, but the government loses much more revenue. Additionally, removing the gas subsidy and GST simultaneously on fertilizer reduces losses to farmers and manufacturers but government gain is nullified because of losing the tax revenue. Our model suggests that removing gas subsidy and investing in agriculture R&D will result in the highest social benefit, where all major stakeholders benefit at least to some degree and the return to the society is highest. An additional advantage of R&D investment compared to other policy scenarios would be the highest increase in agricultural productivity and a generation of a trade surplus, which will create new jobs, instigate overall economic development and help eradicate poverty in rural areas (Schneider and Gugerty 2011). As growth in the industrial sector is closely linked with agricultural sector growth, this will induce overall economic development in the country.

Bibliography

Agritech, 2014. Our Company. Accessed July 25. http://www.pafl.com.pk/our-company.

Anwendung, M., 1999. Utilising Equilibrium-Displacement Models to Evaluate the Market Effects of Countryside Stewardship Policies: Method and Application. *Die Bodenkultur,* 143(50).

Alhashim, I. J., 2013. *Policies Effects of Wheat Production on Groundwater Usage in Saudi Arabia*. Colorado State University, Fort Collins, Colorado.

Ali, M. 1990. The Price Response of Major Crops in Pakistan: An Application of the Simultaneous Equation Model. *The Pakistan Development Review*, 305-325.

Ali, M., Ahmed, F., Channa, H., Davies, S., 2014. *Pakistan's Fertilizer Sector: Structure, Policies, Performance and Impacts.* Pakistan Strategy Support Program, International Food Policy Research Institute, Washington, DC. (unpublished manuscript).

Ali, M., Flinn, J. C., 1989. Profit Efficiency among Basmati Rice Producers in Pakistan Punjab. *American Journal of Agricultural Economics* 71(2), 303-310.

Ayub, M., Nadeem, M., Sharar, M., Mahmood, N, 2002. Response of maize (Zea mays L.) fodder to different levels of nitrogen and phosphorus. *Asian J. Plant Sci*, 1(4), 352-355.

Ayub, M., Tanveer, A., Choudhry, M. A., Amin, M., Murtaza, G., 1999. Growth and yield response of mungbean (Vigna radiata L.) cultivars to varying levels of nitrogen. *Pak. J. Biol. Sci*, 2(4), 1380-1387.

CCP (Competition Commission of Pakistan), 2010. *Competition Assessment Study of the fertilizer sector in Pakistan.* Competition Commission of Pakistan, World Bank, Islamabad.

DoP (Department of Fertilizer), 2012. *Indian Fertilizer Scenario 2012.* Department of Fertilizer, Ministry of Chemicals and Fertilizers, Government of India, New Delhi.

EIA (Energy Information Administration), 2014. Natural Gas. Accessed September 25. http://www.eia.gov/dnav/ng/hist/rngwhhdd.htm.

FFBL (Fauji Fertilizer Bin Qasim Limited), Various issues. *Annual Report 2004-13*. Fauji Fertilizer Bin Qasim Limited, Rawalpindi.

FFC (Fauji Fertilizer Company Limited), Various issues. *Annual Report 2003-13*. Fauji Fertilizer Company Limited, Rawalpindi.

Haerdter, R., Fairhurst T., 2003. Nutrient use efficiency in upland cropping systems of Asia. IFA Regional Conference, Cheju Island, Korea, October 6-8.

Hassan, Ul. M., Pradhan P., 1998. Coordinated services for irrigated agriculture in Pakistan. Proceedings of the IWMI National Workshop, Lahore, Pakistan, October 29-30.

HC Securities & Investment , 2014. Industries Qatar-Setting itself to Attain Higher Peaks. Accessed September 25. Retrieved from http://content.argaam.com.s3-eu-west-1.amazonaws.com/db1d08f5-5287-4531-b421-eaa1c5496ad5.pdf.

HDIP (Hydrocarbon Development Institute of Pakistan), 2013. *Pakistan Energy Yearbook 2012.* Islamabad: Hydrocarbon Development Institute of Pakistan, Ministry of Petroleum and Natural Resources, Government of Pakistan.

Hussain, A., 2011. Seed Industry in Pakistan. Paper presented at World Bank Roundtable Discussion on Agriculture and Water, Islamabad, Pakistan, March 10–11.

IFPRI/IDS (International Food Policy Research Institute/Innovative Development Strategies. Pvt. Ltd.), 2012. *Pakistan Rural Household Survey 2012.* Pakistan Strategy Support Program (PSSP) of IFPRI Washington, DC and IDS Islamabad.

Khan S. A. 2014. *DAP sales plunge on subsidy issue.* Dawn, July 12.

Li, S., Yaoqi Z., Denis N., John D. W., Yeifei Z., and Xian X., 2014. Fertilizer Industry Subsidies in China: Who Are the Beneficiaries? *China Agricultural Economic Review*, 6 (3).

MNFAL (Ministry of Food, Agriculture and Livestock), Various issues. *Agricultural Statistics of Pakistan Volume III-V.* Economic Wing, Ministry of Food, Agriculture and Livestock, Government of Pakistan, Islamabad.

MNFSR (Ministry of National Food Security and Research), 2013. *Agricultural Statistics of Pakistan 2011-2012.* Economic Wing, Ministry of National Food Security and Research, Government of Pakistan, Islamabad.

Muth, R. F., 1964. The Derived Demand Curve for a Productive Factor and the Industry Supply Curve. *Oxford Economic Papers,* 221-234.

NFDC (National Fertilizer Development Centre), Various issues. *Pakistan Fertilizer Related Statistics*. National Fertilizer Development Centre, Planning Commission, Government of Pakistan, Islamabad.

NFDC (National Fertilizer Development Centre), 2014. Statistics. Accessed June 20. www.nfdc.gov.pk/stat.html.

Piggott, R. R., 1992. Some Old Truths Revisited. *Australian Journal of Agricultural and Resource Economics* 36 (2), 117-140.

PPI (Pakistan Press International), 2012. *Gas shortage: Fertilizer manufacturers claim losses of nearly Rs5b*. The Express Tribune, November 21.

Pritchett, J. G., Davies S. P., Fathelrahman, E., Davies, A., 2010. Welfare Impacts of Rural to Urban Water Transfers: An Equilibrium Displacement Approach. In 2010 Annual Meeting, Agricultural and Applied Economics Association, Denver, Colorado, July 25-27.

Rashid, S., Dorosh, P.A., Malek, M. and Lemma. S. 2013. Modern input promotion in sub-Saharan Africa: insights from Asian green revolution, Agricultural Economics 44 (2013) 705–721.

Shafi, M., Bakht, J., Jan, M. T., Shah, Z. 2007. Soil C and N dynamics and maize yield as affected by cropping systems and residue management in North-western Pakistan. *Soil and Tillage Research*, 94(2), 520-529.

Schneider, K. and Gugerty, M. K. 2011. Agricultural Productivity and Poverty Reduction: Linkages and Pathways. The Evans School Review, 1(1), 56-74.

Zhao, X., Garry, G., Mullen J., 2001. Returns to New Technologies in the Australian Beef Industry: On-Farm Research versus Off-Farm Research. *Australasian Agribusiness Review*, 9, 1-18.

Table 1: Subsidy on fertilizer distribution (Billion PKR)

Year	Subsidy on Imported Urea (Billion PKR)	Imports of Urea (000 tonnes)	Subsidy on other P & K Fertilizer (Billion PKR)	Total distribution Subsidy
2004-05	1.85	307	-	1.85
2005-06	4.54	825	-	4.54
2006-07	2.05	281	13.7	15.75
2007-08	2.74	181	17.4	20.14
2008-09	17.23	905	26.50	43.73
2009-10	12.87	1524	0.50	13.37
2010-11	8.41	694	0	8.41
2011-12	9.55	1075	-	9.55
2012-13	10.50	833	-	10.50
2013-14	4.53	1200	-	4.53

Source: Authors' calculation based on NFDC (2014).

Note: Subsidy figures for urea are calculated as import quantity multiplied by the difference between the international and domestic prices. The international is taken as the CIF price($ 30 freight charges) and is inclusive of GST. The figures for 2011--14 are collected from NFDC in Islamabad.

The subsidy for P and K is taken from NFDC (2008, 2014).

Table 2: The simulated results using EDM for various policy interventions with α=1

Variables	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
	Change from 2013-14 base value				
Fertilizer Market					
Domestic Supply of Urea (000 t)	-696(-14.1)	-574(-11.6)	120(2.4)	-576(-11.7)	280(5.7)
Domestic Supply of DAP (000 t)	-49(-7.1)	-45(-6.5)	13(1.9)	-36(-5.2)	25(3.6)
Imports Supply of Urea (000 t)	118(10.2)	154(13.3)	35(3.1)	153(13.3)	-47(-4.1)
Imports Supply of DAP (000 t)	42(4.5)	55(5.9)	45(4.8)	87(9.3)	-21(-2.3)
Demand of Urea (000 t)	-578(-9.5)	-420(-6.9)	155(2.6)	-423(-6.9)	233(3.8)
Demand of DAP (000 t)	-8(-0.5)	10(0.6)	58(3.6)	50(3.1)	4(0.2)
Farmer Price of Urea (PKR/t)	3729(10.2)	4860(13.3)	-5099(-14)	-1369(-3.8)	-1498(-4.1)
Farmer Price of DAP (PKR/t)	3260(4.5)	4309(5.9)	-8882(-12.2)	-5622(-7.7)	-1653(-2.3)
Factory Price of Urea* (PKR/t)	3188(10.2)	4154(13.3)	951(3.1)	4139(13.3)	-1281(-4.1)
Factory Price of DAP* (PKR/t)	2786(4.5)	3683(5.9)	2986(4.8)	5773(9.3)	-1412(-2.3)
Import Cost For Fertilizer (b PKR)	15(15.2)	20(20.2)	7(8.7)	21(24.5)	-6(-6.3)
Output Market					
Overall Pressure on output prices (PKR/t)	0(-0.1)	0(-0.4)	0(-0.1)	0(0)	0(0)
Overall Trade surplus (b PKR)	-1(-0.5)	6(4.6)	1(0.8)	0(0.3)	0(0.2)
Total crop production gain (b PKR)	-7(-0.3)	52(2.2)	11(0.5)	4(0.2)	3(0.1)
Fertilizer Expense for Farmers (b PKR)	4(1.2)	20(5.9)	-37(-10.8)	-29(-8.5)	-3(-1)
Production Revenue (b PKR)	-7(-0.3)	52(2)	11(0.4)	4(0.2)	3(0.1)
Over all Farmer Benefit (b PKR)	-11(-0.5)	32(1.4)	48(2.1)	33(1.5)	6(0.3)
Gas Expense (b PKR)	38(242.4)	40(251.9)	0(2.4)	40(252)	1(5.6)
Fertilizer revenue (b PKR)	-8(-4.8)	0(-0.1)	9(5.8)	1(0.8)	2(1.3)
Overall Manufacturer Benefit (b PKR)	-46(-32.3)	-40(-28.2)	9(6.2)	-38(-27.1)	1(0.9)
Production Subsidy (Urea) (b PKR)	-47(-100)	-47(-100)	1(2.4)	-47(-100)	3(5.6)
Retail Subsidy (DAP) (b PKR)	0(0)	0(0)	0(0)	0(0)	0(0)
Distribution Subsidy (b PKR)	2(16)	3(21)	0(3)	1(13.3)	-1(-6.1)
Tax Revenue from fertilizer (b PKR)	1(1.2)	3(5.9)	-50(-100)	-50(-100)	0(-1)
All subsidies (b PKR)	-45(23.6)	-44(24.6)	1(102.5)	-46(10.9)	2(103.2)
Investment on R&D (b PKR)	0(0)	12(0)	0(0)	0(0)	0(0)
Total Change in Govt. Revenue (b PKR)	46(0)	35(0)	-51(0)	-3(0)	-2(0)
Consumer crop demand (b PKR)	-7(-0.3)	46(1.9)	10(0.4)	4(0.2)	3(0.1)
Eventual social benefit [3] (b PKR)	-18(0)	74(0)	16(0)	-5(0)	8(0)

Source: Authors' estimates

*Exclusive of GST

Notes: Figures in parentheses are percentage changes with respect to the base value of 2013-14

b=billion; t=metric ton.

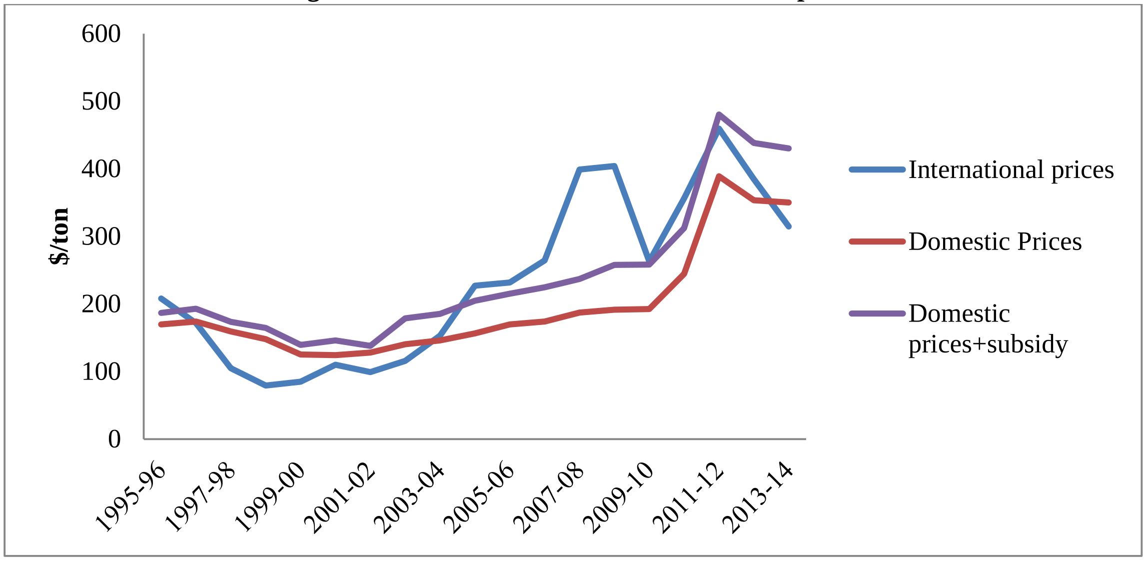
The overall social benefit does not incorporate trade loss/profit. We assumed this is already reflected in the loss/gain in crop production.

Table 3: Summary of policy interventions with α=1

Intervention	Consumer	Farmers	Manufacturer	Government	Social Benefit
Removing Subsidy on Feedstock Gas					
Investing on R&D and Removal of Gas Subsidy					
Removal of GST					
Removal of subsidy and GST					
Increase quantity of Natural Gas					

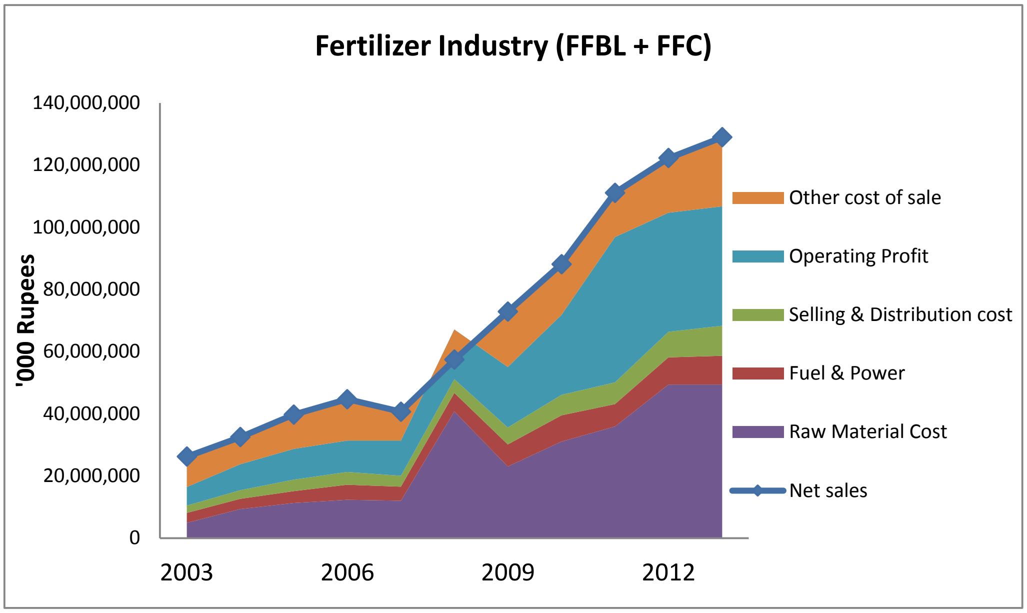
Notes: Shaded boxes represent benefits to each stakeholder. The darker shade in a column represents higher benefit.

Figure 1: International versus domestic urea prices



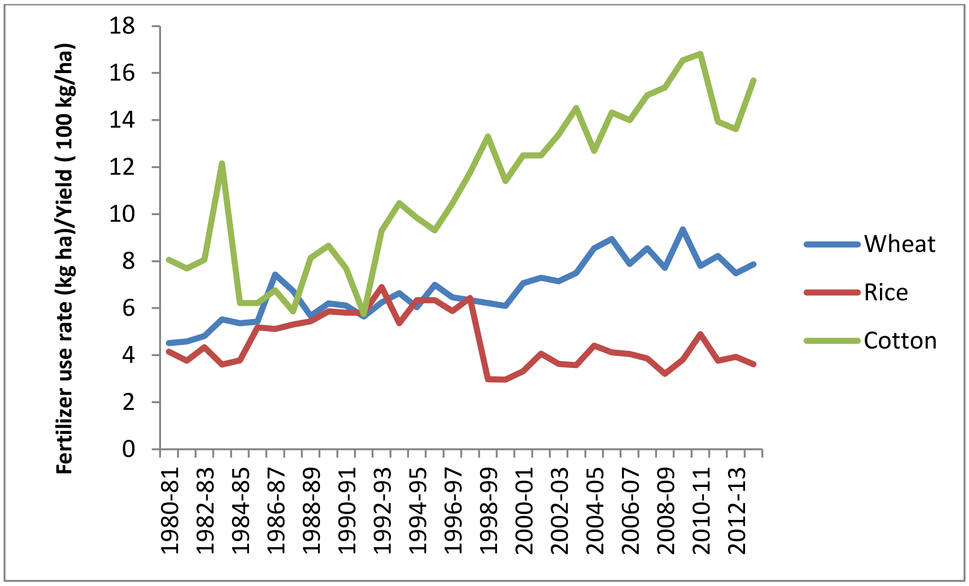
Source: Authors’ estimates based on NFDC (2014) and HDIP (2013).

Figure 2: Trend in cost and profit structure of fertilizer industry (FFBL and FFC) during 2003-13



Source: Authors' estimates based on data collected from company annual reports (FFBL, Various issues); (FFC, Various issues).

Figure 3: Ratio of Fertilizer Use (kg/ha)/Yield (kg/ha)



Source: Authors' calculation based on NFDC (2014), MNFSR (2013), MNFAL (Various issues).

Appendix 1: Transformation of equations

The following shows how linear equations are transformed to provide elasticities, and marginal impacts. We transform the following equation for wheat:

$$Q_i^s = f(P_i^f, P_j^f, P_k, T_i)$$

$$Q_1^s = \zeta_1 + \zeta_2(P_1^f) + \zeta_3(P_2^f) + \zeta_4(P_3^f) + \zeta_5(P_4^f) + \zeta_6(P_u) + \zeta_7(P_o) + \zeta_6 T_1 + u_1 \quad \text{- (a)}$$

Where Q_1^s, domestic production of wheat is a function of P_1, the price of wheat, and shifters including P_2, P_3, and P_4 which are the price of rice, cotton and other crops respectively, P_u is the price of urea, and P_o is the price of DAP, and T, technology adoption.

Total differentiation of Equation (a) yields:

$$dQ_1^s = \frac{\partial Q_1^s}{\partial P_1^f} dP_1^f + \frac{\partial Q_1^s}{\partial P_2^f} dP_2^f + \frac{\partial Q_1^s}{\partial P_3^f} dP_3^f + \frac{\partial Q_1^s}{\partial P_4^f} dP_4^f + \frac{\partial Q_1^s}{\partial P_u} dP_u + \frac{\partial Q_1^s}{\partial P_o} dP_o + \frac{\partial Q_1^s}{\partial T_1} dT_1$$

Multiplying both sides by $\frac{1}{Q_1^s}$ and expanding the right hand side by $\frac{P_1^f}{P_1^f}$, $\frac{P_2^f}{P_2^f}$, $\frac{P_3^f}{P_3^f}$, $\frac{P_4^f}{P_4^f}$, $\frac{P_u}{P_u}$, $\frac{P_p}{P_p}$, $\frac{T_1}{T_1}$ respectively yields:

$$\frac{dQ_1^s}{Q_1^s} = \frac{\partial Q_1^s}{\partial P_1^f}\frac{dP_1^f}{Q_1^s}\frac{P_1^f}{P_1^f} + \frac{\partial Q_1^s}{\partial P_2^f}\frac{dP_2^f}{Q_1^s}\frac{P_2^f}{P_2^f} + \frac{\partial Q_1^s}{\partial P_3^f}\frac{dP_3^f}{Q_1^s}\frac{P_3^f}{P_3^f} + \frac{\partial Q_1^s}{\partial P_4^f}\frac{dP_4^f}{Q_1^s}\frac{P_4^f}{P_4^f} + \frac{\partial Q_1^s}{\partial P_u}\frac{dP_u}{Q_1^s}\frac{P_u}{P_u} + \frac{\partial Q_1^s}{\partial P_o}\frac{dP_o}{Q_1^s}\frac{P_o}{P_o} + \frac{\partial Q_1^s}{\partial T_1}\frac{dT_1}{Q_1^s}\frac{T_1}{T_1}$$

This yields us:

$$EQ_1^s = \eta_1 EP_1^f + \sigma_{12} EP_2^f + \sigma_{13} EP_3^f + \sigma_{14} EP_4^f + \varphi_{1,1} EP_u + \varphi_{1,2} EP_o + \vartheta_1 ET_1$$

The derivation of the tax equation is given below:

$$P_1^f(1 + t_1) = P_1$$

$$dP_1 = P_1^f d(1 + t_1) + (1 + t_1) dP_1^f$$

Where $d(1 + t_1) = dt_1$, multiplying both sides by $\frac{1}{P_1}$ yields:

$$dP_1/P_1 = (P_1^f dt_1/P_1) + ((1 + t_1) dP_1^f)/P_1$$

Substituting $P_1^f = P_1/(1 + t_1)$ and $P_1 = P_1^f(1 + t_1)$ on the right hand side yields:

$$dP_1/P_1 = (P_1 dt_1/(1 + t_1)P_1 + ((1 + t_1) dP_1^f)/P_1^f(1 + t_1)$$

Assuming initial tax rate=0, $dt_1 = t_1$ and $\frac{t_1}{1+t_1} = t_1$

$$EP_U = t_u + EP_u^f$$

Appendix 2: Source and value of different elasticities used in the EDM

Elasticities were drawn from previous literature whenever possible. According to our research, elasticities on fertilizer manufacturing were not available, and are based on feedback from industry professionals.

Descriptor	Symbols	Elasticity	Descriptor	Symbols	Elasticity
			Crop market		
	Demand Elasticity			*Supply Elasticity*	
Own price elasticity			Own Price Elasticity		
Wheat	γ_1	-0.400	Wheat	η_1	0.228
Rice	γ_2	-0.537	Rice	η_2	0.407
Cotton	γ_3	-0.300	Cotton	η_3	0.715
Other crops	γ_3	-0.800	Other crops	η_3	0.500
Cross Price Elasticity Wheat			Cross Price Elasticity Wheat		
Rice	δ_{12}	-0.098	Rice	σ_{12}	0.173
Cotton	δ_{13}	-0.02	Cotton	σ_{13}	-0.151
Other crops	δ_{14}	-0.01	Other crops	σ_{14}	-0.100
Cross Price Elasticity Rice			Urea	φ_{11}	-0.0525
Wheat	δ_{21}	0.098	DAP	φ_{12}	-0.0175
Cotton	δ_{23}	0	Cross Price Elasticity Rice		
Other crops	δ_{24}	-0.02	Wheat	σ_{21}	0.136
Cross Price Elasticity Cotton			Cotton	σ_{23}	-0.098
Wheat	δ_{31}	0	Other crops	σ_{24}	-0.150
Rice	δ_{32}	0	Urea	φ_{21}	-0.0225
Other crops	δ_{34}	0	DAP	φ_{22}	-0.0075
Cross Price Elasticity Other crops			Cross Price Elasticity Cotton`		
Wheat	δ_{41}	-0.01	Wheat	σ_{31}	0
Rice	δ_{42}	-0.02	Rice	σ_{32}	-0.329
Cotton	δ_{43}	0	Other crops	σ_{34}	-0.15
Income elasticity			Urea	φ_{31}	-0.0375
Wheat	μ_1	0.376	DAP	φ_{32}	-0.0125
Rice	μ_2	0.85	Cross Price Elasticity Other crops		
Cotton	μ_3	0.1	Wheat	σ_{41}	-0.1
Other crops	μ_4	1.1	Rice	σ_{42}	-0.15
Import Elasticity			Cotton	σ_{43}	-0.15
Wheat	a_1	-1	Urea	φ_{41}	-0.0075
Rice	a_2	-1	DAP	φ_{42}	-0.0025
Cotton	a_3	1	Technology Elasticity		
Other crops	a_4	-1	Rice	ϑ_1	1
	Trade elasticity of crops		Cotton	ϑ_2	1
Wheat	β_1	-5	Wheat	ϑ_3	1
Rice	β_2	-5	Other crops	ϑ_4	1
Cotton	β_3	5			
Other crops	β_4	-5			
			Fertilizer market		
	Demand Elasticity			*Supply Elasticity*	
Own price elasticity			Own price elasticity		
Urea	τ_1	-0.3	Urea	v_1	0.8
DAP	τ_2	-0.5	DAP	v_2	0.4
Cross elasticity of Urea with supply of crops			Input elasticity in urea		
Wheat	∂_{11}	0.82	Quantity of natural gas	ρ_1	0.32
Rice	∂_{12}	0.368	Price of natural gas	ξ_1	-0.075

Cotton	∂_{13}	0.486	Quantity of phosphate	λ_1	0
Other crops	∂_{14}	0.65	Price of phosphate	ς_1	0
Cross elasticity of DAP with supply of crops			Input elasticity in DAP		
Wheat	∂_{11}	0.41	Quantity of natural gas	ρ_2	0.16
Rice	∂_{12}	0.184	Price of natural gas	ξ_2	-0.03
Cotton	∂_{13}	0.243	Quantity of phosphate	λ_2	0.4
Other Crops	∂_{14}	0.15	Price of phosphate	ς_2	-0.3
Import elasticity					
Urea	b_1	1			
DAP	b_2	1			
Trade elasticity of fertilizer					
Urea	α_1	1 and 5			
DAP	α_2	1 and 5			

Source: Ali, Mubarik. ,1990; Nazli, Hina, et al 2012 and authors' assumptions