

**WHY THE FERTILIZER SUBSIDY
SHOULD BE REMOVED: KEY FACTORS
THAT ACTUALLY DERIVE THE FERTILIZER
DEMAND IN PADDY SECTOR OF SRI LANKA**

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Abstract

This paper examines the factors affecting demand for fertilizer in paddy production in Sri Lanka. A panel-data analysis (1990-2011) reveals that demand for fertilizer is negatively affected by the price of fertilizer and the price of seed paddy and positively by the price of labour. Despite strong demand for fertilizer in commercial paddy production, the impact of the subsidy on demand is low. Results indicate that mechanization will prevent overuse of fertilizer and a seed paddy subsidy will ensure self-sufficiency in rice production. We recommend that the fertilizer subsidy be removed from non-commercial areas in the short-term and from commercial areas in the long-term.

Key words: Fertilizer demand, Fertilizer subsidy, Paddy production, Sri Lanka

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INTRODUCTION

Many developing countries are facing the continual challenges in increasing their agricultural production. Concerns over food security have pushed governments to intervene in the sector, particularly providing input subsidies to farmers to ensure a higher and uninterrupted supply of agricultural commodities (Narayan & Gupta, 1991; Minot & Benson, 2009). Among many input subsidy schemes implemented, subsidies for fertilizer have undoubtedly been a major agricultural intervention for many developing countries (Ahmed, 1987; Baker & Hayami, 1976; Bayes, Parton & Piggott, 1985; Hadley & Tabor, 1998; Renfro, 1992), despite the enormous financial burden on the budget of governments of such countries (Narayan & Gupta, 1991; Mergos & Stoforos, 1997). Due to the availability of subsidized fertilizer, farmers have been found to overuse it, resulting in numerous negative environmental externalities (e.g., soil degradation, surface water pollution, and ground water pollution) and increased concerns about food security through subsidiaries (Manos, Begum, Kamruzzaman, Nakou & Papathanasious, 2007). As such, excess use of fertilizers in agriculture is found to be significantly impacted the economy, society and broader environment of a nation (Manos, Begum *et al.*, 2007; Sharma, 2012).

As in many developing countries, subsidy of fertilizer is a major agricultural policy in Sri Lanka, with the paddy sector being the chief recipient. Rice is the staple food in Sri Lanka and the successive governments over recent decades have significantly provided fertilizer subsidies to farmers with the aim at increasing the paddy production (Gamawelagedara, Wickramasinghe & Dissanayake, 2011; Rajapaksa & Karunagoda, 2009). Since 2005, the fertilizer subsidy has accounted for 2-2.5% of total government expenditure, as the subsidy given for all three major fertilizer components: nitrogen (N), phosphorus (P) and potassium (K). Over the past three decades, the subsidy has significantly contributed to increasing paddy production, stabilizing the price of rice and in achieving self-sufficiency in the production of rice in Sri Lanka (Ekanayaka 2005; Weerahewa, Kodithuwakku & Ariyawardana, 2010). However, researchers conducted by Weerahewa *et al.* (2010) and the Ministry of Finance and Planning, Sri Lanka (2014) has raised the question about the effectiveness and sustainability of the subsidy due to farmers' overuse of subsidized fertilizer as well as using it for crops other than paddy. Furthermore, excessive use of fertilizer has raised fears about soil and water pollution and safety food (Tirado & Allsopp, 2012).

In response to the facts that financial burden, negative environmental externalities and concerns over food security, the government of Sri Lanka let to cut the fertilizer subsidy by 25% in its budget 2012-2013 (Ministry of

Finance and Planning, 2012). The main objective of reducing the subsidy was to encourage farmers to use more organic fertilizers. However, paddy farmers complained to the government about their inability to shift to organic fertilizer at such short notice and they foreshadowed a possible increase in the price of rice. The government led to revise its fertilizer subsidy policy by adjusting the fertilizer subsidy reduction only to 10% in 2013-2014 budget (Ministry of Finance and Planning, 2013) and continue the revision for the financial year 2014- 2015 (Ministry of Finance and Planning, 2014).

Paddy cultivation is one of major sources of livelihood in Sri Lanka, providing employment for more than 1.8 million people. Therefore, in terms of ensuring the food security and reducing unemployment, the government is under constant pressure to continue with the agricultural subsidy programs. As in governments of most developing countries, the subsidy has become a politically sensitive issue in Sri Lanka too, as paddy farmers are the majority voter base (Thenuwara, 2003; Weerahewa *et al.*, 2010, Jayne & Rashid, 2013) in the country. In this context, a clear understanding about the factors that determine the demand for fertilizer is necessary in evaluating the effectiveness of the fertilizer subsidy scheme implemented by the government of Sri Lanka.

Several studies (Ekanayake, 2005; Gunawardana & Oczkowski, 1992; Kikuchi & Aluwihare, 1990; Rajapaksa & Karunagoda, 2009) that attempted to examine the factors determine the demand for fertilizer in paddy cultivation in Sri Lanka. However, analysis of these studies have limited only to handful of factors that determine the demand for fertilizer, such as selling price of rice, price of labour, price of paddy output, and the quantity of paddy produced. Yet many other factors, such as the price of seed paddy, cost of machinery, cost of pesticides (Arriyagada, Sills, Pattanayak, Cabbage & Gonzales, 2010) and whether paddy cultivation is doing at a commercial or non-commercial level have not been found (Gilbert & Jayne, 2008). The gap results ineffectiveness of policy decision making to government of Sri Lanka.

Further research is required on seasonal usage of fertilizer in two main paddy farming seasons¹ in Sri Lanka as *Maha* and *Yala*. Fertilizer usage is differing in the two seasons: the '*Maha*' season consumes more fertilizer than the '*Yala*' season because more area is cultivated during the former

¹ Maha and Yala are synonymous with the two monsoonal periods in Sri Lanka. The Maha season occurs between the months of September to March and is dependent on rainfall from the north-east monsoon. The Yala season is effective during the period from May to August and is cultivated during the south-west monsoon. The particular season is defined by when the crop is sown and harvested.

(Ekanayaka, 2005). Therefore, data from both seasons need to be considered in accounting for this difference.

In addition to the Sri Lankan country context, this study will provide a template for other developing countries in the South-Asian region for estimating demand for fertilizer in agricultural production. For example, economies in the region such as Nepal, India and Pakistan are also highly agriculture-based undertake planting on a seasonal basis (Hutabarat & Ranawana, 2003). Input subsidies for fertilizer are thus a priority on the development agendas of these governments (Mujeri, Shahana, Chowdhury & Haider, 2012). While the empirical model developed in this study is focused on the demand for fertilizer in paddy cultivation, it can be used to examine the determinants of demand for fertilizer in other cereal crops such as wheat, maize and millet, grown in many South-Asian countries (Dev, 2013; Wiggins & Brooks, 2010).

This paper is organized as follows. In Section 2, the background to paddy cultivation in Sri Lanka, including use of fertilizer and its determinants, is provided. The theoretical framework used in deriving the fertilizer demand function is shown in Section 3. Section 4 provides the estimation strategy used to empirically test the demand for fertilizer. Section 5 presents the results from and discussion of the regression analysis. Finally, Section 6 outlines the key policy recommendations for the government of Sri Lanka: control the overuse of fertilizer, remove the financial burden on the government budget, and ensure self-sufficiency in the production of rice.

Fertilizer Subsidies

(a) The Sri Lankan context

The fertilizer subsidy has been a significant part of government expenditure in Sri Lanka since 1962. There are three main nutrients in paddy fertilizer: nitrogen (N), phosphorus (P) and potassium (K). Nitrogen (N) is provided through urea, potassium (K) is provided through murate (or muriate) of potash (MoP; KCl) and phosphorus (P) is provided through triple superphosphate (TSP) (Ekanayaka 2005; Rajapaksa & Karunagoda, 2009; Weerahewa *et al.*, 2010). From 1962 to the present, successive governments have provided the subsidy either as a full subsidy containing all three nutrients, or as a urea-only fertilizer subsidy (i.e., providing only nitrogen in $\text{CO}(\text{NH}_2)_2$, out of these three required elements). A full subsidy was provided during the period from 1962 to 1989. The rates of subsidization, however, changed during the early 1980s with highly volatile prices of

fertilizer in the world market. The policy discouraged the farmers in usage of fertilizer and the problem was addressed by the government introducing the price sealing to paddy sector. Subsidies were not entertained for the period between 1990 and 1994 because of increasing international prices of fertilizer and oil. A full fertilizer subsidy was reintroduced in 1995 and continued until 1996. However, only urea was covered under the fertilizer subsidy between 1997 and 2004. Since 2006, the concurrent government a full fertilizer subsidy has been provided covering all three types of nutrients. In budget for 2015-2016 the fertilizer subsidy converted into a voucher system. Therefore, the fertilizer subsidy in Sri Lanka can be clearly categorised into three groups of policies: (1) a full subsidy 1962-1989, 1995-1996 and from 2006 to 2015 (2) no subsidy from 1990 to 1994; and (3) a urea-only subsidy from 1997 to 2005.

Farmers are eligible to apply for the fertilizer subsidy provided they have a legal title to their paddy lands (Ekanayake, 2005; Rajapaksa & Karunagoda, 2009; Rodrigo, 2013; Weerahewa *et al.*, 2010). Fertilizer is distributed by the Department of Agriculture through Agrarian Service Centres where agrarian service officers are responsible for certifying farmers' eligibility to receive the subsidy. In 2014, the government of Sri Lanka annually spends around SLR50 billion (Sri Lankan Rupees) to import 750,000 tonnes of fertilizer. Over the last nine years the government has spent SLR6.6 trillion (approximately USD50 billion) on importing fertilizer. With the scheme, a 50kg bag of fertilizer is provided at a subsidised rate of SLR350. An unsubsidized bag of 50kg fertilizer would cost approximately SLR4700 (Ministry of Finance and Planning, 2013; 2014; Ponweera & Premaratne, 2011; Weerahewa *et al.*, 2010; Wiggins & Brooks, 2010). However, there is a growing debate on whether or not the fertilizer subsidy has been reached towards its intended outcomes: yield increase, reduction of negative environmental externalities, and improved food safety (Ministry of Finance and Planning, 2014).

In a research study by Ekanayake (2005) found that a positive relationship between the average annual fertilizer consumption by farmers and paddy production in the study period (1962. Findings by Ekanayake (2005) confirmed again by the studies of Department of Census and Statistics, Sri Lanka (2011) and the World Bank (2007), concluding "the average annual paddy production in Sri Lanka has increased over time with increasing use of fertilizer". By contrast, the study conducted by the Department of Agriculture (2011) on fertilizer subsidy programme since 2005 2010 found that a decreasing trend in average use of fertilizer by the paddy farmers. This opposite views can probably to be explained with the fact that the statistics of the Department of Agriculture are restricted to only several paddy-producing areas and do not cover the whole country. We address this

limitation by focusing our analysis on panel data covering all major paddy-producing areas of Sri Lanka.

Several researchers (Ekanayaka, 2005; Rajapaksa & Karunagoda, 2009; Weerahewa *et al.*, 2010) have investigated fertilizer demand in Sri Lanka using two variables of paddy production and fertilizer usage in the period from 1990 to 2005. The current study examines the fertilizer demand in Sri Lanka extending the data for the study period from 2005 to 2011.

Table 1. Annual average paddy production and fertilizer usage

Year	Average fertilizer use (Kg/Acre)	Average price of fertilizer (SLRs/Kg)	Average annual paddy production (Kg/Acre)
1990	136.6	9.35	1950.6
1991	133.8	9.79	1928.8
1992	141.0	10.29	2030.3
1993	132.2	10.95	1943.0
1994	117.5	12.08	1955.7
1995	144.8	11.58	2089.6
1996	155.2	14.74	1895.1
1997	144.0	15.51	1904.2
1998	157.0	9.88	2109.3
1999	154.0	8.13	2156.1
2000	154.1	9.60	2188.8
2001	156.6	10.93	2075.0
2002	164.2	10.31	2107.0
2003	174.0	10.88	2266.0
2004	174.9	11.52	2183.8
2005	166.6	11.62	2151.1
2006	169.9	11.50	2178.9
2007	173.0	11.61	2195.1
2008	162.5	12.88	2176.0
2009	172.2	11.70	2134.5
2010	180.3	11.18	1913.2
2011	179.3	11.82	1758.9

Source: Department of Agriculture (2011)

Table 1 shows the average rice production and fertilizer usage from 2000 to 2011. The data are aggregated to represent both cultivating seasons, as well as all the major paddy-producing administrative districts, including Anuradhapura, Pollonnaruwa, Kurunegala, Hambantota and Kalutara. Amongst, Anuradhapura, Pollonnaruwa and Kurunegala can be considered as the commercial paddy-producing areas since in these areas the paddy farming is a farmer's primary livelihood activity from which the majority of

the household's income is derived. Furthermore, these commercial paddy-producing areas are accounting for more than 80% of the total paddy production in the country. It means that paddy production in non-commercial areas is mainly used by farmers' households themselves for self-consumption (Gamawelagedara *et al.*, 2011; Thenuwara, 2003).

As shown in Table 1, lower usage of fertilizer is recoding from 1990-1994 when the subsidy has not been provided for paddy cultivation. In contrast, with the advent of the full subsidy in 1995 usage amount of fertilizer has increased. Since 1997, average use of fertilizer by farmers has continually increased with the government dual policy to provide either a urea-only or a full subsidy for paddy farmers. Data in table 1 further evidence that corresponding to the higher fertilizer used, paddy production has also increased with the subsidy schemes. However, the price of fertilizer does not necessarily affect an increasing or decreasing production, and it is strongly controlled by the fertilizer subsidy scheme.

(b) *Determinants of fertilizer demand*

Fertilizer is an essential input to the agricultural production process. Demand for inputs in that process is determined by the prices of other competing inputs, quantities of other outputs (either plant- or animal-based), and various cost components (Arriagada, Sills *et al.*, 2010; Mergos & Stoforos, 1997; Rabbi, 1986). Similar to any other agricultural production process, fertilizer is a major input for paddy production. Many factors determine the demand for fertilizer in paddy production with the main factor being the price of fertilizer (Ekanayaka, 2005; Rajapaksa & Karunagoda, 2009). In addition, demand for fertilizer is determined by the price of labour, the price of seed paddy, the quantity of paddy produced, and the area of paddy production (Ekanayaka, 2005; Gamawelagedara *et al.*, 2011; Rajapaksa & Karunagoda, 2009). Paddy production is also subjected to many cost factors such as land preparation, water management, weed management, pest management and mechanization (Arriagada, Sills *et al.*, 2010; Gamawelagedara *et al.*, 2011). Paddy can be produced in commercial and non-commercial areas, with the demand for fertilizer being higher in the former (Ekanayaka, 2005; Gunawardana & Oczkowski, 1992; Kikuchi & Aluwihare, 1990; Rajapaksa & Karunagoda, 2009).

According to Ekanayaka (2005), the demand for fertilizer is likely to be dependent upon its price and therefore a significant difference may exist in demand when the price is subsidized. However, using a simple regression method to estimate demand functions for the three main fertilizers subsidised, Ekanayaka (2005) found that changes in the price of fertilizers and the price of paddy had little impact on the demand for fertilizer. Despite the low significance attached to both of these factors, he found the impact of

the latter to be greater than the former on the demand for fertilizer. Based on these findings, Ekanayaka (2005) concluded that the fertilizer subsidy should be gradually removed and public policy around it be based on the price of paddy output.

While raising a number of valid inferences, Ekanayaka's (2005) study encompassed a number of limitations. First, despite using data from 1981 to 2004, his study contained only 24 observations after sample adjustments. As a consequence, the statistical and explanatory power of his regression analysis was low. Second, Ekanayake only examined fertilizer price, the farm gate price of paddy, and the area under irrigation. Key determinants, such as the price of labour, the price of seed paddy, and the quantity of paddy produced that have been found to influence the demand for fertilizer, were not considered in his analysis. Furthermore, Ekanayake did not look at differences in fertilizer demand between commercial and non-commercial paddy-producing areas, despite established differences in the demand for fertilizer between these areas (Rajapaksa & Karunagoda, 2009). Ekanayaka used data that amount of issues of fertilizer to capture the demand for fertilizer, as opposed to the actual amount of fertilizer used by farmers, assuming that issued fertilizer is used only for paddy farming. However, this may have overestimated demand for fertilizer because paddy farmers have been found to use the subsidized fertilizer for crops other than paddy (Ministry of Finance and Planning, 2014; Weerahewa *et al.*, 2010).

In another study, Rajapaksa and Karunagoda (2009) argued that demand for fertilizer is depending upon such factors as its price, the price of labour, the price of seed paddy, and the cost of machinery (i.e., a proxy variable for the degree of mechanization). They employed a Translog profit function to derive an input demand function to examine the factors that affect the usage of fertilizer. Rajapaksa and Karunagoda's (2009) findings consistent with the findings of Ekanayaka (2005), where the price of seed paddy had a higher impact on fertilizer demand compared to the absolute price of fertilizer. They also found that fertilizer usage does more responsive to the price of paddy in non-commercial areas compared to the commercial areas. Based on the results of their study, Rajapaksa and Karunagoda (2009) concluded that fertilizer subsidies is more important in determining the demand for fertilizer than that of public policy focused on output prices of paddy. While making an important contribution to knowledge of factors that affecting the demand for fertilizer in Sri Lanka, Rajapaksa and Karunagoda's (2009) study evolves with a number of limitations. First, their research relied on data published by the Department of Agriculture from 1990 to 2006, and hence did not account for fluctuations in the demand for fertilizer based on the subsidy scheme implemented after 2006 by the subsequent governments. Second, Rajapaksa and Karunagoda (2009) used only 32 observations from 1990 to 2006 in their time series analysis, which

may have reduced the explanatory power of their regression models. Further, they did not attempt to look at the impact of the subsidy on fertilizer demand in including a control for fertilizer policy. The demand for fertilizer can fluctuate as a consequence of the subsidy (Ekanayaka, 2005; Weerahewa *et al.*, 2010). Therefore, it is important to control for such fluctuations, including a dummy variable in the regression analysis to represent the policy changes, which is an analytical procedure followed in this study.

While empirical studies examining determinants of the demand for fertilizer in Sri Lanka are limited, however, there are several studies available from India, Bangladesh, Indonesia and a few African countries that contributing some empirical evidences. For example, Croppenstadt, Memeke and Meschi (2003) used a double hurdle fertilizer adoption model to assess the adoption of fertilizer in Ethiopia in cultivating cereals. Rather than using country-level data, they used data collected from over 6000 farming households. They found in their study that the level of formal education of the farmers, the size of the household, and the value-to-cost ratios of the farm operations have a significant impact on fertilizer demand. Their study includes many micro-level observations which increase the explanatory power of the regressions, but not included factors such as the fertilizer price, seed price, output price and quantity of production, which may have provided an alternative explanation for the adoption of fertilizer.

Gilbert and Jayne (2008) examined fertilizer demand for Malawi farmers, where fertilizer was distributed by both the public and private sector. They found that the fertilizer subsidy negatively affected on the purchase of fertilizer through commercial markets. They argued that commercial market for fertilizer was being displaced by the introduction of fertilizer subsidies. In Sri Lanka, the distribution of fertilizer for paddy cultivation under the subsidized price is predominantly done through the government fertilizer secretariat. As such, only a negligible amount of fertilizer is purchased from the private sector, even if there is a significant shortage in the supply of fertilizer through the public sector (Ekanayaka, 2005). However, official data collected by the Department of Agriculture of Sri Lanka on the cost of cultivation and demand for fertilizer does not differentiate between the public and the private sector (Rajapaksa & Karunagoda, 2009). Nevertheless, one of the major findings of Gilbert and Jayne's (2008) study was that fertilizer subsidies should be targeted at farmers who are engaged in extensive agriculture with higher inputs of fertilizer. This finding is relevant for Sri Lanka, given that the fertilizer subsidy before 2015 is equally accessible to all farmers, irrespective of whether they undertake paddy cultivation in a commercial (i.e., extensive cultivation of paddy) or non-commercial (i.e., lower cultivation of paddy) area. As noted earlier, research undertaken by Ekanayaka (2005) and Rajapaksa and Karunagoda

(2009) did not investigate the relationship between the land extent of cultivation and demand for fertilizer. Our analysis investigates this unexplored relationship and thus provides an initial step in the discourse surrounding public policy development in relation to the targeting of fertilizer subsidies according to the area of cultivation in Sri Lanka.

In explaining fertilizer usage in Bangladesh, Manos, Begum *et al.* (2007) found remarkable negative relationship between fertilizer prices and the demand for fertilizer. They suggested that increasing fertilizer prices will decrease farm income and farmers will ultimately reduce the demand for fertilizer. Finally, Manos, Begum *et al.* (2007) found that increasing fertilizer prices drove farmers to change their farm plans, resulting in the introduction of less fertilizer-intensive crops and a reduction in labour usage. However, Manos, Begum *et al.* did not examine the impact of the price of labour on the use of fertilizer. Labour remains an essential factor of production in the paddy sector in developing countries, despite its importance receding in recent decades due to mechanization (Department of Census and Statistics, 2013; Nawaratne, 2013). By examining the influence of the price of labour on demand for fertilizer, the current study contributes to current knowledge on public policy development in relation to fertilizer subsidization within the context of a developing nation. Deriving input demand functions from a production process is well-established in the economic literature (Arriyagada, Sills *et al.*, 2010; Rajapaksa & Karunagoda). We therefore now focus our attention on the theoretical explanation for derivation of a fertilizer demand function. We then present the empirical framework for estimating the demand for fertilizer.

THEORETICAL BACKGROUND

Consistent with previous research we used production and profit maximization theories in deriving the input demand function for fertilizer (Acheampong & Dicks, 2012; Arriagada, Sills *et al.*, 2010; Ball, 1988; Lau & Yotopoulos, 1972; Mergos & Stoforos, 1997; Sidhu & Baanante, 1979; Yotopoulos, Lawrence & Wu-Lon, 1976).

If we assume that farmers behave rationally, the input demand function, such as one for fertilizer demand, can be derived from a normalized profit function which can take the following form:

$$\pi = PQ - WX \quad (1)$$

The production of paddy which uses fertilizer as an essential variable input will take the form:

$$Q = f(W, Z) \quad (2)$$

In equations (1) and (2), π is the farm profits, Q is the quantity of rice produced, P is the price of rice, X is the quantity of variable inputs and W the price of variable inputs. Z is the vector of fixed factors of rice production. Both profits and the prices of variable inputs are normalized by the price of paddy output. Based on these, a profit maximization problem can be written as:

$$\text{Max } PQ - WX \text{ Subject to } Q = f(X, Z) \quad (3)$$

Solving the profit maximization problem shown in equation (3) will yield a set of input demand and output supply functions, as shown by equations (4) and (5):

$$X = x(P, W, Z) \quad (4)$$

$$Q = q(P, W, Z) \quad (5)$$

The profit maximizing input and output levels can be derived by substituting the relevant input demand and output supply functions expressed by equations (4) and (5) back to the profit function explained by equation (1). It can be explained as:

$$\pi = P q(P, W, Z) - W x(P, W, Z) \quad (6)$$

Input demand function can be obtained by differentiating the profit function (equation 6) with respect to input price X , and the output supply function can be obtained by differentiating the same function with respect to output price P . The resulting functions are illustrated below as equations (7) and (8):

$$X_I^* = - \frac{d\pi}{dw_I} = X^*(P, W, Z) \quad (7)$$

$$Q^* = \frac{d\pi}{dp} = Q^*(P, W, Z) \quad (8)$$

However, in this study we employed a Cobb-Douglas functional form to describe the technology used in the production of rice in Sri Lanka. Therefore, the production technology shown in equation (2) will take the form explained in equation (9):

$$Y = A \prod_{i=1}^n X_i^{\beta_i} \quad (9)$$

where $\beta_i > 0$ and $i = 1, 2, \dots, n$

The Cobb-Douglas production function will result in a log-log fertilizer demand function. This function was then estimated, using a single function Ordinary Least Square (OLS) procedure. Use of the Cobb-Douglas functional form allowed us to estimate the demand elasticity of independent variables directly. A single equation OLS procedure is more likely to provide accurate and reliable estimates, especially with a small sample, compared to other estimation procedures (Arriagada, Sills *et al.*, 2010; Griffin, Montgomery & Rister, 1987). Chembezi (1990) highlighted possible statistical concerns over the simultaneity of fertilizer demand and prices. However, in Sri Lanka, whether it is the subsidized price or the market price, fertilizer prices are announced in advance of the cultivation season. Therefore, in a given time period, farmers will decide on the amount of fertilizer to be used based on the already known fertilizer prices, and hence are not affected by the local demand for fertilizer of the area (Arriagada, Sills *et al.*, 2010).

EMPIRICAL MODEL

In the literature, different methods have been used by the researchers to estimate fertilizer demand functions. Over the last three decades, numerous researchers have consistently employed the profit function approach as a mechanism to estimate demand for fertilizer in both developing (Abrar & Morrissey, 2006; Arriagada, Sills *et al.*, 2010; Bapna *et al.*, 1984; Fulginiti & Perrin, 1990; Lau & Yotopoulos, 1972; Sidhu & Baanante, 1979; Sidhu & Baanante, 1981; Yotopoulos *et al.*, 1976) as well as developed economies (Gunjal & Earl, 1980; Mergos & Stoforos, 1997). Following these researchers, the profit function approach was used in empirically estimating the demand for fertilizer in Sri Lanka. Adoption of the Cobb-Douglas functional form for production technology allowed us to derive an input demand function for fertilizer as depicted in equation (10). Following the arguments postulated by Arriagada, Sills *et al.* (2010), Griffin *et al.* (1987), and Mergos and Stoforos (1997), we used a single function approach in

estimating the stated empirical relationship, as opposed to a system of equations.

The empirical form of the fertilizer demand function can be depicted as follows:

$$\ln F = \alpha + \beta D_c + \gamma \ln Y + \sum_{i=1}^3 \delta_i \ln W_i + \sum_{j=1}^4 \vartheta_j \ln Z_j + \epsilon. \quad (10)$$

In equation (10) F is the fertilizer usage based on the major paddy-producing area, Y is the paddy output, Z_1 is the price of rice fertilizer, Z_2 is the price of labour, Z_3 is the price of seed paddy, W_1 is the cost of machinery, W_2 is the cost of materials, W_3 is the cost of pesticides, D_{c1} is the dummy variable to represent the subsidy years (subsidy dummy) and D_{c2} is the dummy variable to represent commercial paddy-producing areas (area dummy). The α , β , γ , δ , and ϑ are estimated parameter coefficients and ϵ is the random error. Fertilizer prices, labour prices and seed paddy prices are expected to have a negative sign. Consistent with cost minimization theory, the rice output is expected to have a positive sign. The different cost components (i.e., cost of machinery, cost of materials and cost of pesticides) are expected to have a negative sign. The dummy variable on the subsidy is also expected to have a positive sign, where fertilizer usage is expected to be high when the subsidy is provided. Finally, the dummy variable on area is expected to have a positive sign where commercial paddy-producing areas are expected to use more fertilizer than non-commercial areas (Arriagada, Sills *et al.*, 2010; Ekanayaka, 2006; Rajapaksa & Karunagoda, 2009).

This study used secondary data collected and published by the Department of Agriculture, Sri Lanka. The data is focused on the costs associated with the cultivation of paddy and are based on the major paddy-producing areas reflecting the two major cultivating seasons: ‘*Yala*’ and ‘*Maha*’. For each major paddy-producing area, the Department conducts a bi-annual farm household survey based on a random sampling method, and data published at an aggregated level in area wise. The selected major paddy-producing areas have evolved over the years. Since 2010, data have been available for 15 major paddy-producing areas. Data on seven major paddy-producing areas have been consistently available since 2000. However, this number is reduced to only five such areas once data are considered from 1990. Our focus on fertilizer demand is from 1990. Therefore, the data we used in our analysis are based on five major paddy-producing areas: Anuradhapura, Pollonnaruwa, Hambantota, Kurunegala and Kaluthara. As explained earlier, we used the classification suggested by Gamawelagedara *et al.*, (2013) and Thenuwara (2003) in categorizing these into commercial and non-commercial paddy-producing areas.

The data is organised into a panel data architecture. Balanced panels are being used and paddy producing area is the panel identifier. Fixed and random effect regression models are being run by STATA.

RESULTS AND DISCUSSION

This research used fertilizer consumption and cost of production data for the paddy sector in Sri Lanka from 1990-2011. It is the first study focused on Sri Lanka to examine data from 2005 onwards with the new fertilizer subsidy scheme was introduced in the period under study. Initially we used a fixed effect panel data model in estimating a direct fertilizer demand function. The Hausman test was conducted to determine the fact that whether a fixed effect or random effect model was more appropriate for our analysis. Results of the Hausman test (see Appendix A) supported the use of a fixed effect model. However, the area dummy variable could not be used in a fixed effect regression analysis, since for a given panel the dummy variable did not change. Therefore, the area dummy variable was excluded from the fixed effect regression model. In order to address this issue, a random effect model was employed with the area dummy variable controlling for fertilizer demand among commercial and non-commercial paddy farming areas.

Price variables in input demand systems tend to have a lower variation. Therefore, it is recommended to normalize the input prices and profits using the price of output (Arriagada, Sills *et al.*, 2010). In our regression, we normalized the price of fertilizer, price of labour, and the price of seed paddy, using the price of paddy output. In panel data regressions it is essential to establish that data are stationary. Therefore, we performed the Harris-Tzavalis (HT) test for stationary recommended by STATA for panel data (Harris & Tzavalis, 1999; Hlouskova & Wagner, 2005). All the variables used in the regression analysis showed stationary properties. However, the HT test was significant only at the 90% significance level for the price of fertilizer and cost of machinery variables. Therefore, as recommended by Harvey and Trimbu (2008) and Hodrick and Prescott (1997), the Hodrick–Prescott (HP) filter was used to improve the level of significance of the HT test to the 99% significance level. Consequently, all variables used in the regression were found to be stationary and the HT test results were significant at the 99% significance level.

Table 2 provides the descriptive statistics of the variables used in the regression analysis. The coefficient of variations suggested enough variations for the variables to be used in the regression analysis.

Table 2. **Descriptive Statistics of the Variables Included in the Regression**

Variable	Description	Mean	Standard deviation	Coefficient of variation (%)
F	Fertilizer demand (Kg/Acre)	160.17	33.5	20.93%
Y	Paddy output (Kg/Acre)	1953	479.1	24.53%
Z1	Price of fertilizer (Rs/Kg)	1.25	1.1	93.46%
Z2	Price of labor (Rs/Man-days)	21.54	4.5	20.89%
Z3	Price of seed price (Rs/Kg)	1.67	0.27	16.13%
W1	Cost of machinery (Rs/Acre)	4721.51	3396.5	71.93%
W2	Cost of materials (Rs/Acre)	4478.80	2172.6	48.50%
W3	Cost of pesticides (Rs/Acre)	584.47	533.8	91.33%
D1	Subsidy dummy variable =1 if farmers were given a fertilizer subsidy	0.77	0.42	-
D2	Area dummy variable = 1 if the area is a commercial paddy farming area	0.60	0.49	-

Source: Based data collected from Department of Agriculture (2011)

The price of fertilizer was measured through the aggregate and average unit price of fertilizer that farmers face in a particular area for the ‘Yala’ and ‘Maha’ cultivating seasons. Farmers require to buy fertilizer from commercial fertilizer outlets exception with fertilizer subsidy. In such instances, the unit price that farmers paid varied, based on the type of fertilizer they bought and the proximity of the commercial fertilizer outlet to Colombo (i.e., the commercial capital of Sri Lanka). In a non-subsidy situation (i.e., 1990-1994), the commercial fertilizer outlets located far from Colombo would have a higher price, reflecting the additional transportation costs. Therefore, there is sufficient variation in the fertilizer prices among paddy-cultivating areas. Cost of machinery will vary based on the type and the brand of the machinery that farmers use for farming. For example, the

cost of machinery would vary depending on whether farmers used a four-wheel or a two-wheel tractor for ploughing. Furthermore, the cost of machinery would be the proxy for level of mechanization (Rajapaksa & Karunagoda, 2009). That is, higher allocations to machinery refer to higher mechanization. Cost of materials (other than fertilizer) and cost of pesticides will also vary according to the type and brands farmers used. For example, farmers in a certain area during a given cultivating season might use expensive and broad-base pesticides, depending on the type of pest attack experienced.

Table 3. Regression Results

Variable	Data from 1990-2011		Data from 1990-2005	
	Fixed effect (Model A)	Random effect (Model B)	Fixed effect (Model C)	Random effect (Model D)
Price of fertilizer	-0.232 (0.000)***	-0.224 (0.000)***	-0.297 (0.000)***	-0.296 (0.000)***
Price of labour	0.154 (0.091)*	0.190 (0.034)**	0.166 (0.118)	0.177 (0.084)*
Price of seed paddy	-0.197 (0.096)*	-0.279 (0.014)**	-0.272 (0.065)*	-0.259 (0.068)*
Quantity of output	0.152 (0.077)*	0.309 (0.000)***	0.304 (0.003)***	0.320 (0.000)***
Cost of machinery	-0.097 (0.101)	-0.115 (0.050)**	-0.152 (0.001)***	-0.146 (0.001)***
Cost of materials	0.213 (0.000)***	0.234 (0.000)***	0.281 (0.001)***	0.279 (0.000)***
Cost of pest management	-0.064 (0.092)*	-0.051 (0.157)	0.072 (0.174)	0.078 (0.107)
Subsidy dummy	0.074 (0.067)*	0.056 (0.157)	0.006 (0.991)	-0.007 (0.877)
Area dummy		0.103 (0.002)***		0.174 (0.000)***
R square overall	0.4690	0.5383	0.5215	0.6168

*** = 1% significant level, **=5% significant level, *=10% significant level

Source: Based data collected from Department of Agriculture (2011)

Table 3 shows the results of the regression analyses. Model A represents the fixed effect regression results, using data from 1990-2011. As expected, we found the price of fertilizer have a negative and statistically significant relationship with the demand for fertilizer. According to our results, a 1%

increase in the price of fertilizer would decrease the demand for fertilizer by 0.23%.

As it was expected, the price of seed paddy also had a negative as well as significant relationship with the demand for fertilizer, that is, a 1% increase in the price of seed paddy was found to decrease the amount of fertilizer usage by 0.19%. The amount of seed paddy was found to be directly related to paddy yield. When the price of seed paddy increased, farmers either reduced the area cultivated or the intensity of cultivation (i.e., the number of plants per acre) or used organic fertilizer, all actions that reduced paddy yield. Given that the rice varieties cultivated in Anuradhapura, Pollonnaruwa, Hambantota, Kurunegala and Kaluthara are mainly new improved varieties and hardly respond to organic fertilizers (Gamawelagedara *et al.*, 2011; Rodrigo, 2013), it is important that the seed paddy prices are maintained at a lower price to sustain consistent paddy production.

Furthermore, there is remarkable positive relationship between paddy output and demand for fertilizer. For example, 1% increase in the amount of paddy output was found to result in a 0.15% increase in the use of fertilizer. Increased output has the potential to attract higher farm profits, which in turn allows farmers to allocate more money for fertilizer, especially if the subsidy is not provided. Therefore, it is important to find methods which improve the yield but utilize lesser amounts of chemical fertilizers since high chemical fertilizer use has been found to cause negative environmental externalities or higher opportunity cost (e.g., soil and water pollution) and impose financial pressure on the government (Ministry of Finance and Planning, 2013; Tirado & Allsopp, 2012). One such method is to utilize high-yielded paddy varieties. While farmers are using such varieties at present, more research is needed to explore additional varieties that are more fertilizer-responsive (Senaratne & Rodrigo, 2014; Rodrigo, 2013). As suggested by Nawaratne (2013) alternative strategy that can be employed to reduce dependency on chemical fertilizer is to introduce more mechanization into industry. Mechanization would increase farm productivity while limiting the use of inputs such as fertilizer and labour.

Cost of pest management was found to have a negative and significant relationship with the demand for fertilizer. For example, 1% increase in the cost of pest management will decrease the usage of fertilizer by 0.64%. Pest attacks can target paddy plants at any stage of their growth. Farmers use fertilizer mainly in the early stages of paddy cultivation, and, once the plants are established, fertilizer is not required. Therefore, use of fertilizer and pest management correlate mainly during the early stages of plantation. Early pest attacks will give the farmer a clear idea about the potential future performance of paddy cultivation. As such, once paddy cultivation is

affected by pests in its early stages, farmers will be discouraged from using successive rounds of fertilizer in the future, as the potential of paddy cultivation is decreased. That is, the opportunity cost of applying more fertilizer under such circumstances is higher than the potential gains from the yield.

Contrary to our expectations, the price of labour had a positive and significant relationship with the demand for fertilizer. For example, 1% increase in the price of labour was found to increase the demand for fertilizer by 0.15%. We expected farmers to use less fertilizer when the price of labour increased, as a higher labour price would decrease the amount of labour employed and possibly change the farm management plan (Manos, Begum et al., 2006). Labour is increasingly becoming a scarce resource for paddy farming in Sri Lanka due to internal migration of labour from rural (i.e., where paddy is cultivated) to urban areas and aging labour force (Nawaratne, 2013) and therefore, farmers who depend on hired labour are likely to maximize the investment they have made in labour by utilizing more fertilizer. This could potentially lead to an overuse of fertilizer, resulting in a number of negative environmental externalities, such as water and soil pollution (Weerahewa *et al.*, 2010). Therefore, it is important that the price of hired labour is maintained at an affordable level to prevent overuse of chemical fertilizers.

Surprisingly, our results indicate that an increase in the cost of materials will also push farmers to use more fertilizer. In particular, a 1% increase in the cost of materials was found to increase the demand for fertilizer by 0.21%. Cost of materials here excludes fertilizer, seed paddy and pesticides. Therefore, it mainly consists of the cost of weedicides and any other material, such as paddy husks, coir dusk, ropes, etc. Applications of weedicides have the potential to destroy micro and macro organisms (Edmeades, 2003). As such, once weedicides are applied, farmers tend to use more fertilizer to rejuvenate the damaged soil in the paddy land. Similar to increased labour prices, increased material costs will also result in the overuse of fertilizer. One possible way to prevent this from happening is to adopt cultivation methods that facilitate low-cost manual weeding and the prevention of weeds. For example, use of dry sowing methods will prevent the emergence of weeds during the early stages of paddy planting (Senaratne & Rodrigo, 2014).

The subsidy dummy variable, which represents the policy decisions on the fertilizer subsidy, had a positive and significant relationship with the demand for fertilizer, implying that farmers tend to use more fertilizer when the subsidy was given. Results suggest that, on average, farmers increase the use of fertilizer by 0.74% when the fertilizer subsidy is given. Therefore, the fertilizer subsidy plays an important role in increasing the use of

fertilizer as a means of increasing the production of paddy. The government of Sri Lanka started the fertilizer subsidy in the first instance with an objective of promoting its use to ensure increased production and self-sufficiency in rice (Weerahewa *et al.*, 2010). However, based on the results depicted in Model A of Table 3, it can be seen that the marginal effect of the fertilizer subsidy is quite small and of low significance (i.e., at only 10%). It means that the existence of the subsidy is of significantly less importance compared to effect of other variables such as the price of seed paddy, price of labour etc. this finding suggest that the fertilizer subsidy could be removed gradually in the long-term. Earlier attempts by the government indicate that significant reductions in the fertilizer subsidy (such as the proposed reduction of 25%) as a one-off strategy will not encourage farmers to less-use of fertilizer nor adopt organic fertilizers (Ministry of Finance and Planning, 2013). All these findings suggest that Sri Lanka can remove the fertilizer subsidy gradually.

Model B in Table 3 represents a random effects model, which was undertaken to evaluate the impact of the area dummy variable (i.e., commercial or non-commercial) in the demand for fertilizer. A positive and significant relationship was found between the area dummy variable and the demand for fertilizer, suggesting that, on average, demand for fertilizer increases by 0.10% when the paddy cultivating area is in commercial cultivation. These results are consistent with our hypothesis, that more fertilizer is demanded by commercial paddy-cultivating areas. Based on these results, we further argue that the fertilizer subsidy can be reduced by a significant amount from the non-commercial paddy-producing areas in the short-term. As explained earlier, regardless of whether it is applied to commercial or non-commercial farming, the fertilizer subsidy has played little influence on the demand for fertilizer. If fertilizer is being demanded more by commercial farmers, then it is possible to take the fertilizer subsidy away from non-commercial farmers within the next two to three years. However, in order to ensure self-sufficiency in rice and to stabilize the local prices for rice, it is important that the fertilizer subsidy be continued with the commercial farmers, at least in the short-term. It can be removed gradually from commercial farming within the next 3-5 years, taking a long-term perspective.

One important study that motivated us to look at the factors that affect the demand for fertilizer was done by Ekanayaka (2005), suggesting to remove the fertilizer subsidy since the price of fertilizer had only limited significance (i.e., at the 10% level) on the demand for fertilizer ($p < 0.093$). Ekanayaka used data for the period from 1990-2005. However, according to our panel data regression analysis (Models A and B), for the period from 1990-2011 suggest otherwise, where the impact of the price of fertilizer on the demand for fertilizer was significant at the 1% significance level ($p <$

0.000). Therefore, the same data used by Ekanayaka (2005) for the period of 1990-2005 was reanalysed using a panel data regression for comparison purposes. In contrast to the findings of Ekanayaka, our results indicate that the price of fertilizer significantly impacts the demand for fertilizer at the 1% level significance ($p < 0.000$) for the period 1990-2005. The difference between our results and those of Ekanayake (2005) may be due to the fact that Ekanayaka used national-level aggregated data and only a handful of observations ($n = 24$), whereas our analysis is a panel data regression based on area-level data and a much larger number of observations ($n = 220$). Results of this analysis are reported in Models C and D in Table 3.

Our findings suggest that, since 2005, the price of labour and cost of pest management have significantly contributed to the demand for fertilizer (comparing Models A and C). The relationship between the demand for fertilizer and the other variables, such as the price of seed paddy, paddy output and cost of materials, does not change with the addition of data from 2005-2011. However, cost of machinery negatively and significantly affected the demand for fertilizer during 1990-2005 but not beyond 2005. This suggests that farmers have been using less fertilizer with increased use of machinery. However, over the last six years (2006-2011) their demand for fertilizer appears to be more dependent on the cost of labour. This result further confirms the increasing scarcity of labour in paddy cultivation and therefore suggests mechanization as an alternative solution to address the scarcity of labour while reducing the overuse of fertilizer.

DISCUSSION

Estimated results suggest that the factors such as price of fertilizer, price of seed paddy, price of labour, quantity of paddy output, cost of materials, cost of pest management, provision of the fertilizer subsidy, and commercial paddy cultivation have a significant impact on the demand for fertilizer. The estimated function explains by 46% of the variation in the quantity of fertilizer demanded.

The price elasticity of fertilizer demand was -0.232. The cross price elasticity with respect to the price of seed paddy was -0.197 and the cross price elasticity with respect to the price of labour was 0.154. Demand for fertilizer is relatively inelastic to the price of fertilizer. This is acceptable, given the lack of close substitutes to chemical fertilizer. Organic fertilizer is practiced at a very lower level in Sri Lanka and commercial paddy farming is predominantly based on chemical fertilizers (Rodrigo, 2013). The demand for fertilizer is relatively inelastic to the price of seed paddy, which is understandable, given that seed paddy is an essential component of

cultivation. The demand for fertilizer is relatively inelastic to the price of labour given that labour is an essential cost component of paddy cultivation. The most effective way to reduce its significance is to introduce a higher degree of mechanization.

One of the major issues associated with the fertilizer subsidy is the overuse of fertilizer by farmers. Fertilizer is necessary for sustainable paddy production, but overuse will result in many negative externalities, including water pollution, damage to favourable micro and macro soil organisms, thereby reducing soil fertility, and making paddy safety-less for consumption because of cumulative chemical effects in the paddy (Gerowitt, Isselstein & Marggrat, 2003). Furthermore, as explained earlier, the fertilizer subsidy is a politically sensitive policy area in Sri Lanka (Thenuwara, 2003; Weerahewa *et al.*, 2010). Therefore, there is a political economy dimension to the implementation of the fertilizer subsidy program (Ministry of Finance and Planning, 2012). Accordingly, in providing policy recommendations, we primarily focus our attention on the economic aspect of fertilizer demand. Our recommendations, based on the analyses above, are focused on three major outcomes: self-sufficiency in the production of rice; prevention of the overuse of chemical fertilizer; and the gradual removal of the fertilizer subsidy.

First, we find that the price of seed paddy has a greater impact in sustaining paddy production in Sri Lanka than the fertilizer subsidy. While increasing seed price will reduce farmers' attempts to overuse fertilizer, this might actually limit farmers' full potential to sustain production. Therefore, measures are required for the stabilization of seed paddy prices. In its budget proposal for 2014-2015, the government of Sri Lanka announced that seed paddy will be provided to farmers for free for the upcoming 'Maha' season (Ministry of Finance and Planning, 2014). This policy measure is in line with the recommendations of this study. However, we suggest that the policy measures need to be focused on at least 2-3 years (short-term), rather than a single cultivation season, as announced in the most recent budget.

Second, we recommend to reduce overuse of fertilizer, the price of labour needs to be stabilized and measures to reduce the cost of weedicides should be enacted. The policies in which encourage the farmers to increase the level of mechanization (e.g., subsidies for purchasing machinery, government-funded educational programs for farmers on mechanization, etc.), is necessary for reducing their overuse of fertilizer.

Finally, we recommend the gradual removal of subsidy in the long-term. However, a short-term reduction (within the next 2-3 years) in the fertilizer subsidy can be implemented for non-commercial paddy-producing areas,

since fertilizer usage in such areas is relatively lower. However, the small-farmer concentration is also high in non-commercial areas (Thennakoon & De Silva, 2013). Therefore, removal of the fertilizer subsidy could reduce the yield, which might impact on producers' household rice consumption and self-sufficiency. One way in which the government can reduce farmer dependency on chemical fertilizer in non-commercial areas is to encourage the use of organic fertilizer (Ghosh, 2004; Cordell, Drangert & White, 2009 & Leifeld, & Fuhrer, 2010).

The removal of the fertilizer subsidy brings about two main advantages (1) encourage farmers to adopt more organic fertilizer (2) allow the private fertilizer market to develop. Adoption of organic fertilizer will take time and will be determined by many factors. The establishment of the private fertilizer market will reduce the miss-use of fertilizer and would remove the inefficient farmers from paddy farming. Now that Sri Lanka has removed the fertilizer subsidy and introduced a voucher system, the above mentioned advantages will start taking place. However, it might take several more years for the paddy farming sector to operate with minimum support from the government and to determine the prices and the quantity of fertilizer through the market forces.

CONCLUSION

This study has explained the central importance of understanding the factors affecting to fertilizer demand in the paddy sector in Sri Lanka for the purpose of exploring the possibility to total removal of fertilizer subsidy and substitutability of chemical fertilizer from organic fertilizer. The study used the secondary panel data gathered by the Department of Agriculture and Department of Census and Statistics for the period of 1990-2011 to estimate the input demand function for paddy cultivation sector. The most obvious finding to emerge from this study is that the factors such as price of fertilizer, price of seed paddy, price of labour, quantity of paddy output, cost of materials, cost of pest management, provision of the fertilizer subsidy, and commercial paddy cultivation have a significant impact on the demand for fertilizer. The study further found that the demand for fertilizer is relatively inelastic to the price of fertilizer, price of seed paddy, and the price of labour however, the price of seed paddy has a greater impact in sustaining paddy production in Sri Lanka than the fertilizer subsidy.

In the discussion it is found two major issues: the overuse of fertilizer by farmers and the politically sensitive of the policy associated with the fertilizer subsidy.

The findings of this study suggest that Government of Sri Lanka can remove gradually fertilizer subsidy for commercial paddy sector in the long run using two strategies. First is the development of organic fertilizer industry for non-commercial paddy sector and second is adoption of competitive chemical fertilizer market for commercial paddy sector which is mostly used the chemical fertilizer.

The current findings add to a growing body of literature on practice the indigenous growth strategy in small open economy like Sri Lanka. Future research should therefore concentrate on the investigation of strategies to develop the organic fertilizer industry using new technologies, and natural and human resources endowment in the rural sector.

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Appendix A

Table 1. Results of the Hausman test for data from 1990-2011

Variable	Fixed Coefficients	Random Coefficients
Price of fertilizer	-0.232	-0.219
Price of labor	0.154	0.044
Price of seed paddy	-0.197	-0.111
Quantity of output	0.152	0.387
Cost of machinery	-0.097	-0.119
Cost of materials	0.213	0.239
Cost of pesticides	-0.064	-0.071
Subsidy dummy	0.074	0.086

The Hausman test is focused on the null hypothesis that the efficient estimates of the random effect model have no significant difference from the efficient estimates of the fixed effect model. Therefore, if the null hypothesis fails to get rejected (P value is less than 0.05), then there is no significant difference between the two approaches and a random effect model can be used. However, if the null hypotheses get rejected (P vale is less than 0.05), then the fixed effect model should be used.

Test Value: 18.95

Prob>Chi2 = 0.01