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## Abstract

This research is conducted to study the output choice of rubber farmers with the special interest in measuring the neighbourhood effect in the choice production choice. We make inferences about the choice of production of Ribbed Smoked Sheets (RSS) for selling. In doing so, we estimate a Spatial Autoregressive Probit Model (SAPM) using recently developed Bayesian techniques in estimating the SAPM. We find that significant spatial relations exist in the production of sheet rubber and there are considerable amounts of spill over effects. The overarching issues of product choice are the availability of physical resources and the lack of proper grading system. Our findings reveals the possibility of central processing to overcome resource limitations, significant reductions in extension efforts in promoting good manufacturing practices by taking stock of the 'neighbourhood' effect present in farmer choices and the necessity of proper grading and quality management system to win producer trust.



**Keywords**: Spatial Autoregressive Probit, Bayesian Analysis, Ribbed Smoke Sheet, Neighborhood effect

## 1. Introduction

Smallholder rubber producers in Sri Lanka sell their production as Ribbed Smoked Sheets (RSS) and/or as latex. The sale of latex does not involve any form of processing. However, the production of RSS undergoes some form of processing and is produced in 5 grades (RSS1 to RSS5). The prices fetched in the market declines in the order: RSS1>RSS2>....>RSS5>Latex. Therefore, production of RSS 1 will increase farmer income. However, it is found that a considerable number of farmers sell as direct latex though they are attracting the lowest prices. Therefore, it is important to assess the reasons for smallholder farmers' unwillingness/inability to produce RSS.

This can be due to personnel views, availability of resources, and setback in production system of RSS or conflicts in marketing system for rubber.One usual complaint by the smallholders is that because sheet rubber is graded visually, even if they (smallholders) produce higher quality sheets, they are graded lower and are offered low prices by the buyers. As there is a truth in this fact, sometimes it may lead to prevent smallholder rubber producers from producing RSS.

Thus, in order to assess the reasons for lackluster production of rubber sheets, on one hand, we have to assess the factors that influence the production choice. We hypothesize that these are market related factors and "neighborhood" related factors. Market related factors can be transaction costs involved in production and sale of rubber sheets. By neighborhood we attempt to assess how the decision of a farmer to sell field latex or rubber sheet is influenced (affected) by the decision of a neighboring farmer. Such information would reduce extension efforts to promote quality rubber production considerably. On the other hand, we also have to assess the deficiency in resources to "enter" into the sale of RSS.

## 2. Objectives

***General:***

To find out major reasons for the smallholder rubber farmers' lackluster performance in producing sheet rubber

***Specific:***

- To find whether there is spatial relationship on the choice of production of RSS by smallholder rubber farmers
- To find out the reasons for not producing RSS
- To find out whether there is an insufficiency of resources, knowledge, and intellectual capacity of smallholder farmers to produce RSS
- Derive policy measures to improve production of RSS by smallholder farmers

## 3. Literature Review

This section includes a review of literature in relation to the study. We attempt to review literature in four fronts: studies that are related to rubber cultivation/production, researches that look at market access of smallholder farmers, and researches specifically related to the methodology used here, the Bayesian approach to spatial econometric modeling and Bayesian networks.

***Rubber cultivation/production***

Vongkhamor et al. (2007), explores four interlinked factors: land management, technical issues, livelihood issues and contract farming in understanding the emerging challenges and opportunities for smallholder rubber development. The study indicates that farmers who choose to plant rubber in general have more access to agricultural land (i.e. paddy field) than those who do not plant. The study also highlights that the main reasons for farmers to start planting rubber is their high expectation on income and their interest in commercial agriculture production. However, they find that the greater part of farmers cannot access information on agricultural markets and have not organized themselves into production groups to better take advantage of emerging market opportunities. Similarly, Manivong, (2007) examines the economics of smallholder rubber production in an established rubber-growing and models the likely expansion of smallholder rubber Luangnamtha province in Northern Laos. This study report that in the present market conditions, expansion of rubber is profitable and rubber can be considered as one of the potential alternatives for poor upland farmers, in line with the government policy of stabilizing shifting cultivation and supporting new livelihood options for poverty reduction. However, smallholders face many constraints in trying to maintain a profitable farming operation, including fluctuating prices, low capital for investment, disease and pests, insufficient water and poor water management systems. To overcome these issues the authors suggest providing improved credit systems, modern tapping methods, provision of soil and leaf analysis, provision of infrastructure and financial incentives, provision of information on high yield varieties, and new water resources infrastructure development. To help increase farm income directly, it is suggested to implement government programs which focus on the needs of smallholders, and encourage agents of technology transfer (Somboonsuke and Cherdchom, 2000). A Yield Performance Index (YPI) is developed by Wijesuriya*et al* (2007) exactly for this purpose. They state that these indices together with their distributional properties can be effectively used for analyses of risks associated with introducing new technologies for different groups of farmers and economic efficiency of rubber lands. Studies on efficiency of rubber cultivation are abundant. Mesike and Ubani (2008) estimate the resource-use efficiency among rubber smallholders in Edo and Delta states of Nigeria revealing the implication for the environment. Their findings reveal that farmers are concerned with short term benefits

and therefore are interested in innovations that would increase incomes even if it meant damaging the environment. Aiming to analyze economic efficiency and the comparative advantage under the existing technologies, output prices, input prices and policy transfers of the Sumatran smallholder rubber, Hadi and Budhi (1997) employs a Policy Analysis Matrix (PAM). output marketing system by provision of price information, transparent quality determination related to output farm gate price discovery, improvement of transportation facilities, etc; shift from over valuation to the true values of exchange rates and deeper and thorough research on marketing and processing systems of smallholder rubber is warranted for from the results of this study.

***Market Access***

Although, studies of market access by smallholder farmers are frequent, such studies on the rubber sector are less frequent. We review some selected studies on market access in this section.

Market access is said to be favorably influenced by institutional innovations such as collective actions and marketing cooperatives. Acting collectively, smallholders would be better positioned to reduce transaction costs for their market exchanges, obtain necessary market information, secure access to new technologies, and tap into high-value markets, allowing them to compete more effectively with large farmers and agribusinesses. Producer groups can simplify long marketing chains by connecting smallholders directly to markets, bypassing various marketing intermediaries (Markelova and Meinzen-Dick (2009). Literature suggests that transaction cost is one major impediment for market access. It plays a major role in farmer choice of market channels (de Bruyn, 2001). Transaction costs not only decrease market surplus but that they can substantially reduce the elasticity of supply and demand. Generally, transaction costs increase the price elasticity of marketed surplus (Minot, 1999). It is also found that small scale farmers generate higher levels of transaction costs than medium/larger farms (Sartorius and Kirsten, 2004).

***Spatial Econometrics***

Paelinck and Klaassen (1979) is arguably the first comprehensive attempt at outlining the field of spatial econometrics and its distinct methodology. Paelinck and Klaassen (1979) specify five principles of spatial econometric models. They are, (i) the role of spatial interdependence; (ii) the asymmetry in spatial relations; (iii) the importance of explanatory factors located in other spaces ('space distant explanatory factors');(iv) differentiation between ex post and ex ante interaction; and (v) the explicit modeling of space (topology) in spatial models. Twenty years later, Anselin (1988) defines spatial econometrics as "the collection of techniques that deal with the peculiarities caused by space in the statistical analysis of regional science models". There are three major spatial econometric models, Spatial Autoregressive Models (SAM), Spatial Error Models

(SEM) and a combination of the two. SAM models are of particular interest in this research as our interest lies in the measurement of 'Neighborhood' effect.

By neighborhood effect we mean the impact of decision of one individual by other individuals in the first's neighborhood. This has found an important place in development literature (Holloway and Lapar, 2007; Holloway, et al., 2002). With the interest in measuring neighbourhood effect in individual decisions, there is a proliferation of using spatial probit and Tobit models in the recent literature. This is largely because of the work by Lesage (2000) where a Gibbs sampling (Markov chain Monte Carlo) method for estimating spatial autoregressive limited dependent variable models is presented. Holloway et al., (2002) use this model in estimating neighbourhood effect of adoption of high yielding rice varieties. Holloway and Lapar (2007) use spatial probit model to investigate market participation in Filipino smallholder farmers.

## 4. Methods

Because of the dichotomous nature of data on production of sheet rubber (or not producing it), we use a probit model, which is the appropriate methodology in such cases. The probit model falls in the general category of 'random utility models'. This is because of the assumption of an underlying latent distribution ($z_i$) of utility differences of choices, which follow a normal linear regression model with observed characteristics contained in a covariate matrix ($x_i$) and a normally distributed error ($\varepsilon_i$){Koop, 2003 #9}. In general, the random utility model can be specified as below

$$z_i = x_i'\beta + \varepsilon_i \qquad (0)$$

In the probit model, only two outcomes are observed. Hence, when production of RSS is not observed, the latent utility difference is assumed to be less than or equal to zero while it is more than zero when RSS production is observed. Thus the actual production can be related to latent utility as below.

$$\begin{aligned} y_i &= 1 \text{ if } z_i > 0 \\ y_i &= 0 \text{ if } z_i \leq 0 \end{aligned} \qquad (2)$$

Where, $y_i$ is observed and $z_i$ is latent. This model is implemented in the Bayesian framework by specifying a prior pdf over parameters, $\pi(\theta)$, and the likelihood $f(\mathbf{y}|\boldsymbol{\theta})$ is formed and the posterior distribution $f(\boldsymbol{\theta}|\mathbf{y})$ for the parameters is studied with the standard relationship in Bayesian analysis stated below.

$$\pi(\boldsymbol{\theta} \mid \mathbf{y}) \propto f(\mathbf{y} \mid \boldsymbol{\theta})\, \pi(\boldsymbol{\theta}) \tag{3}$$

Here, the data generating density is normal $f^{N}(\mathbf{y} \mid \boldsymbol{\theta})$. The likelihood for this model is $f^{N}(\mathbf{y}|\boldsymbol{\theta})=\prod_{i=1}^{N}(\Phi(-\mathbf{x}_i'\beta))^{1-y_i}(\Phi(\mathbf{x}_i'\beta))^{y_i}$; The notation, $\boldsymbol{\Phi}(.)$, denotes the cumulative distribution function of the normal distribution. The parameters of interest in the probit model are $\theta$ ? ($\beta$), which are the regression coefficients. In estimation, the Gibbs sampling with data augmentation following Albert and Chib {, 1993 #15} is used. It is implemented by mixing the likelihood above with relevant prior and obtaining conditional distributions below.

$$\begin{aligned} \beta|z, y &\sim f^{N}(\hat{\beta}, \mathrm{cov}_{\hat{\beta}}) \\ z|\beta, y &\sim f^{tN}(\hat{z}, \mathrm{cov}_{\hat{z}}) \end{aligned} \tag{4}$$

With priors for regression parameters assumed to be normal with mean $\beta_0$, and covariance, $C_0$, definitions appearing on the right hand side of the above are respectively, $\mathrm{cov}_{\hat{\beta}} \equiv (X'X+C_0)^{-1}$; $\hat{\beta} \equiv \mathrm{cov}_{\hat{\beta}}(X'z+C_0\beta_0)$

Because prior beliefs about regression parameters are vague, a sufficiently diffuse normally distributed prior is used. Therefore, the prior mean ($\beta_0$) and the precision ($C_0^{-1}$) is set at 0 and $10^{-2}$. The Gibbs algorithm proceededby sampling sequentially from the distributions in 5-4, until convergence is achieved. Convergence assessment is by observing trace plots.

Apart from observing the covariates that drives production of sheet rubber, we are also interested in estimating whether neighbors influence this production choice. Literature terms this as neighborhood effect. Following Lesage and Pace (2009), we define neighbors by their location and relate the production choice of one farmer to his immediate neighbors. We do this by resorting to techniques developed in spatial econometrics. More succinctly, we use a Spatial Autoregressive Probit (SARP) model in estimation, following ideas of Lesage and Pace (2009). The SARP model is specified as;

$$z = \rho Wz + X\beta + \varepsilon \tag{5}$$

We have included a latent autoregressive component in the latent regression to capture the 'neighborhood effect'. The weighted sum of utility derived by neighbors (spatial lag) is entered into the model as an explanatory variable in this model. Therefore, a particular farmers' latent utility is allowed to depend on this weighted sum as below.

$$z_1=\rho(W_{12}z_2 + W_{13}z_3 +...+ W_{1N}z_N)+ X\beta + \varepsilon_1 \quad (6)$$

The spatial weight matrix, $W_{ij}$ links the observation *i* and *j*. Because spillover effects take place between neighbors in close proximity, only few of the $W_{ij}$ are non zero (Anselin, 1988). By this spatial lag, the extent of a decision variable for a farmer is allowed to depend on the extents of decision variables of other farmers in the neighborhood. The parameter ρ, which is a scalar, defines the strength of spatial dependence. If ρ is found to be zero, then the spatial dependence is unfounded. In estimating this SARP model, setting the spatial weight matrix W is crucial. We set it by using the 'location' of each farmer. The location of each farmer is captured from a GPS devise whose coordinates are read into MATLAB and the spatial weight matrix was developed by the procedure described in Lesage and Pace (2009).

## 5. Variables and Data

### *Study Area*

Out of all district under rubber cultivation, Kalutara is a major growing area with 33,598 holdings with an extent of 19,058 ha (Rubber Research Institute, 2010). Marketing channels are well developed and Rubber Research Institute is situated in the district. In Kalutara there are 14 Divisional Secretariat (DS) Divisions. They are: Panadura, Horana, Ingiriya, Bandaragama, Kalutara, Millaniya, Madurawala, Bulathsinghala, Dodangoda, Agalawaththa, Palindanuwara, Beruwala, Mathugama, and Wallalawita (Figure 1).

### *Sample Selection*

The total sample size is 500 growers and it is distributed throughout the Kalutara district. Within the district, there are 14 Divisional Secretariat (DS) divisions and they are divided in to 762 GramaNiladhari (GN) Divisions. Targeted GN divisions are selected from the DS divisions using a multistage cluster sampling technique. Number of growers who are selected into the sample from each DS division is determined based on the weighted proportion as;

$$samplesizeperDSdivision = \frac{\text{No of smallholders in DS division}}{\text{No of smallholders in district}} \times 500$$

Growers are selected purposefully from each GN division according to the concentration of the smallholders.

***Data Collection***

Primary data are used for the study. A pre-tested structured questionnaire and a Participated Rural Appraisal (PRA) are used to collect data. The questionnaire survey covered different farmers' socio-economic and demographic characteristics that included: age and gender of the household head, production details, fertilizer application, production and sales, clean production, cost of production, social capital, marketing inefficiency, transaction cost, resource endowments, perception, knowledge, contact with extension, income and employment, and credit use (Questionnaire given in Annex 01). Data were collected from May to June, 2012. Selected sample of 500 smallholding growers were interviewed during the survey with the help of Rubber Development Officers employed in the district by the Rubber Development Department. The data from questionnaires were entered in excel and cleaned to eliminate errors and then analyzed.

***Variables***

We use demographic, human/social capital, financial capital, physical capital and market related variables to define the production choice (TABLES

). We suspect that a male farmer would be in a better position to sell sheet rubber than a female. This is because in most cases, sheet rubber is not bought at farm gate but have to be transported to the buyer. Education, experience, extension service and training are expected to improve human capital, which enables farmers to comprehend complex situations and make best choices. Therefore, these variables are expected to have a positive sign on the assumption that production of RSS is profitable than selling as latex in general. We proxy the financial capital by using a variable related to the income source. If rubber cultivation is their primary source of income, we set this variable to 1 and zero, otherwise. We assume that if a farmer solely depends on rubber cultivation, his income to be low, making him unable to invest on vital fixed assets needed to produce RSS such as rollers and smokehouses. Therefore, we presume that this variable would produce a negative sign. We define physical capital by incorporating three variables: presence of a smoke house, roller and storage space. These are vital elements in producing sheet rubber, presence of which will show high probability of sheet production. However, it should be noted that, even on the absence of these, there is possibility of producing RSS, given that services from these capital items can be outsourced. We use several variables related to market, including perceptions of farmers about the market and its services. The variable time to market measures the return time taken to visit the buyer. For those farmers that sell at farm gate, this is zero. Because latex is collected mostly at farm gate and is difficult to be transported, it is expected that with the increasing time to market, the production of RSS to rise. The

'price reasonable' variable record 1 if the farmer believes that his buyer always pay reasonable prices. If he thinks that this is true most of the time, it is recorded as 2 while for farmers who believe prices they get are never reasonable, it is recorded as 3. Therefore, this variable is expected to be negative.

## 6. Results and Discussion

We iterate the Gibbs sample for 5000 times with a sample of 1500 iterations discarded as 'burn in'. This is to remove any impact of starting values given to initiate the Gibbs sample. To make inferences about the estimated parameters, the convergence of the MCMC sequence needs to be verified. We do this by observing trace plots which are shown in annex 02 (Figure A1).

The results of SARP analysis on the choice of sheet production is reported in Table 2:Posterior Means of SARP analysis. We report posterior means of coefficients and their significance level. We further report three types of marginal effects: Direct, indirect and total effects. The direct effect measures the partial derivative of $\partial y_i/\partial x_i$ while the indirect effect measure $\partial y_j/\partial x_i$. In other word, the former indicate the effect of an independent variable x of the $i^{th}$ farmer on the dependent of the $i^{th}$ farmer himself. But the latter indicate the amount of effect of change of an independent variable of the $i^{th}$ farmer on the dependent of a neighboring $i^{th}$ farmer.

Contrary to our expectation, education returned a significant negative sign. Wehypothesized that with increasing education; the probability of production of sheet rubber may rise assuming that sheet production is profitable and hence educated being able to comprehend costs and benefits would be producing sheet rubber more than latex. However, it also may be that as educated is increasingly being able to find employment elsewhere relative to uneducated may leave them with less time to attend to sheet production process and hence may sell as direct latex. In our data set, majority of farmers has a schooling level of grade 6-10 (Figure 2).

However, data does not show a clear relationship between the production type sold and education (Figure 3).

However, our results show that membership in farmer organization has a positive impact on the choice of sheet rubber. Membership of farmer societies is believed to be an important source of improvements in human capital. It is a place of interaction of farmers and therefore, they are able to learn from each other. This is the place where they get information about the profitability of various production processes and market conditions. However, the main reason for farmers who are members of farmer groups having a higher probability of producing RSS may be because that most farmer groups are specialized in collecting sheet rubber rather than direct latex. In most places, latex is directly collected by different dipped product manufacturers who is in need of field latex rather than sheet rubber. In addition, farmer groups do not have facilities to

collect latex and hold it not letting it to coagulate until a buyer arrives. Therefore, we find the few observations of farmers who produce RSS1 to be members of rubber societies. We note however, that overwhelming majority of farmers whether they are members or not are selling rubber as 'bulk' (Figure 4)

We further find that availability of physical capital related to sheet rubber production is vital in the increased probability of sheet manufacture. The availability of a smoke house, roller and storage facilities increases the production of RSS. Availability of these resources is not a necessity for production of RSS, because farmers can always outsource such activities. However, results show that when such physical capital is available, tendency to produce sheet rubber increases.

Looking at descriptive statistics, we find that there is a slight increase in moving to production of higher grades of rubber with ownership of a smokehouse (Figure 5)

Our data show that although majority of farmers do not own smoke houses or rollers, they do have storage facilities and hence the production of sheet rubber is encouraged (Table 3)

When time taken to travel to the buyer increases, the probability of producing RSS rise. This indicates that if the transaction cost of selling is high, sheet production increases. From the farmer's point of view, this is prudent because, he/she can reduce unit transaction costs by collecting and selling at once. This is possible only in the case of production of RSS and not in production of latex. Thus, higher the selling transaction costs, the higher the probability of producing sheet rubber.

The variable, production is incorporated to capture the size effect. It shows a negative and significant sign. This may indicate that larger farmers have a lesser probability of producing RSS.

We show in our results in Table 2 and Figure 2 that the spatial correlation coefficient is positive and significant. A neighboring farmers' production choice (production of RSS) have a positive impact on the owner farmers' production choice. Thus, a neighborhood effect exists. Understanding such neighborhood effects is important in attempting to precipitate farmers into production of sheet rubber. Clear understanding of this fact is essential because this can vastly reduce the effort in extension services to promote production of sheet rubber.

***Spatial spillovers***

One advantage of using Spatial Autoregressive models is its ability to predict spatial spillover effects. Spatial spillovers are effects are impacts of independent variables of one farmer on the dependent of a neighboring farmer. In Table 4

[redacted] we report two types of marginal effects. Direct effects show the marginal effect of a change of a unit of independent variable of farmer *i* on the change of the dependent variable of the farmer i, $(\partial y_i^*/\partial x_i)$,while indirect effects show the change of independent variable of farmer *i*, on the change of the dependent variable of the farmer $j,(\partial y_i^*/\partial x_j)$. Therefore, the latter (indirect effects) measure the spatial spillover effect.

We find positive and significant spillover effects with respect to ownership of rollers, storage facilities; correct grading by buyers and production. A farmer who has a roller will have a 6.4% chance (probability) over its counterpart in producing sheet rubber (direct effect). At the same time it will have a 4.4% cumulative increase in probability of neighboring farmers (indirect effects) and a total effect of 10.7% on the probability of sheet production. Therefore, we note that providing rollers to farmers would increase the chances of producing sheet rubber by 10.7%. However, contrary to expectation, the direct, indirect and total effect of education level of farmers on the probability of adoption is -3%, -2.2% and -5.2% respectively. This indicates that education has a negative externality on sheet production. Although, not significant, training in rubber processing, extension visits, and membership in rubber societies show positive externalities.

## 7. Conclusion

This research attempts to investigate reasons for small farmers' inability to produce sheet rubber. It analyses the choice of production of sheet rubber. In doing so, spatial relationships are explicitly modeled in a spatial econometric framework. Specifically, a Spatial Autoregressive Probit Model (SAPM) is estimated. Findings show a strong spatial relationship in production of sheet rubber. Thus, a neighborhood effect is evident. This has important implications in design of extension services. Understanding the nature of this relationship can greatly reduce extension effort and thus its expenditure. Present data set reveals that neighborhood effect spans for three neighbors. Thus, to have the full effect of extension service, visits to all farmers is unnecessary. Also, it is spatial spillover effect is evident with respect to ownership of fixed assets (rollers) needed to produce sheet rubber. This has important implications because it hints the ability for group processing. For example, it shows the usefulness of establishing a central processing facility for smallholders to be run either by the government or a farmer group. This is yet to be practiced in Sri Lanka. Overarching finding on how to make smallholder farmers to increase sheet production is the necessity to improve physical capital. It is evident that these not only have a marked impact on farmer choice of production of RSS but also have an indirect spillover effect on production choice of neighboring farmers.

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# TABLES

**Table 1: Descriptions and expected signs of variables in the model**

| Variable | Description | Expected sign |
|---|---|---|
| Human Capital | | |
| Gender | Household head is a male = 1 | Positive |
| Education | Education in years of schooling | Positive |
| Experience | Years in rubber farming by the household | Positive |
| Member | Household head is a member of rubber society=1 | Positive |
| Training | Household head attended training on sheet manufacture = 1 | Positive |
| Extension | Extension visits to household in last month | Positive |
| Financial Capital | | |
| rubber only | Rubber is only income source = 1 | negative |
| Physical Capital | | |
| smoke house | Owns a smokehouse =1 | Positive |
| Roller | Owns a roller = 1 | Positive |
| Storage | Have storage facility = 1 | Positive |
| Market Related | | |
| time to buyer | Time to closest buyer in minutes | Positive |
| grade correctly | Perception about grading by the buyer: Never =1, Most of the time = 2, Always = 3 | Positive |
| price reasonable | Perception about prices paid by the buyer: Never =1, Most of the time = 2, Always = 3 | Positive |
| Production | Production in last month | Ambiguous |

**Table 2:Posterior Means of SARP analysis**

| Variable | Coefficient | Std Deviation | p-level |
|---|---|---|---|
| Constant | 0.000 | 0.001 | 0.444 |
| Gender | 0.131 | 0.447 | 0.401 |
| **Education** | **-0.456** | **0.221** | **0.011** |
| Experience | -0.012 | 0.014 | 0.201 |
| **Member** | **0.666** | **0.428** | **0.035** |
| Training | 0.288 | 0.404 | 0.245 |
| Extension | 0.057 | 0.394 | 0.457 |
| rubber only | -0.024 | 0.528 | 0.475 |
| **smoke house** | **0.552** | **0.451** | **0.095** |
| **Roller** | **0.935** | **0.504** | **0.020** |
| **Storage** | **0.956** | **0.438** | **0.014** |
| **time to buyer** | **0.013** | **0.007** | **0.015** |
| grade correctly | 0.865 | 0.862 | 0.147 |
| price reasonable | 0.263 | 0.273 | 0.175 |
| **Production** | **-0.004** | **0.002** | **0.002** |
| **Rho** | **0.447** | **0.111** | **0.000** |

**Significant variables at 5% are in bold**

**Table 3: Ownership of physical capital**

| | Smokehouse | | Roller | | Storage | |
|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | Yes | No |
| Number | 174 | 318 | 154 | 338 | 446 | 46 |
| Percentage | 35.4 | 64.6 | 31.3 | 68.7 | 90.7 | 9.4 |

**Table 4: Marginal effects of the SARP model**

| Variable | Direct effect | | | Indirect Effect | | | Total effect | | |
|---|---|---|---|---|---|---|---|---|---|
| | lower 05 | Coeffic ient | upper 95 | lower 05 | Coeffic ient | upper 95 | lower 05 | Coeffic ient | upper 95 |
| Constant | 0.000 | **0.000** | 0.000 | 0.000 | **0.000** | 0.000 | 0.000 | **0.000** | 0.000 |
| Gender | -0.054 | 0.007 | 0.067 | -0.032 | 0.008 | 0.065 | -0.085 | 0.015 | 0.128 |
| Education | -0.062 | **-0.030** | -0.004 | -0.062 | **-0.022** | -0.002 | -0.117 | **-0.052** | -0.007 |
| Experience | -0.003 | -0.001 | 0.001 | -0.003 | -0.001 | 0.001 | -0.005 | -0.001 | 0.002 |
| Member | -0.003 | 0.044 | 0.109 | -0.002 | 0.032 | 0.106 | -0.005 | 0.076 | 0.207 |
| Training | -0.031 | 0.019 | 0.081 | -0.021 | 0.014 | 0.069 | -0.052 | 0.033 | 0.147 |
| Extension | -0.047 | 0.004 | 0.065 | -0.033 | 0.004 | 0.055 | -0.079 | 0.008 | 0.118 |
| rubber only | -0.074 | -0.001 | 0.076 | -0.061 | -0.002 | 0.051 | -0.129 | -0.003 | 0.124 |
| smoke house | -0.016 | 0.037 | 0.111 | -0.012 | 0.025 | 0.082 | -0.028 | 0.063 | 0.186 |
| Roller | 0.002 | **0.063** | 0.149 | 0.001 | **0.044** | 0.123 | 0.004 | **0.107** | 0.257 |
| Storage | 0.008 | **0.064** | 0.129 | 0.005 | **0.045** | 0.108 | 0.013 | **0.108** | 0.226 |
| time to buyer | 0.000 | **0.001** | 0.002 | 0.000 | **0.001** | 0.001 | 0.000 | **0.001** | 0.003 |
| grade correctly | -0.047 | 0.058 | 0.195 | -0.037 | 0.038 | 0.134 | -0.085 | 0.095 | 0.318 |
| price reasonable | -0.020 | 0.017 | 0.055 | -0.011 | 0.013 | 0.048 | -0.031 | 0.030 | 0.101 |
| Production | -0.001 | 0.000 | 0.000 | 0.000 | **0.000** | 0.000 | -0.001 | 0.000 | 0.000 |

# FIGURES

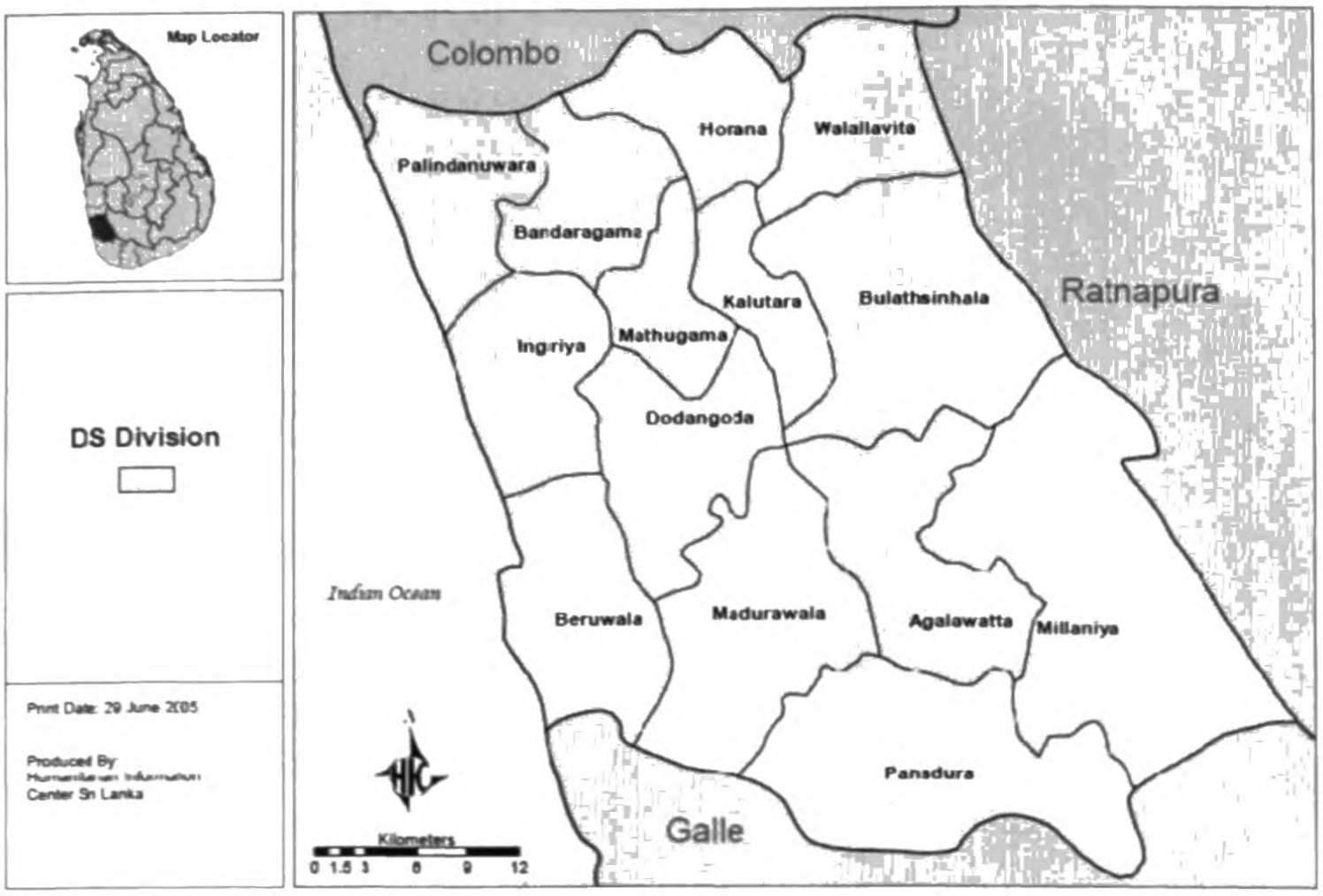


**Figure 1: Administrative map of Kalutara District**

Source: Humanitarian Information Center, (2005)

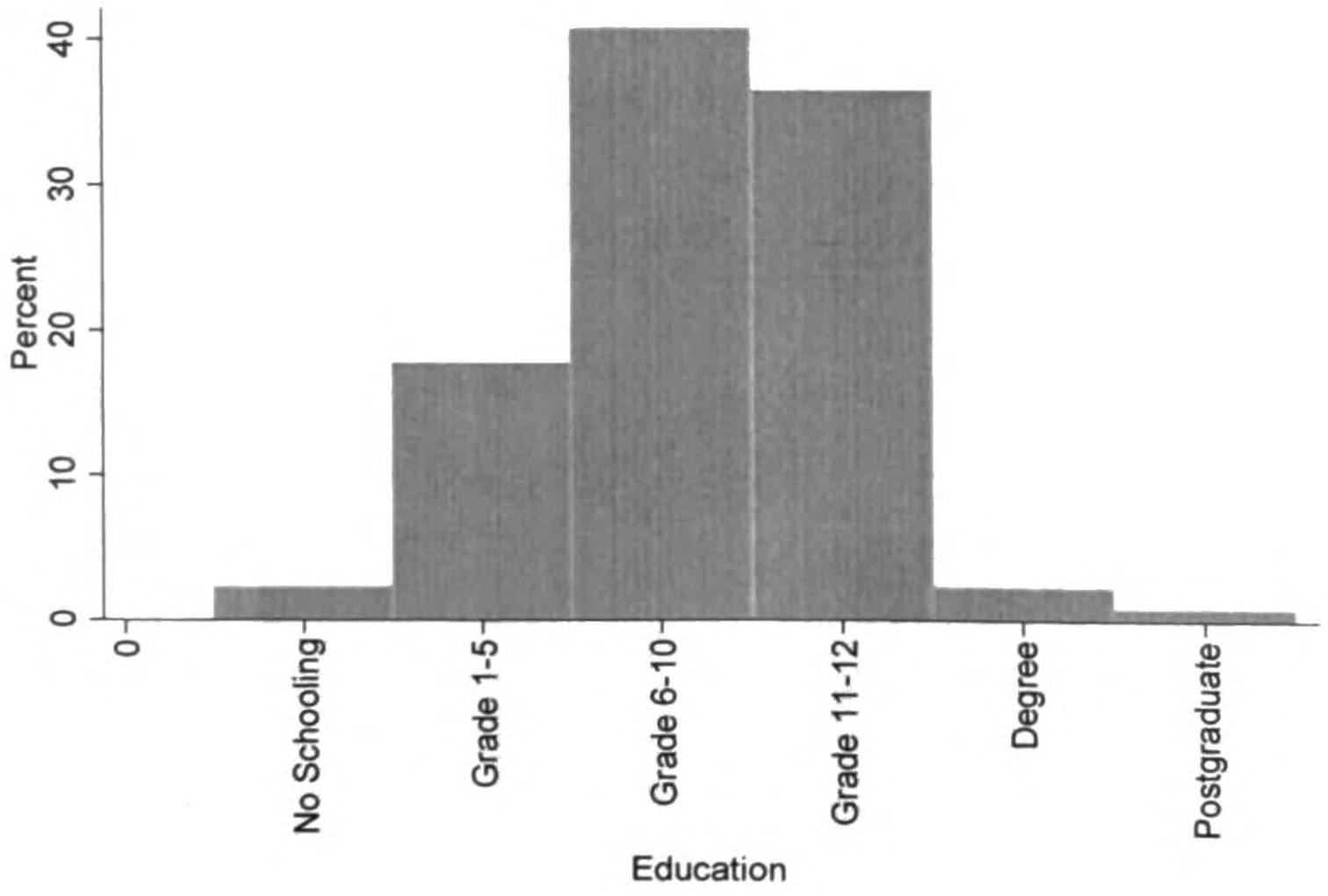


**Figure 2: Level of education of rubber farmers in the data**

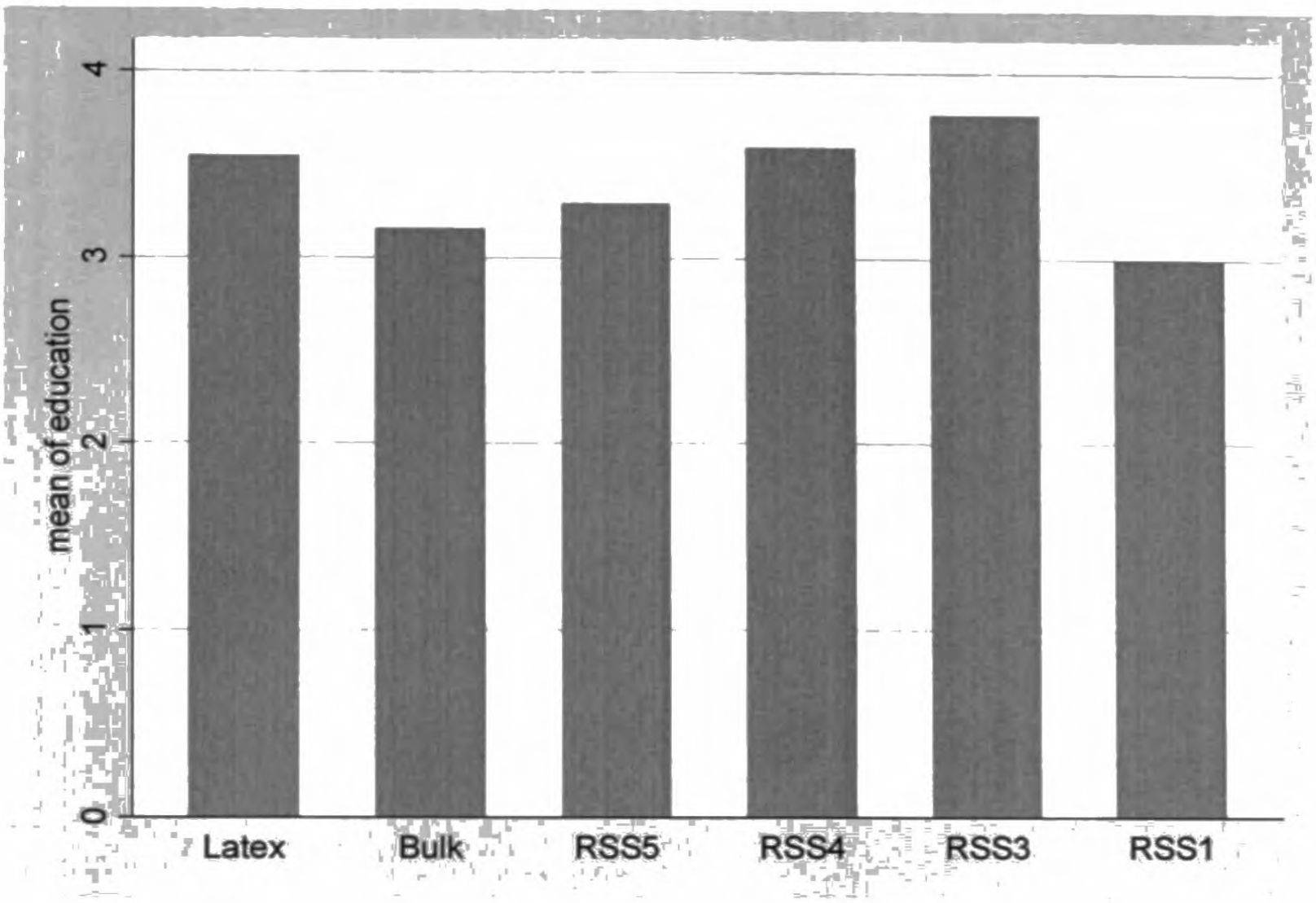


**Figure 3: Level of education of rubber farmers in the data**

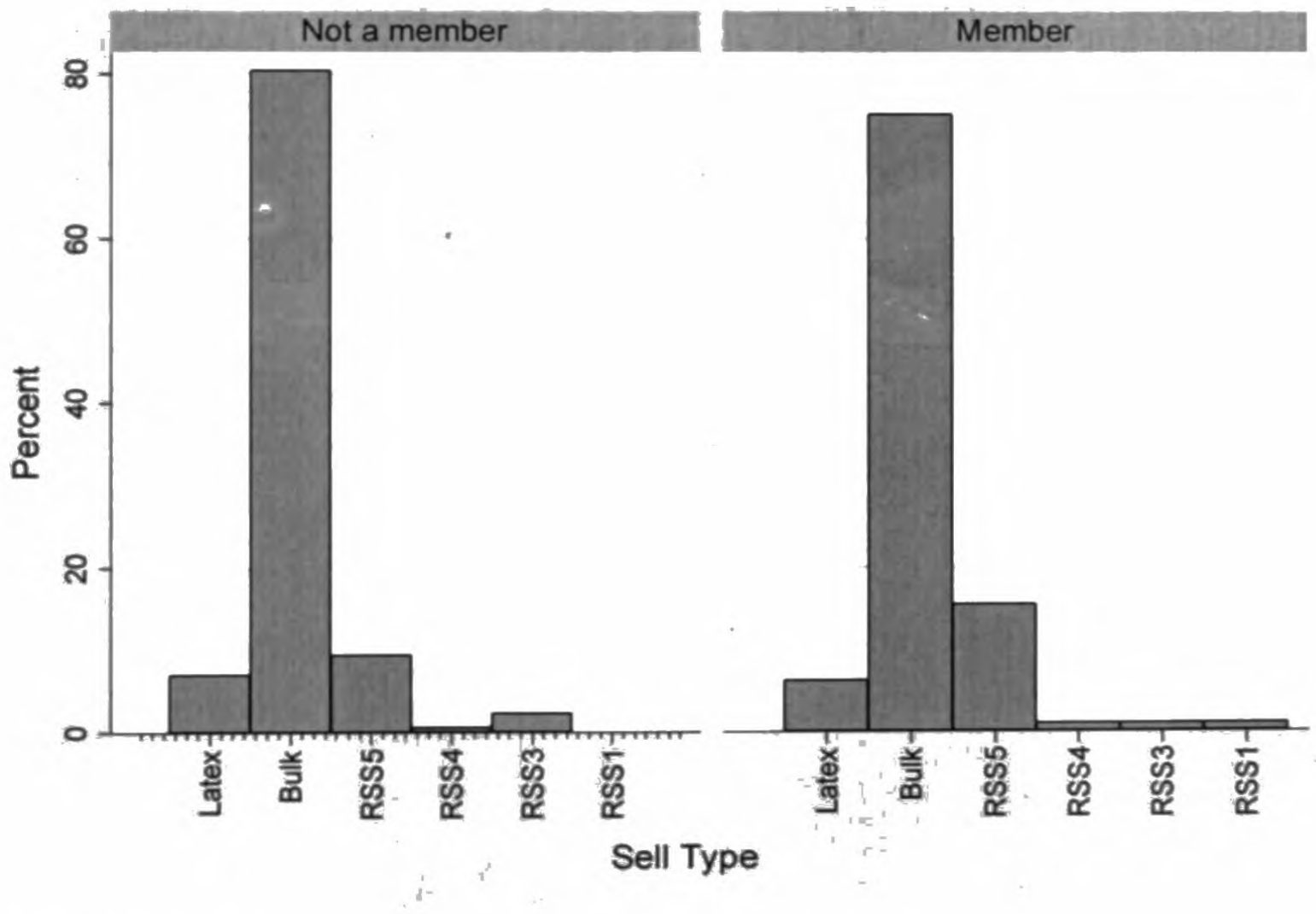


**Figure 4: Selling type by membership of farmer group**

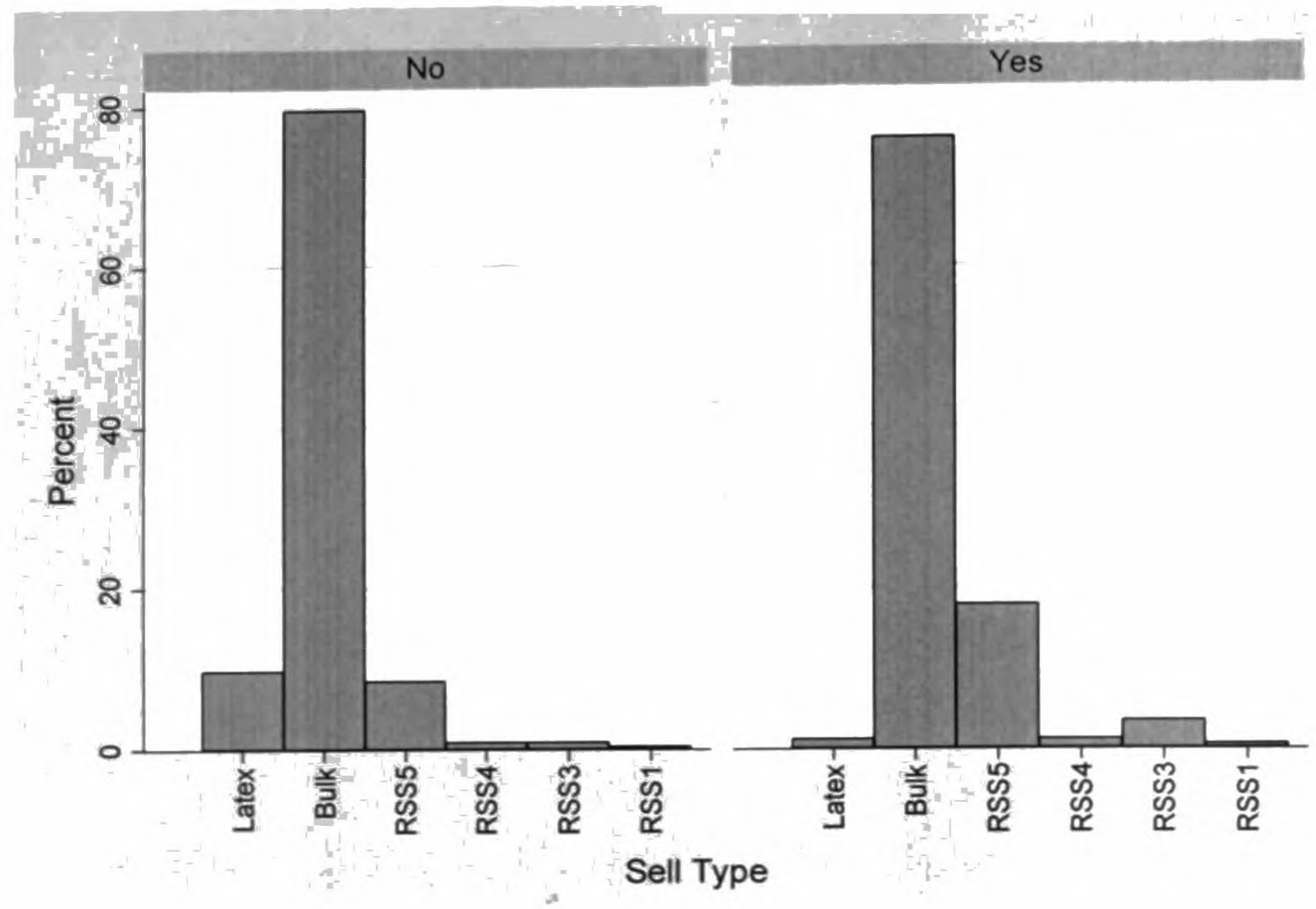


**Figure 5: Smokehouse ownership and selling type**

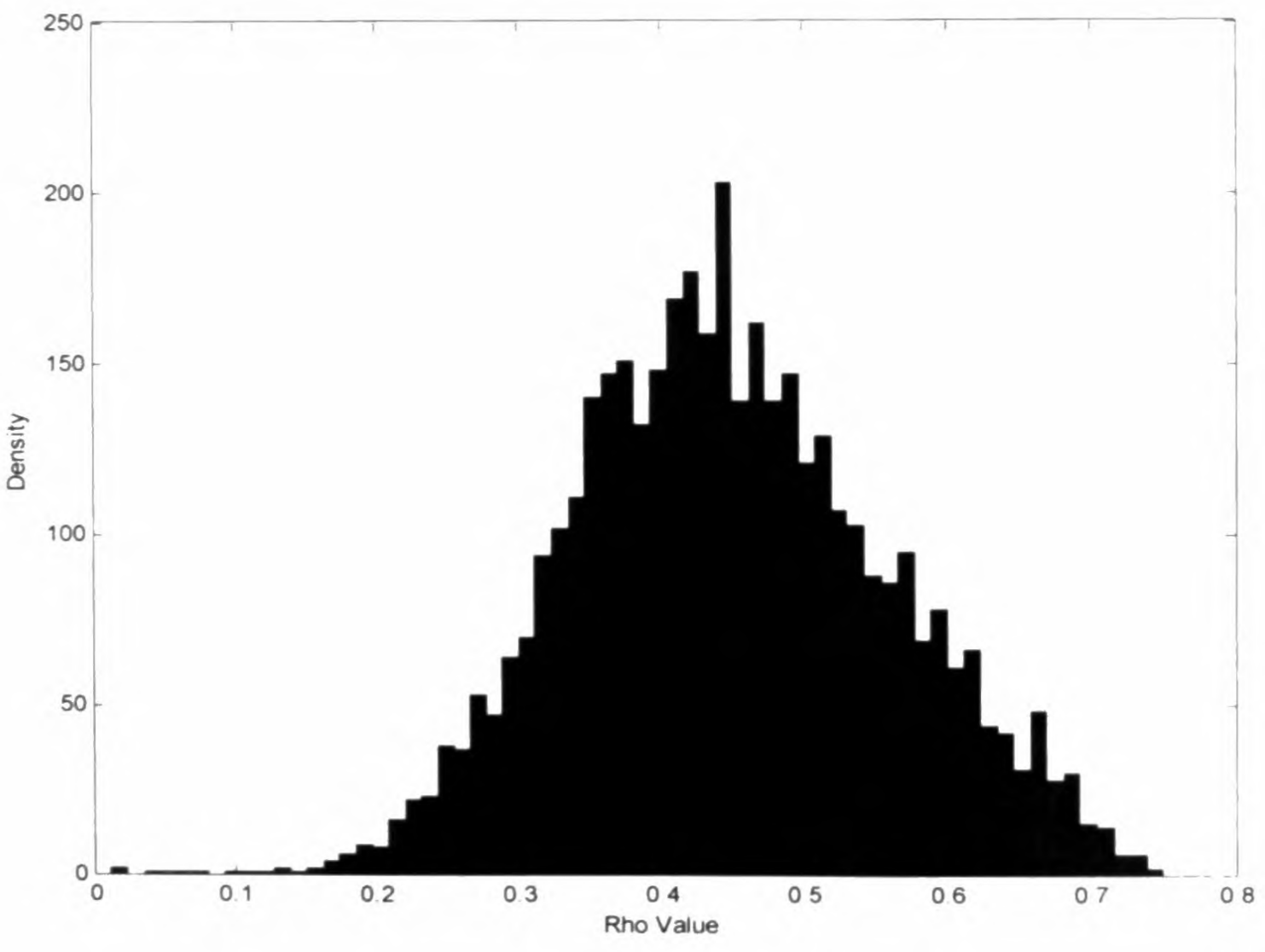


**Figure 6: Distribution of estimated spatial correlation coefficient (Rho)**

**Annex 01**

Questionnaire Survey
Enhancing Production of Higher Grades Rubber Sheets
1.Location Details:

District ..... GN division .....
GPS :
North..... East..... Location code.....

2.Personal Details:

Age of the house hold head: ..... Gender: .....

Education level:

No schooling [ ] 1 – 5 [ ] 6 – 10 [ ] 11 – 12 [ ] Degree [ ] Postgraduate [ ]

Experience in Rubber cultivation(Years): ..... Total family size: .....

No of family members involved in Rubber Cultivation: .....

3.Production Details:

3.1 Inputs:
Extent cultivated: Mature: ..... Immature: ..... Rubber clone cultivated in Mature: ..... Immature: .....

3.2 Labour usage:
How many people work in the rubber land each day? (For tapping, Fertilizer application, weeding etc.)

Family members: ..... Hired: .....

3.3 Please state following details of the people work in your land

| | Usual activity performed | Type (hired/family) | Gender | Age | Education | Skill level |
|---|---|---|---|---|---|---|
| Person 1 | | | | | | |
| Person 2 | | | | | | |
| Person 3 | | | | | | |

.....

Codes:

*Usual activity performed:*

1.Tapping 2.Fertilizer application 3.Weeding 4.Rolling
5.Smoking(smokehouse) 6. Fuel wood preparation 7. Other (specify)

*Education:* 1.No schooling 2.(1 – 5) 3.(6 – 10) 4.(11 – 12) 5.Degree 6.Postgraduate

*Skill level:*

1.Very good 2.Good 3.Bad 4.Very bad

4. Fertilizer Application:

Did you apply Fertilizer last year? YES [ ] NO [ ]
Mature ..... Immature .....

Amount applied (in kg or if otherwise state units): Mature land ..... Immature land : .....

Did you obtain subsidy for fertilizer? YES [ ] NO [ ]
Mature [ ] Immature [ ]

Do you have a cover crop in lands? YES [ ] NO [ ]
Mature land [ ] Immature land [ ]

Do you have any of the following soil conservation practices :

| | Mature | immature |
|---|---|---|
| Terracing | ..... | ..... |
| Bunds | ..... | ..... |
| Cover-crops | ..... | |

5. Production and Sales:

5.1 What is your daily production in a normal tapping day (Kg/day)? .....

5.2 Do you produce sheet rubber? YES [ ] NO [ ]

If no;

Why?

No price incentive to produce sheet [ ]
Latex buyers buy it from the land itself and therefore no travelling [ ]
Rubber processing is cumbersome [ ]

Do not have rollers [ ] Do not have a smoke house [ ] Fuel wood is expensive [ ] Other (specify)..... [ ]

5.3 What is the number of tapping days in a typical month?.....

5.4 Please indicate your sales details for the last week in the table below

| | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | Q | P | Q | P | Q | P | Q | P | Q | P | Q | P | Q |
| | Rs | kg | Rs | kg | Rs | kg | Rs | kg | Rs | Kg | Rs | kg | Rs | kg |
| Latex | | | | | | | | | | | | | | |
| RSS 1 | | | | | | | | | | | | | | |
| RSS 2 | | | | | | | | | | | | | | |
| RSS 3 | | | | | | | | | | | | | | |
| RSS 4 | | | | | | | | | | | | | | |
| RSS 5 | | | | | | | | | | | | | | |
| Scrap | | | | | | | | | | | | | | |

P = price, Q = quantity

5.5 What is the most common type that you sell (Latex, RSS1, RSS2...RSS5)? .....

5.6 Why do you tend to sell this type? (Select all that is relevant)

It is economical this type [ ] Whatever I produce, buyer grades it as [ ] types [ ] I do not know to produce other (Specify) [ ] Other

5.7 What is the current RSS 1 price given by your buyer? Rs/kg .....

6. Clean Production:

6.1 I clean the equipment used to collect latex Everyday[ ] Every other day [ ] Once a week [ ]

6.2 If Latex is pre-coagulated do you use Sodium Sulphite Liquid? YES[ ] NO[ ]

6.3 Do you strain latex using a strainer (Sal Ada)? YES [ ] NO[ ]

6.4 Do you cover the latex coagulation trays while coagulation? YES[ ] NO[ ]

6.5 Do you wash the rollers using fresh water before moulding? YES[ ] NO[ ]

7. Costs of Production:
What do you think your average cost of production (COP) is ? ..... Rs/Kg

7.2 How much did you spend on fertilizer last year (Rs)?
Mature land: ..... Immature land .....

What is your average daily expenditure on labour ( tapping, cleaning etc. excluding family labour)?
Mature extent ..... Immature extant .....

Please state the average daily expenditure (in a normal tapping day) in each of the following cost components. ( If you cannot give it on daily basis, indicate it for last week / month )

Smoke house charges (Rs) ..... Chemicals (Rs) .....

Fuel wood (Rs)..... Other (specify).....

8. Social capital:
Are you a member of a rubber society? YES [ ] NO [ ]
Are you a member of any other society? YES [ ] NO [ ]

9. Marketing Inefficiency:

9.1 From where do you normally get to know the prices of rubber?
From the trader (buyer) [ ]
From the media (papers, TV, radio, etc) [ ]
From neighbors [ ] From
the market [ ]
Other (specify) [ ]

9.2 Your buyer grades your rubber sheets correctly.....?

Always [ ] Most of the times [ ] Never [ ]

9.3 The prices paid by your buyer is reasonable?

Always [ ] Most of the times [ ] Never [ ]

9.4 You sell to this buyer because, (you can tick more than one)

Price paid is reasonable [ ]
Grades rubber correctly [ ]
He provides loans [ ]
He is the closest buyer [ ]
I do not know any other buyer [ ]
other (specify) [ ]

9.5 Rate the following factors that you consider in selecting a buyer

| | Strongly affect | Affect | Neutral | Not affect |
|---|---|---|---|---|
| Price | [ ] | [ ] | [ ] | [ ] |
| Distance to marketing channel | [ ] | [ ] | [ ] | [ ] |
| Transport facilities | [ ] | [ ] | [ ] | [ ] |
| Relationship with seller | [ ] | [ ] | [ ] | [- ] |
| Neighbors' action | [ ] | [ ] | [ ] | [ ] |
| Decisions of the farmer organization | [ ] | [ ] | [ ] | [ ] |
| Other (specify) | [ ] | [ ] | [ ] | [ ] |

9.6 How often does your buyer pay you?

Daily [ ] Weekly [ ] Monthly [ ] Other (Specify) [ ]

9.7 What do you think about the following in considering rubber marketing?

| | Strongly agree | Agree | Disagree |
|---|---|---|---|
| Price variation is a problems | [ ] | [ ] | [ ] |
| Purchases in bulk discourage me to produce RSS1 | [ ] | [ ] | [ ] |
| Price difference is low between RSS1 and other RSS grades | [ ] | [ ] | [ ] |

10. Transaction costs:

Return time taken to take rubber to the buyer .....
Return time taken to visit rubber land .....
Return time taken to travel to closest bank .....
How do you rate the condition of roads in your village?
very good [ ] good [ ] bad [ ] very bad [ ]

11. Resource Endowments:

11.1 Do you own a smoke house? YES[ ] NO[ ]

11.2 If yes,
When did you build it (year) .....
Capacity of the smoke house .....
Source of fuel used:
From forest [ ] Buy [ ] My own land [ ] Other specify)..... [ ]
Problems of operating a smoke house:
Not enough production [ ] Difficulty in finding fuel wood [ ]
Other (state)..... [ ]
The condition of your smoke house is:
Poor [ ] Adequate [ ] Good [ ] Best [ ]

11.3 If no;
Why didn't you build a smoke house ?
I do not have enough money [ ]
I do not know how to do it [ ]
It is cheaper to use external smoke house [ ]
I do not have enough production to operate a smoke house [ ]
Other (Specify) [ ]
What is the cost of smoking if you smoke outside? Rs/sheet .....

11.4 Do you own a Roller ? YES[ ] NO[ ]
11.5 Do you own a mobile phone? YES[ ] NO[ ]
11.6 Do you own a land line? YES[ ] NO[ ]
11.7 Do you have storage facilities to store rubber? YES[ ] NO[ ]
11.8 Do you own a: Bicycle [ ] Motorbike [ ] Three wheeler [ ] Car [ ] Van [ ]

12. Perception
12.1 What is your view on rubber prices in the next 12 months?
It will decrease [ ]
Remain as same as today [ ]
It will increase [ ]

12.2 Do you think that rubber cultivation is profitable? YES[ ] NO[ ]
12.3 You can get the highest profit if you can produce.....
RSS 1/RSS 2/RSS 3/RSS 4/RSS 5/Latex/Scrap
12.4 What is the most important constraint/problem faced by you in producing/selling rubber (Select all in the order of importance)
Labour shortage [ ]
High cost of inputs [ ]

Transporting rubber to the buyer [ ]
Insufficient knowledge on rubber production [ ]
Marketing problems [ ]

12.5 Please indicate your agreement/disagreement with following statements:

| | Agree | Disagree |
|---|---|---|
| System used to grade sheet rubber in this country is poor | [ ] | [ ] |
| Producing RSS1 is uneconomical | [ ] | [ ] |

13. Knowledge:

13.1 What is the correct weight of rubber sheet ? .....
13.2 Have you ever attended a training on rubber sheet manufacture? YES[ ]NO[ ]
13.3 Have you ever attended a training on any rubber cultivation practice?YES[ ]NO[ ]
13.4 How many times a rubber sheet should be sent through the water exhausting roller (Diya rola)? Once [ ]Twise[ ] Three times [ ] More than three [ ]
13.5 The thickness of a rubber sheet should be
Around 3.2 mm [ ]
Around 4.2 mm [ ]
Around 1.2 mm [ ]
13.6 What is the best way to dry rubber sheets?
Sun drying [ ] Air drying [ ]

14. Contact with extension:
14.1 How many times did you meet the rubber extension officer in,
Past week .....
Past month.....
Past year.....

14.2 What is the most common reason you meet the rubber extension officer in your area?
To get information about:
1. Land preparation up to planting [ ]
2. Intercropping & Mixed cropping [ ]
3. Use of fertilizer [ ]
4. Tapping methods [ ]
5. Common diseases [ ]
6. Use of rain guards [ ]
7. Marketing advice [ ]

8. Helping getting credit [ ]
9. Processing [ ]
10. Other (specify)..... [ ]

14.3 How do you rate your extension officer?
He do not know anything about rubber cultivation [ ]
He has a fair understanding about rubber cultivation [ ]
He has a good knowledge in rubber cultivation [ ]
He has a very good knowledge in rubber cultivation [ ]

14.4 Have you ever discussed about rubber sheet manufacture with your extension officer?
YES [ ] NO [ ]

15. Income and Employment:

15.1 What is your average monthly income from rubber cultivation?
(Rs/Month).....

15.2 Is rubber cultivation your only income earning activity? YES[ ] NO[ ]
If YES,
What are your other income earning activities
Self employment [ ]
Farming other crops [ ]
Livestock rearing [ ]
Salaried employment (private / Government) [ ]

15.3 What is your average monthly household expenditure?.....

16. Credit Use:

16.1 Did any member of your household borrow money for agricultural activities?
YES[ ] NO[ ]
If yes, reason for borrowing (code)
1. To buy inputs [ ]
2. Buy heavy equipment [ ]
3. Buy other equipment [ ]
4. To build a building for Rubber production [ ]
5. Buy agric. Land [ ]
6. Other (specify)..... [ ]
Amount borrowed (Rs):.....
Repayment (Rs /month):.....

## Annex 02

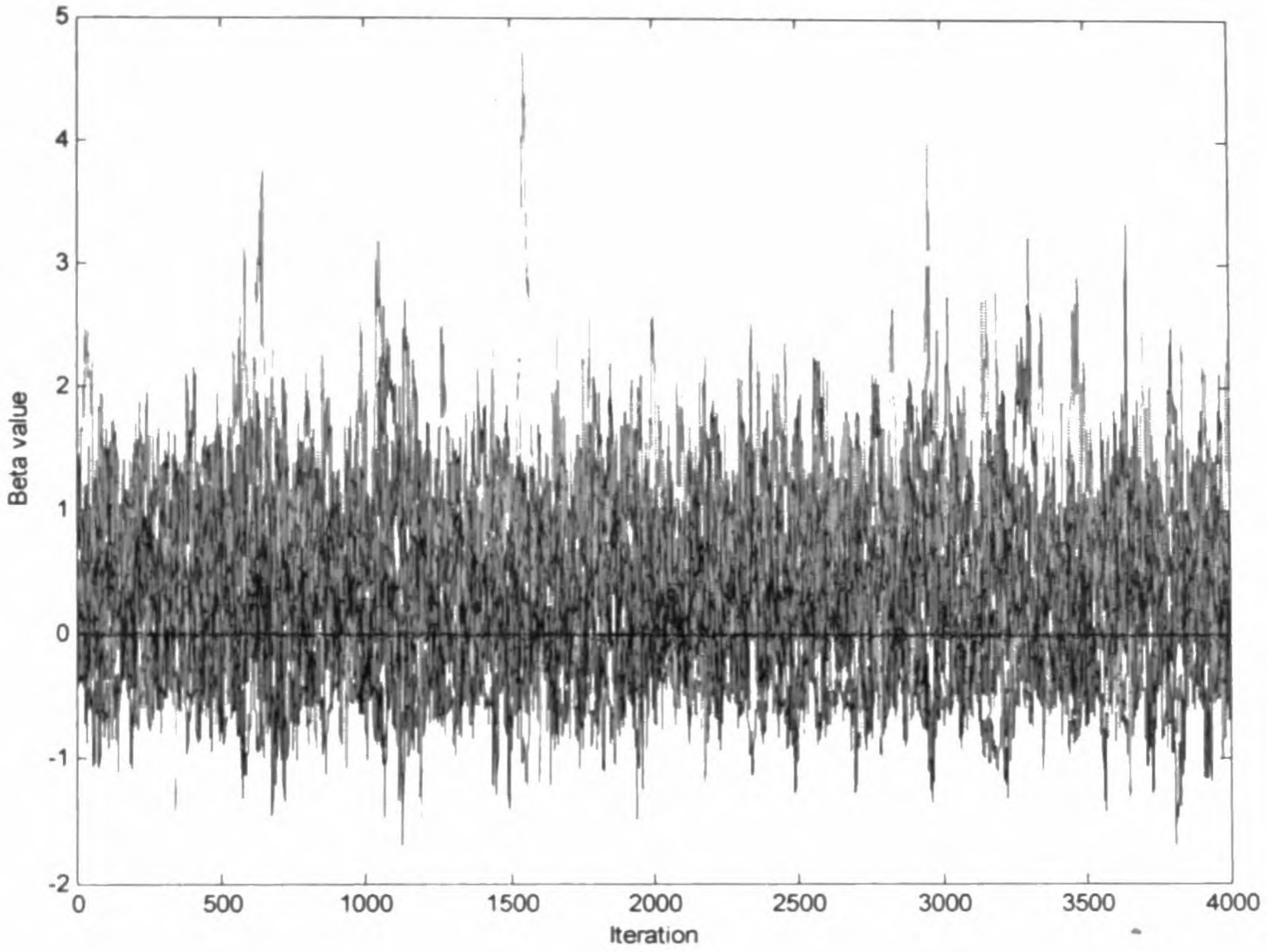


**Figure A 1: Trace plot for all betas in SARP model**

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