Chapter 9

ECONOMIES OF SCALE IN PADDY FARMING IN THE MAJOR SETTLEMENT SCHEMES IN SRI LANKA: A QUANTILE REGRESSION ANALYSIS

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1. INTRODUCTION

Theoretically, economies of size or scale economies refer to a firm ability to minimize the costs of production by increasing output. In agriculture, it means the ability of a farmer to expand its production by expanding the size of the farm with a fixed or relatively low increase in costs of production. The empirical studies in agriculture generally provide evidence over an 'L' shaped cost curve (Hallam, 1991). Scale economies or returns to scale of a farm could arise due to the various reasons and among them, marketing advantage of the bulk product due to the improved marketing power or negotiation power, the advantage in purchasing bulk inputs, ability to improve resource use efficiency particularly labor, machinery and water resources or managerial ability, ability to effectively control of pest, weeds, and diseases, etc. are largely cited in the literature (Duffy, 2009; Chavas, 2008; Hallam, 1991; Faris, 1961). Thus, the scale economies in agriculture associates with external or non-size factors as well.

In Sri Lankan agriculture, lowering the cost of production along with increasing farm size is a debatable topic due to the constant nature of the land resources devoted to the agriculture at the aggregate level and structural rigidities or inflexibility in the land market (Samaratunga, 2010). In agriculture colonization schemes, land fragmentation is one of the issues due to the pressure of second and third generations of settled families over-allocated fixed amount of land and inadequacy of off-farm employment generation, specifically through

Cite this chapter: Abeyrathne, G., Lalani, J., Senadeera, P. & Prasanna, R., 2021. Economies of Scale in Paddy farming in the Major Settlement Schemes in Sri Lanka: A Quantile Regression Analysis. In: R. Prasanna, ed. *Sustainability of Agriculture Settlement Schemes in Dry Zone of Sri Lanka: Issues, Challenges and Path ahead.* Mihintale: Rajarata University of Sri Lanka, pp. 157-176.

agro-based industrialization, in the agriculture regions of the country. This has currently led for informal fragmentation of paddy land affecting to reverse one of the main objectives of establishing the agriculture colonies – from generating marketable paddy surplus or commercial farming system to subsistence farming system. Many studies have cited the less profitability of paddy farming in the country due to various issues. Among them, issues in the paddy marketing, high cost of production, and stagnated nature of productivity are mainly highlighted in the literature (Thiruchelvam, 2005; Aheeyar, et al, 2003; De Silva & Yamao, 2009; Wijesinghe & Wijesinghe, 2015). As a result, government intervention in agriculture could be observed in various forms to sustain the paddy farming in the country and among them, fertilizer subsidy program, credit schemes with interest subsidies, guaranteed price schemes, extension services, etc. are the programs which make a heavy burden on government annual budget. For instance, in 2017, the government had to spend LKR 30.1 billion for fertilizer subsidy scheme (CBSL, 2017).

Given this backdrop, one of the topical subjects which recently gained interest among the scholars to address the issue of the economic viability of paddy farming is the scale economies of paddy farming (Samaratunga, 2010; Weerahewa, et al., 2003; Thibbotuwawa & Weerahewa., 2004). According to the World Bank (2007), the rigidities in the land market has affected low-income growth in rural areas of the country as it limits farmers' interest in agriculture product diversification and investment in farm productivity enhancement. The studies carried out by Weerahewa et al. (2004) and Thibbotuwawa & Weerahewa (2004) confirmed the positive relationship between the scale of cultivation, and productivity and competitiveness in paddy farming. Several studies have revealed that paddy farming with smallholder does not have comparative advantages (Rafeek & Samaratunga, 2000; Kikuchi, et al., 2002). Bandara, 2008) emphasized the cost of production difference between small scale and large scale farming noting the capital intensive nature of large scale farming. Studying economies of scale in agriculture, Samaratunga (2010) noted the small size of the farm as a cause of low agricultural income of farm households.

This research evidence provides justification to large scale farming in the country as it generates economies of scale and thereby support to generate adequate agricultural income (Wickramaarachchi and Weerahewa, 2018; Sheng, et al., 2019; Bhatt and Bhat, 2014). Further, these studies' findings support the agricultural land market liberalization. As the majority of paddy farmers are smallholders, it is a critical and debatable argument – specifically due to its link with land market liberalization- thus, further studies are needed to exhibit the problem of economies of scale in paddy farming in Sri Lanka in the context of smallholder settings. Also, it is evident that economies of scale are related to structural change in agriculture, particularly due to the change in technology, consumer preferences, and world conditions (Hallam, 1991).

Thus, the central aim of this paper is to test the hypothesis that large paddy farms generate the economies of scale in terms of paddy farming in the agriculture colonization schemes. In this connection, following three points will be in the consideration – 1) exploration of effects of farm size on acreage production by taking into account the heterogeneity nature of land ownership due to informal land fragmentation issue in the agriculture colonization schemes, 2) exploration of effects of other farm-specific scale variables on acreage production of paddy farm, and 3) discussion over derived relationships in the context of nature of emerging informal land ownership issue in the agriculture colonization schemes. The specific contribution of this study is that it uses a different method – quantile regression model – to capture the effects of informal land ownership based heterogeneity amongst the farmers.

2. ANALYTICAL TECHNIQUES USED IN PREVIOUS STUDIES AND KEY RESULTS

The issue of agricultural land fragmentation is one of the topical subject in the research arena due to increasing population pressure on constant land resources. On the hand there is a theoretical debate over relationship between land size and acreage production with inconclusive results. Table 1 presents the summery of data and techniques used in previous research in studying relationship between farm size and productivity and key concluding points. The concluding points of the studies provide rather mixed evidence over the research subject with different explanations over scale merits.

Table 1: Data and techniques used in previous research in studying relationship between farm size and productivity

Researcher(s)	Data description	Analytical tools used	Nature of relationship – Farm size and productivity
Thapa (2007)	The primary data collected from cross sectional random sample survey including 250 farm households in Mardi watershed area of Nepal.	Regression models and Cobb-Douglas production function	• Inverse relationship between farm size and acreage production. • A higher input usage – cash inputs and labour hours – at the small farm setting. • Use of other inputs as a cause of inverse relationship at the small farm setting rather than the diseconomies of scale.
Wickramaarachchi & Weerahewa (2018)	Primary data gathered from 1230 lowland pots covering 935 paddy farms from three irrigated settlements in Anuradhapura District, Sri Lanka.	Bivariate Probit model	• Positive relationship between plot size and land productivity, but found the inverse relationship as land size increase beyond certain limit.
Bhatt & Bhat (2014)	Primary data covering 461 farmers in Pulwama district of Jammu and Kashmir (India)	Non-parametric data envelopment analysis	• Technical efficiency of farms first falling and then rising with size. • Higher net farm income per acre in large farms with technically efficient than small farms.
Ladvenicova & Miklovicova (2015)	Balanced panel data collected from farms in each region of the Slovak republic	Ordinary least squire and fixed effect model regression framework	• Inverse relationship
Masterson (2007)	Secondary data on a sample of 8131 representative Paraguayan households.	Data envelop analysis and Stochastic	• Confirmed the ability of deriving higher net farm income being technically more efficient by the small farmers.

		Production Frontier method.	
Sial, et al. (2012)	Primary data gathered from 302 farmers from six districts of Central Punjab of Pakistan.	Regression approach	• Inverse relationship
Ahmad & Qureshi (1999)	The farm level data gathered by Rural.Finance Survey of Punjab	Cobb-Douglas Production Frontier and Regression Models	• Explained the nature of intensive input usage and higher level of cropping intensity in small farm as main reasons for inverse relationship between farm size and acreage production.
Sheng, et al. (2019)	Farm-level panel data from 2003 to 2013 in Northern China with the total sample of 641.	Cobb-Douglas Production Function and regression models	• The farmers' input choice between labour and capital is likely to smooth the non-linear farm size-productivity relationship, with capital use being more likely to affect the farm-size productivity relationship at a larger scale.
Sundqvist & Andersson (2006)	The data collected by Vietnam Household Living Standard Survey 2004 based on 9000 rural households.	Regression model	• Weak correlation between land fragmentation and productivity • The land fragmentation likely to be positively correlated with productivity due to higher use of fertilizer and labors.
Chen, et al. (2005)	The data set consisted by randomly selected 591 farm households collected by the Survey of Chinese Rural Households in the period of 1995-1999.	Regression models in logarithm	• The consolidated farms are likely to be more productive, but this seems to be explained by initial differences in land productivity.

3. RESEARCH METHODOLOGY

3.1 Study setting

The study selected '*Huruluwewa* Agriculture Colonization Scheme (HACS)' as a study setting to generate primary data for quantitative analysis. The HACS was selected due to the several reasons. According to agricultural statistics, the scheme was established in 1952, and about 6,000 families have been settled giving 3 acres – *mud-land,* mainly for paddy farming and 0.5 acres of upland. Thus, state lands have been given under the Land Development Ordinance (LDO) in 1935, which is the central legal framework - specifically of the state land (Crown Land)- for systematic development and alienation. The ordinance provides a legal setting for government officials to work on the use and distribution of state land. Thus, the area is much appropriate to study the effects of land fragmentation on farm productivity as now second and third generations of initial settlers are doing farming in the scheme being mostly in an informal setting. Herath (2006) reported that most of the dry zone farmers are dependent on subsidies and close to the poverty line, indicating that land policy enacted at the macro-level has not benefitted farmers.

3.2 Sampling and data collection in the field

This research aimed to generate empirical evidence on the impacts of farm size on farm productivity by taking into account the heterogeneity nature of informal land ownership in the HACS as a case. Data for the study was primarily drawn from an empirical survey conducted in February to March 2019 among the farm households in the scheme.

The field sites were selected considering both right-bank and left-bank of the HACS due to the differences between the people settled in the area—traditionally lived, and outside people. Four typical *Grama Niladari* (GN) divisions from both the left-bank and right-bank were selected for the farmer household survey. The survey covered 110 farm households by giving equal probabilities to all farm households to be in the sample. Sampled farmers were interviewed by administering a pre-tested survey questionnaire. The questionnaire was designed to elicit the data on socioeconomic background of the farm households, farm size, paddy production and productivity, cost of production, and marketing, etc. The secondary data for the study is drawn from available reports in the irrigation department at the scheme and published research articles on the subject. Sampled data on farm size clearly indicated that 86 farmers, which is 78% of total sample, are in the informal setting (see Figure 1).

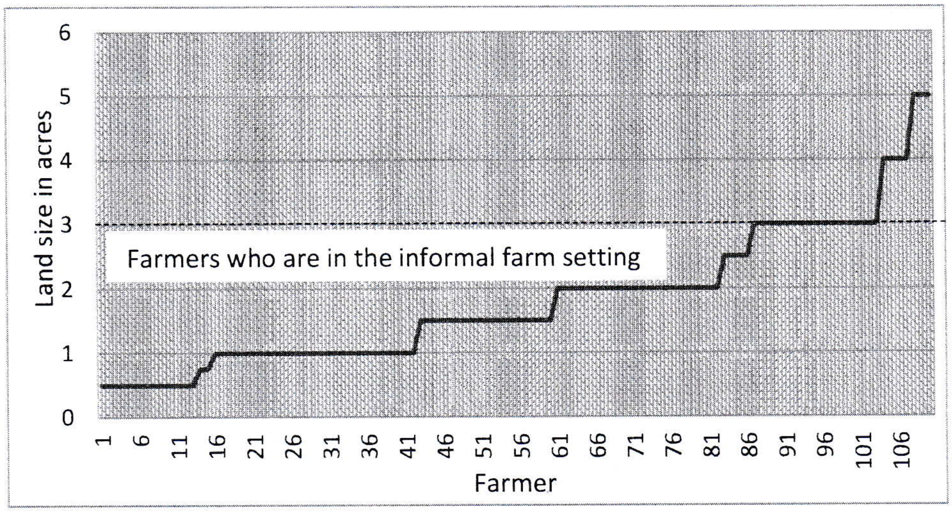

Figure 1: Distribution of land size among the sampled farmers in the scheme

3.3 Empirical Model

This study tests the hypothesis that small size of paddy farms are less productive compared to large farm size in the context of informal land fragmentation in the agriculture colonization schemes in the Anuradhapura district in Sri Lanka using the sampled data collected in the *HACS*. The root cause of the research problem of the study which motivated to carry out this study to test above mentioned hypothesis is the informal land fragmentation issue in the agriculture colonization schemes.

To study the relationship between farm size and acreage production of paddy farming, the study uses the Quintile Regression Model (QRM) as expressed Koenker & Bassett (1978) and applied by Savastano and Scandizzo (2017). The reason of using the QRM is that, the QRM provides the estimates with distribution of response variable and accommodate heteroscedasticity (Savastano and Scandizzo, 2017). This supports to distinguish the relationship among less productive farmers and more productive farmers. Thus, the basic model was specified as follow.

$$\frac{y_i}{x_i} = \beta_0 + \beta_1 x_i + \gamma Z_i + \epsilon_i - - - - - - - - -(1)$$

Where, y_i is the paddy production of i^{th} farm, x_i is the size of the i^{th} farm, Z_i is the set of other scale variables and ϵ_i is the random disturbance term. According to this equation, conditional mean value of β_1 would be zero when yield adjustment is taken place purely to conditions outside their control. It means no variations in the acreage production due to the farm size. It further means if $\beta_1 \neq 0$ there is a systematic difference in acreage production in farms that are not accounted in the rest of the equation. As explained by Savastano and Scandizzo (2017), these differences may be due to the different behavioural rules, different abilities in following the same rules or different level of information or other omitted variables that are correlated with farm size.

As proposed by Binswanger, et al., (1995), following functional form is used to drive the estimates.

$$\frac{y_i}{x_i} = \beta_0 + \beta_1 x_i + \beta_2 x_i^2 + \gamma Z_i + \alpha_i + u_i ------(2)$$

In equation (2), x_i^2 is used to test the non-linearities in the relationship between farm size and acreage paddy production. Z_i represents the set of other scale variables. The QRM make the estimations for potential deferential effects of a covariate on various quantiles in the conditional distribution. With the consideration of deferent quantiles, the QRM estimates that how the effect of a covariate varies with the distribution of response variable and accommodates heteroscedasticity (Savastano & Scnadizzo, 2007). The QRM with respect to equation (1) can be presented as follows;

$$y_i = \beta_0^q + \beta_1^q x_i + \beta_2^q x_i^2 + \gamma^q Z_i + \alpha_i + u_i ----- (3)$$

Where y_i is the acreage production of i^{th} farm, and parameters $\beta_0^q, \beta_1^q, \beta_2^q$ and γ^q are in q^{th} quantile of acreage production.

Minimization of the sum of absolute deviations from an arbitrary chosen quantiles of a farm productivity across different paddy farms gives the parameter vector $|\beta_0^q \quad \beta_1^q \quad \beta_2^q \quad \gamma^q|$. This sum of absolute deviations can be presented as follows,

$$Minimize \sum i \left| y_i^q - [\ \beta_0^q + \ \beta_1^q x_i + \ \beta_2^q x_i^2 + \ \sum_j \gamma_j^q z_{ij}\ ] \right| ----(4)$$

Where y_i^q is the acreage productivity of i^{th} paddy farm at quantile q, (i=1,2,...,n); x_i is farms size and z_{ij} is the covariate j for farm i (j = 1,2,.......,k).

The solution for above equation can be found by reviewing the equation as a linear programming problem over the entire sample (Chamberlain, 1994) and solving for values of the parameters and for each quantiles, those parameters show the direction of the effects of farm size on productivity and how large that effect is compared to the different quantiles.

4. RESULTS AND DISCUSSION

4.1 Results

In the quantile regression, the dependent variable (y_i) is acreage paddy production. The acreage production was calculated as the kilogram of paddy per acre (output/farm size in acres). The independent variables are farm size, Labor (Z1) and Capital (Z2). Capital expenditure was calculated summating all expenditures related to packaging, transportation, machinery usage, fertilizer application, and pesticide and herbicide usage. Figure 2, 3 and 4 shows the scatter plots for three independent variables – farms size, Z1 and Z2 with the dependent variable – acreage paddy production.

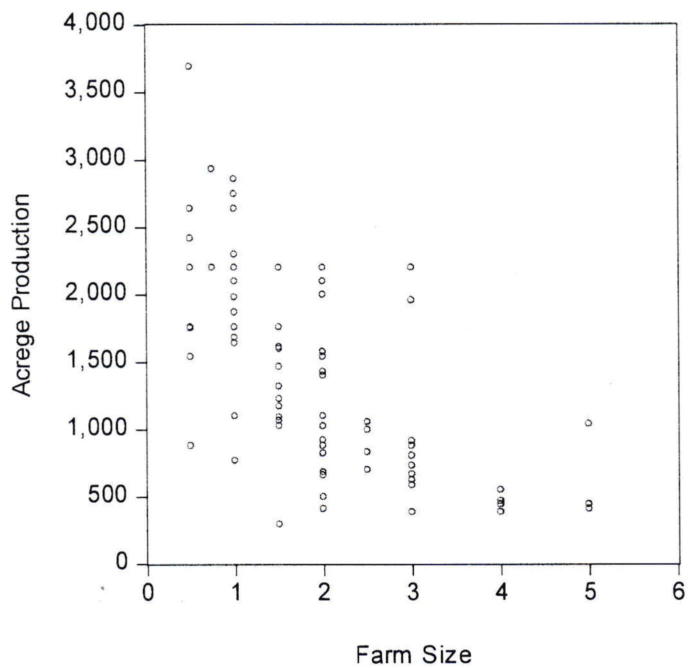

Figure 2: Relationship between farm size and acreage production

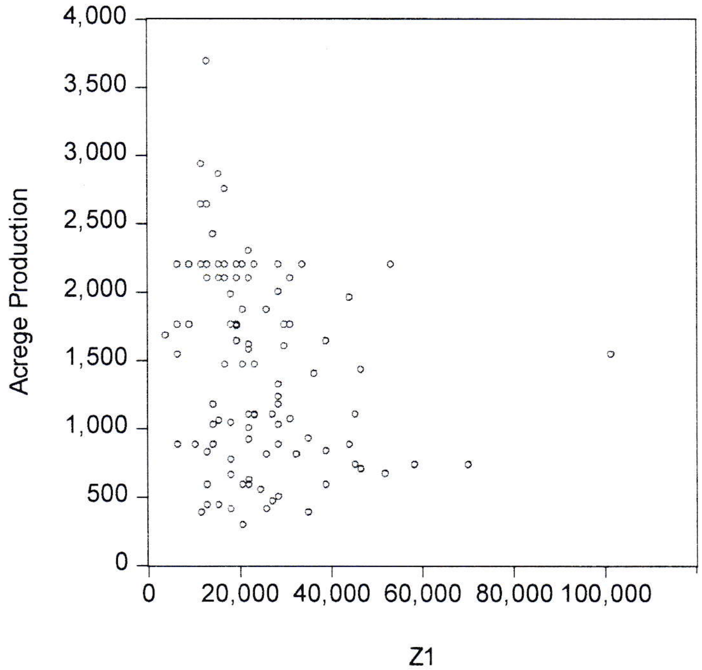

Figure 3: Relationship between labor expenditure and acreage production

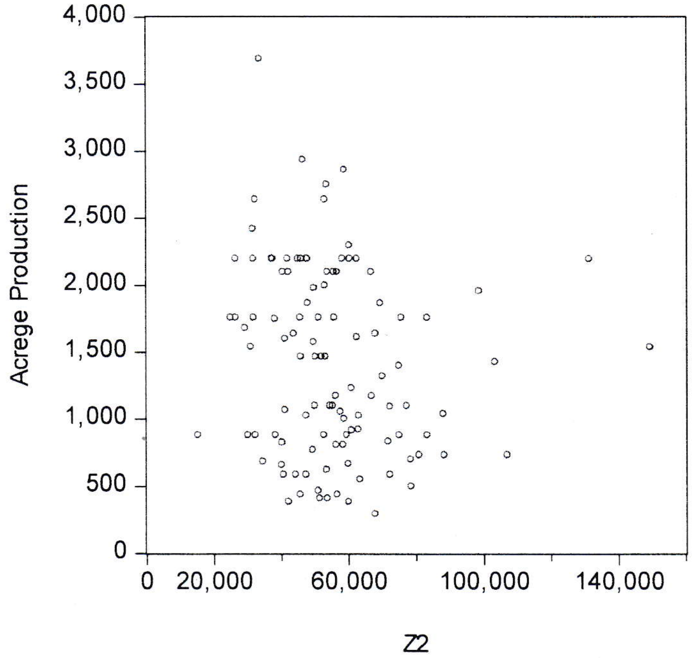

Figure 4: Relationship between capital expenditure and acreage production

As illustrated by figures, it is easy to see a higher variability in each independent variable, and as the independent variable gets bigger it is very difficult to identify a pattern in the behavior of dependent variable – acreage paddy production. The variability of those variables violate a key assumptions of linear regression estimation – the normally distributed errors with constant variance. Thus the linear regression have lower value for above relationship. Thus, the QRM is selected as a way to deal with non-constant variance.

As discussed in the methodology section, the QRM can be estimated without making any assumption about the distribution like linear regression. In the linear regression models, researches applied a log transformation to the original skewed data in order to fulfill some distributional assumptions such as normality. As there are no assumptions in quantile regression it is not necessary to apply log transformation. In this study, quantile regression has performed for 0.1, 0.2, 0.3,…,0.9 quantiles and we obtained following output (see Table 1).

According to the QRM output the estimated constant and the slope coefficients of each independent variables have changed much with the increasing quantiles. The constant is statistically significant in all the quantiles in the 0.05 significant level. Coefficients of all the independent variables are statistically insignificant in 0.1 quantile. The variables $Farm\ size$ and $Farm\ size^2$ show a significance since 0.2 quantile. The variable $Farm\ size$ show a negative values in all the quantiles. The value of the coefficient of farm size has continuously declined from 0.1 to 0.7 quantile, but show a slight improvement between 0.7 – 0.9. The variable $Farm\ size^2$ show the same pattern, but positive coefficients. Other two independent variables – Z1 and Z2 – show different trends. The variable Z1 (Labor) shows a significance in 0.8 and 0.9. The coefficient of Z1 has a negative value and that value shows a continuous decline after 0.5 quantiles. The variable Z2 shows a significance in 0.6, 0.7 and 0.9, but the coefficient is insignificant in the 0.05 significance level in 0.8 quantile. The value of the coefficient has increased continuously since 0.5 quantile.

Hence, the most interesting results are the coefficients Z1 and Z2. The magnitude of impact of Z1 on acreage paddy production has decreased as the acreage paddy production move from the 0.8 quantile to those in the 0.9 quantile. Z1 is more significant in 0.9 quantile than 0.8. The magnitude of impact of Z2 on dependent variable has increased as the acreage paddy production move from 0.6 quntile to 0.9 quantile. Same as the Z1, Z2 is more significant in 0.9 quantile than the lower quantiles.

Table 1: Quantile analysis: Dependent variable acreage paddy production

	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Constant	1083.734	2009.482	2037.567	2502.075	2544.351	2567.888	2718	2697.411	2659.4
	0.003	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Farm Size	-369.626	-881.663	-912.614	-1106.02	-1130.33	-1154.97	-1204.82	-1163.17	-817.476
	0.153	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.090*
Farm Size^2	32.51574	103.5837	105.3565	129.2652	129.2553	128.9047	136.1803	120.0795	52.61627
	0.441	*0.003*	*0.003*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.507*
Z1 (Labor)	-0.00225	-5.16E-05	-0.00415	-0.00072	-0.00505	-0.00603	-0.00861	-0.01154	-0.02369
	0.692	*0.992*	*0.466*	*0.898*	*0.344*	*0.262*	*0.098*	*0.039*	*0.004*
Z2 (Capital)	0.005631	0.004104	0.00762	0.00539	0.008368	0.011025	0.012453	0.015493	0.021179
	0.288	*0.426*	*0.125*	*0.276*	*0.062*	*0.024*	*0.031*	*0.079*	*0.000*

Note: Parentheses are *P* values

Source: Authors estimation based on field survey data

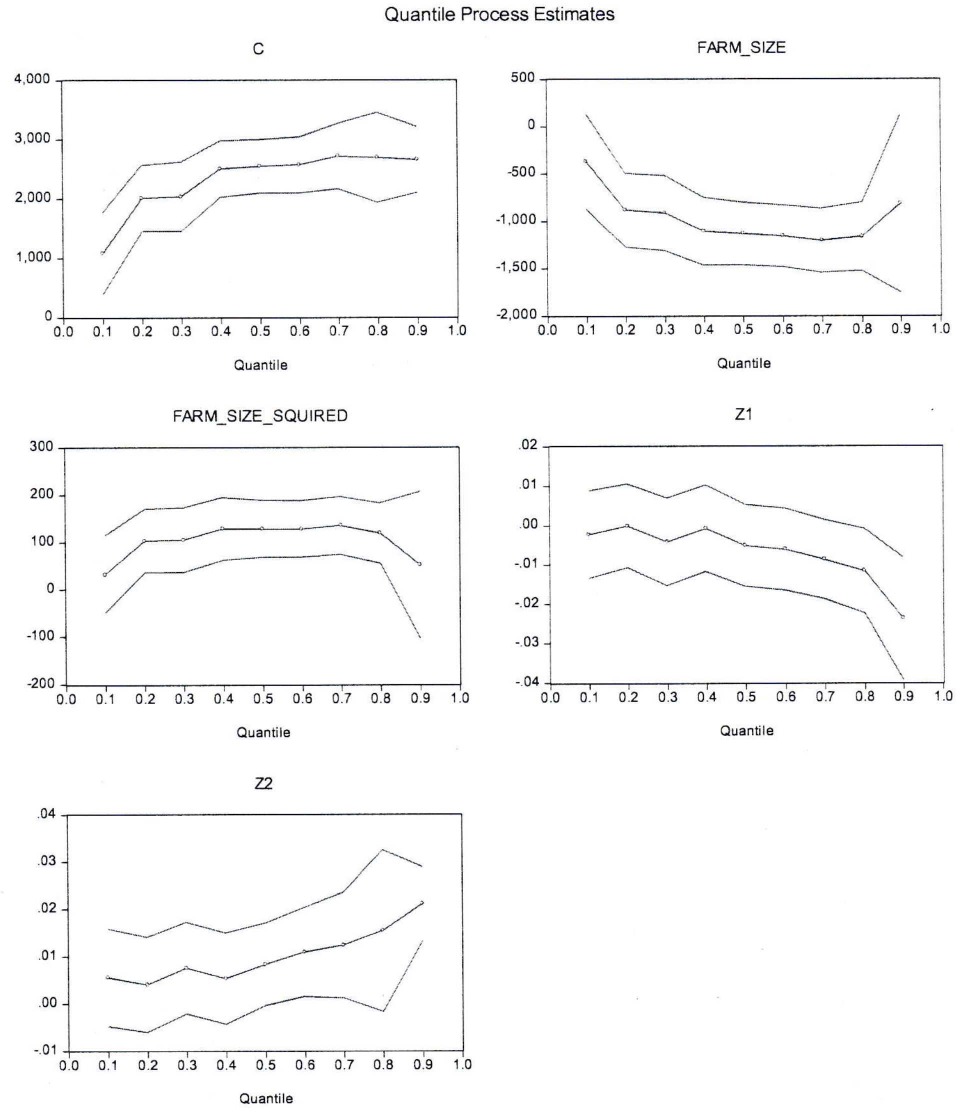

Figure 5: Quantile Process Estimates

Above graphs provide a visualization of the differences in the slope values of independent variables across the quantiles with the confidence intervals considered. Each dot in the blue lines shows the slope coefficient for the quantile indicated on the X axis. The red lines indicate the least squire estimates and its confidence intervals. The quantile coefficients fall within the confidence intervals of OLS coefficients. Then, above graphs appears the linear regression slopes are sufficient to describe the relationship between each independent variables and the acreage production. That means the quantile slopes are not statistically different from the OLS estimates.

Table 2: Slope equality test result for the determinants of acreage production

Test summery	Chi-Sq. Statistic Chi-Sq.	d.f.	Prob.
Wald Test	57.28870	32	0.0039

Table 2 presents the results of slope equality test for the determinants of acreage productions. The Chi-quire statistics value of 57.288 is statistically significant at 0.95 confidence level. With the test results it can be concluded that the coefficients differ across quantile values.

5. DISCUSSION

Results of this study rises interesting questions for discussion. First, why is there a negative coefficients of farm size in each quantile and is there a specific reasons for getting improve condition since 7^{th} quantile. The QRM outputs support us to discuss heterogeneity nature of acreage production with farm size. The nature of the land allocation for settlers in the agricultural settlement schemes in dry zone of the country is that all settlers were given fixed amount of mud- and up-land. At the early stage of the settlements, farmers in some schemes were given 10 acres of mud-land. Later, it was reduced to 5 to 3 acres of mud-land in different settlement schemes. The main argument of reducing the size of land given to each farmer in the settlement schemes was the incapability of management of large size of farm by the farmers. It has resulted largely for less land use efficiency in the settlement schemes. Thus, size of land given to each farmer was reduced to the 2 to 3 acres of new settlements.

However, the heterogeneity in the variable of land size was aroused due to the informal land fragmentation in the scheme. The main Land Act used for the agriculture settlement schemes was the Land Development Ordinance of 1935. It was enacted to facilitate the government settlement schemes alienating Crown Land to the landless people. The ordinance has established regulatory provisions with limitations preventing transfer, mortgage, sale or sub-division of holdings. The provision of minimum-sub division of holdings has resulted for informal land fragmentation in the scheme due to the pressure of second and third generations of the scheme. The results of the QRM should be interpreted by taking into consideration this informal land fragmentation. Particularly, until 7^{th} quantile, conditional mean value of farm size is getting worst and then after it improves indicating potentiality in large size farm in improving acreage production (see the graph 2 of Figure 5). The field interviews with farmers revealed that informality in land ownership has created a series of issues in farm management such as water management at the farm level, agriculture subsidy related matters, pest and disease controlling. Even they reported the farmer conflict due to informal land fragmentation. Less cost effectiveness of use of farm machineries by the farmers was also reported. Thus, possible reasons for worsening status of conditional mean value of farm size until 7th quantile may due to the informal land fragmentation as conditional mean value of farm size since 7th quantile improve the condition. Mostly, farmers in the 7th, 8th and 9th quantiles are relatively large scale farmers with better ability in farm resource management due to relatively low or no informality in land ownership. Thus, informality in the land ownership in the lower quantiles is the main reason for worsening condition of farm size and acreage production relationship as some studies (Thapa, 2007; Sundqvist & Andersson, 2006; Ahmad & Qureshi, 1999) cited ability of intensive use of farm inputs with small size.

Second, how do we interpret negative conditional mean value of variable Z1 (labor expenditure) and Z2 (capital expenditure)? It shows that until 7th quantile, the coefficient of variable Z1 is not significant and but, from 7th quantile it is significant but impact on acreage production is negative. This indicates the need of deviating from labor intensive nature of farming to capital intensive nature – more mechanization - in order to derive higher productivity in paddy farming. This explanation was further supported by quantile results on variable Z2 – capital expenditure. It shows that coefficient of variable Z2 is significant with positive and improving status since 5th quantile to upward. It indicates need of capital intensive nature of farming in order to derive higher farm productivity. Moreover, this findings can be connected with quantile results of variable farm size as many literature note the effectiveness of farm mechanization with large farm.

Figure 6 provides the base for theoretical discussion on the research subject. The history of agricultural settlement schemes revealed that size of the land given to the farmers was reduced due to the managerial inefficiencies of farming. Later, 2 to 3 acres were recognized as optimum land size. Theoretically, managerial inefficiency due to farm size expansion leads to increase the cost of production. It leads for less economic viability of rice farming. Second, efficiency of resource use is caused by the expansion farm size due to the due to the technological advantages, marketing advantages (both input and output), economies of transport, specialization in management, etc. The analysis of survey data clearly shows decreasing cost of production along with increasing farm scale (see Figure 6). The optimum farm size which gives minimum level of cost of production ranges between 3 to 4 acres in the surveyed sample. However, informal land fragmentation in the scheme has led to reverse the scale merits as it has resulted to increase the cost of production at small farm setting compared to the land size 3 to 4 acres. Figure 7 shows the relationship between total revenue (TR) and total cost (TC) ratio. TR reflects the both production (Quantity) and marketing sides (Price), thus it is the best represents of resource use efficiency in production and marketing gains of output selling. Figure 7 clearly indicates the increasing trend of TR/TC ratio up to a certain level of scale and then it begin to decrease. The optimum level of the ratio gives at the range of land scale – 2.5 to 3 acres. Figure 6 and 7 clearly indicate that reduction in farm size from the optimum level lead for higher inefficiency in resource use and lessor returns.

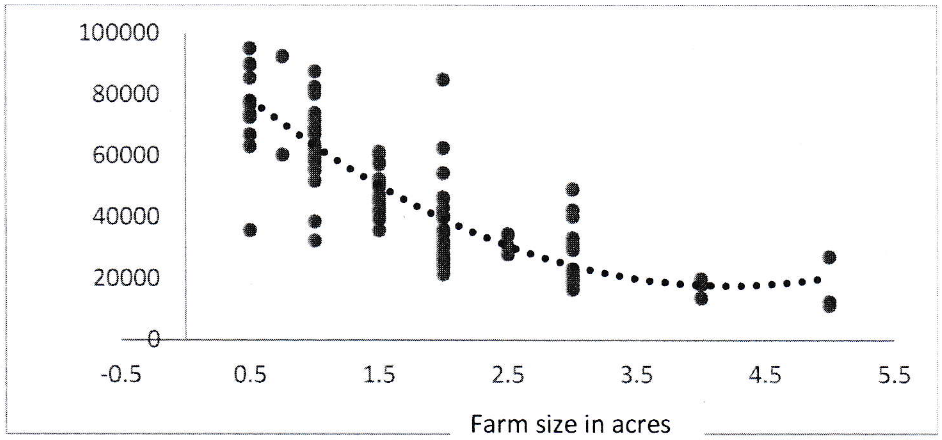

Figure 6: Empirical validation: Relationship between acreage cost of production and farm size in paddy farming

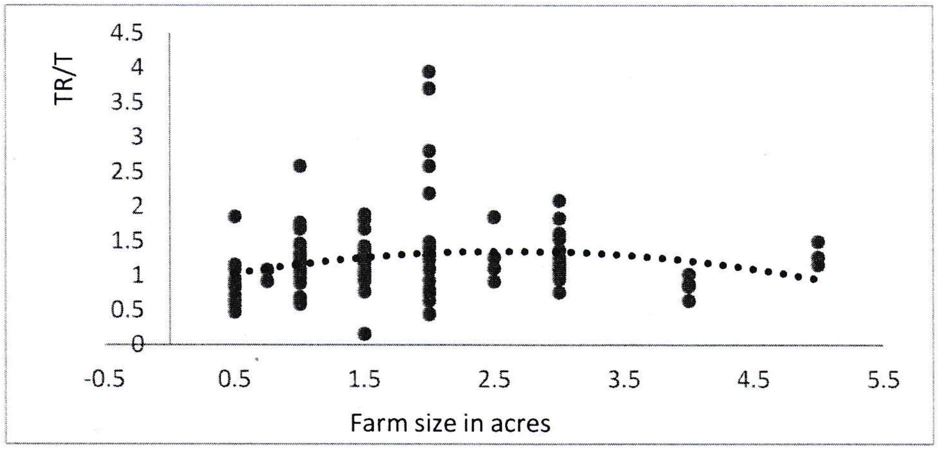

Figure 7: Empirical validation of the theory: Total revenue cost (TR/TC) ratio in paddy farming

6. Concluding Remarks

This study attempted to study nature of relationship between farm size and acreage production in rice farming in the agriculture colonization schemes in Sri Lanka testing the hypothesis that large farms contributes to higher acreage production by taking a paddy farm sample from Huruluwewa Agriculture Colonization Scheme in the Anuradhapura district. The main motive for the study was the issue of informal land fragmentation in the schemes due to the limitations for sub-division of land holdings enacted by the Land Development Ordinance of 1935 and increased population pressure. Due to the nature of the phenomenon, the study employed the quantile regression approach.

The results of quantile regression revealed negative relationship between farm size and acreage production in paddy farm in the scheme in all quantile but condition improve since 7^{th} quantile and negative conditional mean value of variables labor and capital, but significant since 7^{th} and 5^{th} quantiles respectively. The study identified less productivity of land use in the lower quantiles due to the informality in land ownership. This is contradict to some findings of other works which indicate high intensity in use of resources at small farm settings. Further, the study confirmed resource use inefficiency in informal small farm settings and decreasing trend of returns when the farm size decline from the initially recognized optimum level. Thus, the study first concludes that informal land fragmentation has negatively affected for derivation of scale of economies in the paddy farming in the agriculture colonization schemes. Second conclusion is that labor intensive nature of the paddy farm is less effective at the upper quantiles and thus, capital intensive farming – farm mechanization – is encouraged. Thus, the policies, which aimed to address the informality in the land ownership and created issues by the informal land fragmentations in the colonization schemes, should be formulated.

References

Aheeyar, M. M., Henegedara, G. M. & Rupasena, L. P., 2003. *The factors affecting the cost of production of rice in Kegalle & Kurunegala districts of Sri Lanka*, Colombo: Hector Kobbekaduwa Agrarian Research and Trainning Institute.

Ahmad, M. & Qureshi, S. K., 1999. Recent evidence on farm size and land productivity: implications for public policy. *The Pakistan Development Review*, 38(4), pp. 1135-1153.

Bandara, M., 2008. *Country Report - Sri Lanka*, http://www.unapcaem.org/Activities%20Files/A09105thTC/PPT/lk-doc.pdf.

Bhatt, M. S. & Bhat, S. A., 2014. Technical efficiency and farm size productivity- micro level evidence from Jammu and Kashmir. *International Journal of Food and Agricultural Economics,* 2(4), pp. 27-49.

Binswanger, H., Deininger, K. & Feder, G., 1995. Power distortions revolt and reform in agricultural land relations.. In: J. Behrman & T. Srinivasan, eds. *Handbook of Development Economics.* Amsterdam: Elsevier Science B.V..

CBSL, 2017. *Annual Report,* Colombo: Central Bank of Sri Lanka.

Chamberlain, G., 1994. Quantile regression, censoring, and the structure of wages. In: C. S. (ed), ed. *Advances in Econometrics, Sixth World Congress, Volume 1.* Cambridge: Cambridge Univerity Press.

Chavas, J. P., 2008. On the economies of agricultural production. *Agricultural and resource economics,* Volume 52, pp. 365-380.

Chen, Z., Wallace, E. H. & Rozelle, S., 2005. *The relationship between farm size and productivity in Chinese agriculture,* Providence, Rohde Island: American Agricultural Economics Association.

De Silva, D. A. & Yamao, M., 2009. Rice pinch to war trown nation: An overview of the rice supply chain of Sri Lanka and the consumer attitudes on government rice risk management. *The Journal of Agricultural Sciences,* 4(2), pp. 77-96.

Duffy, M., 2009. Economies of size in production agriculture. *Joural of Hunger & Environmantal Nutrition,* 4(375), pp. 375-392.

Faris, E. J., 1961. Economies of scale in crop producion. *American Journal of Agricultural Economics,* 43(5), pp. 1219-1226.

Hallam, A., 1991. Economies of Size and Scale in Agriculture: An Interpretive Review of Empirical Measurement. *Review of Agricultural Economics,* 13(1), pp. 155-172.

Herath, J., 2006. Distributional Impact of Land Policies in Sri Lanka. *Sri Lankan Agricultural Economics Association, Movement for National Land and Agricultural Reforms,* Colombo. Sri Lanka.

Koenker, R. & Bassett, G., 1978. Regression Quantiles. *Econometrica,* 46(1), pp. 33-50.

Kikuchi, M., Barker, R., Samad, M. & Weligamage, P., 2002. Comparative Advantages of Rice Production in Sri Lanka with Special Reference to Irrigation Cost. *Development in Asian Rice Economy* , pp. 343-368.

Ladvenicova, J. & Miklovicova, S., 2015. The relationship between farm size and productivity in Slovakia. *Visegrad Journal on Bioeconomy and Sustainable Development,* 4(2), pp. 46-50.

Masterson, T., 2007. *Productivity, technical efficiency, and farm size in Paraguayan agriculture,* New York: The Levy Economics Institute of Bard College.

Rafeek, M. I. & Samaratunga, P. A., 2000. Trade liberalisation and its impact on the rice sector of Sri Lanka. *Sri Lankan Journal of Agricultural Economics,* 3(1), pp. 143-154.

Samaratunga, P., 2010. Achieving economic efficiency and equitable distribution of land use through reforms and/or market discipline. *Buddhadasa Hewavitharana Felicitation*, Volume 2.

Savastano, S. & Scnadizzo, P. L., 2007. *Farms size and productivity : a "direct-inverse-direct" relationship,* Rome: World Bank Group.

Sheng, Y., Ding, J. & Huang, J., 2019. The relationship between farm size and productivity in agriculture: evidence from maize production in Northern China. *American Journal of Agricultural Economics,* 101(3), pp. 790-806.

Sundqvist, P. & Andersson, L., 2006. *A study of the impacts of land fragmentation on agricultural productivity in Northern Vietnam,* Vietnam: Uppsala Univerity.

Sial, M. H., Iqbal, S. & Sheikh, A. D., 2012. Farm size-productivity relationship: recent evidence from Central Punjab. *Pakistan Economic and Social Review,* 50(2), pp. 139-162.

Thapa, S., 2007. *The Relationship between Farm Size and Productivity: Empirical Evidence from the Nepalese Mid-Hills,* Trento: CIFREM.

Thibbotuwawa, R. M. & Weerahewa, J., 2004. *Policy options for sustainable paddy farming: Scope for land consolidation in Sri Lanka.,* Peradeniya: Proceedings of the annual research sessions, University of Peradeniya.

Thiruchelvam, S., 2005. Efficiency of rice production and issues relating to cost of production in the districts of Anuradhapura and Polonnaruwa. *Journal of National Science Foundation, Sri Lanka,* 33(4), pp. 247-256.

Weerahewa, J., 2004. *Impact of Trade Liberalization and Market Reforms on the Paddy/Rice Sector in Sri Lanka,* Washinton DC: International Food Policy Research Institute .

Weerahewa, J., Gunathilake, H. & Pitigala, H., 2003. Future of Paddy Farming in Sri Lanka: Scale, Comparative Advantage and Rural Poverty. *Sri Lanka Economic Journal,* 3(2), pp. 104-144.

Wickramaarachchi, N. & Weerahewa, J., 2018. Relationship between land size and productivity: empirical evidence from paddy farms in irrigation settlements of Sri Lanka. *Sri Lanka Journal of Economic Research,* 5(2), pp. 125-142.

Wijesinghe, P. & Wijesinghe, R., 2015. *Technical efficiency of paddy farming in low country wet zone,* Colombo: Hector Kobbekaduwa Agrarian Research and Training Institute.

World Bank, 2007. *The World Bank Annual Report,* Washington, D.C: World Bank Group.