JOURNAL OF AGRICULTURAL RESEARCH, DEVELOPMENT, EXTENSION AND TECHNOLOGY
Volume 5, Issue 1 | 2023 | Open-access
The official agricultural research journal of the University of Southern Mindanao

Full Text Article

Estimation of supply and demand of rubber in Cotabato Province, Philippines

Jennet R. Mag-aso* and Francisco Gil N. Garcia

Department of Agricultural Economics, College of Business, Development Economics and Management, University of Southern Mindanao, Kabacan, Philippines

Citation: Mag-aso, J.R. & Garcia, F.G.N. (2023). Estimation of supply and demand of rubber in Cotabato Province, Philippines. *Journal of Agricultural Research, Development, Extension and Technology*, *5*(1), 64-75. https://doi.org/10.5281/zenodo.10984220

Received: November 17, 2021
Revised: August 9, 2023
Accepted: October 3, 2023

Keywords: cup lumps, demand estimation, supply and demand of rubber, supply estimation, rubber industry, rubber production

*Corresponding Author: *Jennet R. Mag-aso* – jrmagaso@usm.edu.ph

Abstract

The demand for rubber by-products has the potential to significantly impact rubber supply. However, rubber production in the province of Cotabato has not returned to its peak production reached prior to the El Niño phenomenon of 2016. It is essential to study the factors affecting rubber supply and demand as they form the basis for strengthening the rubber industry. This study aimed to describe the distribution flow of rubber by-products from the major sources to processors, assess cup lump demand by processors and its supply from farmers, and investigate factors impacting rubber supply and demand in Cotabato province. Results revealed that the rubber supply chain in the province encompasses various steps, including rubber farming, product trading, and rubber byproduct processing, which eventually leads to the production of rubber sheets and cup lumps. These products are both distributed locally and exported, depending on market demand and processing capabilities. Trade relationships within the supply chain rely on mutual trust and verbal agreements. Despite the potentially stable supply of cup lumps resulting from the presence of processors and traders, the market price remains unstable, due to dynamics of supply and demand, particularly the shortage of cup lumps. To ensure price stability, consistent supply is essential. As a recommendation, the government should formulate policies and programs to encourage farmers to engage in rubber production and help them improve rubber productivity to increase supply and meet the demand for cup lumps.

Introduction

In Southeast Asia, natural rubber (*Hevea brasiliensis*) is recognized as an important high-value export-oriented agro-industrial crop (Chawananon, 2014). While rubber trees are native to the tropical zones of mainland Southeast Asia, including the Malaysian Peninsula and the southern parts of Thailand, Vietnam, and Myanmar, hybrids have been successfully grown in areas with cooler climates such as China, Laos, and northern Thailand, Vietnam, Cambodia, and Myanmar (Fox & Castella, 2013). In recent years, rubber farming has grown dramatically in response to the rising demand for natural rubber and the growing economies of countries like China and India (Ziegler et al., 2009; Sturgeon, 2010). Rubber plantations worldwide stand at 12.9 million hectares which produce an average output of 14.0 million MT (Food and Agricultural Organization of the United Nations [FAO], 2023). Mainland Southeast Asia and China are the dominant production regions (Warren-Thomas et al., 2015), with Thailand as the top producer of natural rubber, accounting for approximately one-third of the volume of global natural rubber in 2021 (FAO, 2023). Extensive plantations in these areas have been advocated to alleviate poverty, especially in rural areas

(Agence France-Presse, 2009; Dwyer, 2007). There continues to be a bright prospect for rubber, with estimated global demand for natural rubber reaching 29.6 million MT (Statista Research Department, 2023), particularly with the Asian and European markets (Fertilizer and Pesticide Authority, n.d.).

In 2021, the Philippines had an estimated 239,140 hectares planted with rubber, producing approximately 431,000 MT, which accounts for only 3% of global supply (FAO, 2023). Rubber production is mainly in Mindanao, particularly in Zamboanga and the SOCCSKSARGEN region, where the agro-climatic condition is favorable for growth (Department of Agriculture Philippine Rural Development Project [PRDP], 2014). In the Philippines, the major demand comes from the manufacturing of tennis balls (Dunlop Slazenger Philippines, Inc.) and tires (Manhattan Rubber and Plastic Manufacturing Corporation, Mitsubishi Belting Philippine Corporation, and Yokohama Tire Philippines) (Bureau of Plant Industry, 2016). Despite the government's initiative to strengthen the rubber industry, the Philippine rubber industry still faces some challenges that make it difficult to expand and compete globally. Lack of support for advanced technology for rubber among farmers and fluctuating rubber prices due to a fluctuating supply were two of the most prominent difficulties confronting the Philippine rubber sector (Department of Science and Technology-Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development [DOST-PCAARRD], n.d.; Department of Science and Technology-Philippine Council for Industry, Energy, and Emerging Technology [DOST-PCIEERD], 2020).

Cotabato province, belonging to the SOCCSKSARGEN region, is one of the leading producers of raw and semi-processed rubber and industrial trees in the Philippines, contributing 143,422 MT, or approximately 33%, of the total production of the country in 2021 (Philippine Statistics Authority, 2023). Further, the rubber industry can provide much-needed livelihood in the province, which has the highest number of food-insecure families (30.3 thousand) in 2018. The province also has the highest number of low-income families in the region, at 90.09 thousand, in the same year (Philippine Statistics Authority, 2022).

There was an increasing trend in rubber cup lumps production in Cotabato province from 1990 to 2019, with the years 2010 through 2015 generating the highest volume of cup lumps. However, Figure 1 shows that rubber output declined during the El Niño phenomenon in 2016, with rubber production comparatively lower than the previous years.

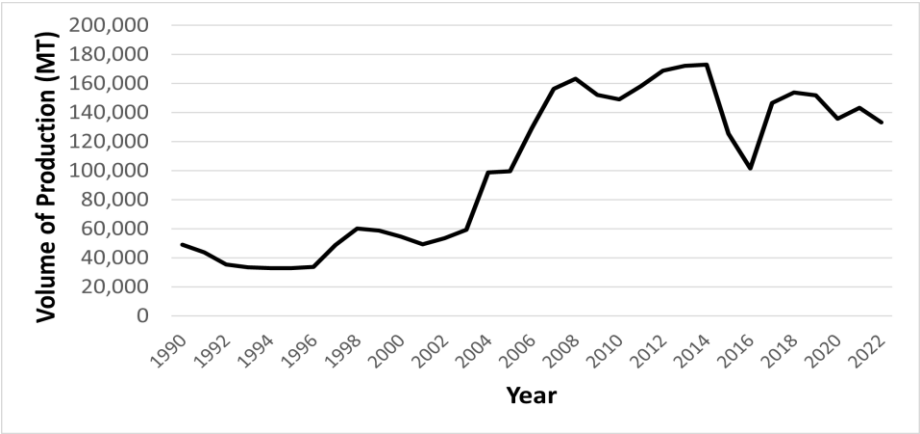

Figure 1. Volume of rubber cup lump production in Cotabato Province, 1990-2019. Source: Philippine Statistics Authority (2020, 2023)

Since the province of Cotabato is one of the country's primary sources of natural rubber, a decline in rubber cup lumps production in the province impacts the supply for

the product in the area and throughout the country. To date, there is no research on the simultaneous estimation of supply and demand for rubber in province. Thus, this study aimed to estimate the supply and demand of rubber in Cotabato Province. Specifically, it aimed to (a) identify the major sources of rubber seedlings, (b) determine the distribution flow of the cup lumps from the major sources to the processors, (c) determine the demand of cup lumps by the processors and its supply from the rubber farmers, and (d) determine the factors affecting supply and demand of rubber in the province.

Materials and Methods

Site Description

Cotabato Province is located in Mindanao, Philippines (7.1083°N, 125.0388°E) with a total land area of 900,890 hectares (National Statistical Coordination Board, 2012). It is bounded to the north and northeast by Maguindanao, to the west by Sultan Kudarat, and to the east by the Davao Region. The geography of the province is varied, with mountains, plateaus, valleys, and rivers. It is also home to the Ligawasan Marsh, one of the Philippines' largest marshland areas. Cotabato Province is primarily an agricultural province, with extensive agricultural lands dedicated to rice, corn, coconut, sugarcane, and other crops. The province is also known for its livestock and poultry farming. The province is one of the country's leading producers of raw and semi-processed rubber with markets in the locality and other countries such as Malaysia, China, and Korea, among others (Philippine Rubber Technical Working Group, 2017). The study was conducted in the major production and consumption areas of rubber in the province, particularly in the municipalities of Carmen, Matalam, Kidapawan, Makilala, Arakan, Alamada, and Tulunan.

Respondents

The initial respondents of this study were rubber growers or farmers. From the total population of 26,000 rubber growers in Cotabato as of 2016 during the time of the study, the margin of error was set to 7%, the maximum deviation desired between the sample estimate and the true value. The confidence level was set to 90%, which corresponds to a z-value of 1.645. The sample size was calculated using the following formula:

$$\boldsymbol{n = \frac{z^2 \times p(1-p)}{e^2}}$$

where:

z is the *z*-score
e is the margin of error
n is the population size
p is the population proportion

Therefore,

$$\boldsymbol{n = \frac{1.645^2 \times 0.5(1-0.5)}{0.07^2} = 139} \text{ respondents}$$

A total of 150 rubber farmers were randomly selected for interviews, which were performed with permission obtained from the respective municipal mayors and barangay captains. These interviews aimed to identify significant sources of rubber in the province, involving questions about where the farmers obtained their rubber seedlings for planting and where they sold their cup lumps. The initial interviews with the farmers provided insights into 5 rubber crumb processors, 25 trader-consolidators, and 3 village trader-consolidators, who were subsequently interviewed to gather data on the volume they handled and their

demand for cup lumps. Consequently, the study's respondents comprised key figures in Cotabato Province's rubber industry, including rubber farmers, crumb-rubber processors, and trader-consolidators. Interviews with these respondents enabled the researchers to determine the demand for cup lumps among processors, the factors affecting the demand and supply of rubber cup lumps, and the distribution of flow of the rubber byproducts from the major sources to processors in Cotabato Province, Philippines, 2016.

Data Analysis

The initial respondents of this study were rubber growers or farmers. From the total population of 26,000 rubber growers in Cotabato as of 2016 during the time of the study, the margin of error was set to 7%, the maximum deviation desired between the sample estimate and the true value. The confidence level was set to 90%, which corresponds to a z-value of 1.645. The sample size was calculated using the following formula:

The model for the estimation of the supply of cup lumps in the province is shown in Equation 1.

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \mathcal{E}, \qquad \text{Equation 1}$$

where:

Y_i = volume of production, in kilogram
β_0 = intercept or constant term
$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ = slope or coefficient
X_1 = cost of land preparation, PhP
X_2 = cost of planting, PhP
X_3= cost of harvesting, PhP
X_4= farm size, ha
X_5= planting distance
$\mathcal{E}$ = error term/residual

Moreover, the model for the demand for cup lumps in the province is shown in Equation 2.

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \mathcal{E}, \qquad \text{Equation 2}$$

where:

Y_i =volume of cup lump handled, in kilogram
β_0= intercept or constant term
β_1, β_2= slope or coefficient
X_1= years in operation
X_2= number of workers
$\mathcal{E}$= error term/residual

Results and Discussion

Major Sources of Rubber Seedlings in the Province

Based on the survey, majority of the rubber seedlings were from Makilala, Cotabato. The municipality of Makilala had the highest number of rubber nurseries in the province. This area is also where the big local processors are located. Other sources of rubber seedlings were found in the City of Kidapawan and the municipalities of Kabacan, Pigcawayan, and Aleosan. Table 1 shows the location of rubber seedlings mentioned by the respondents of this study.

Table 1. Major sources of rubber seedlings in Cotabato Province, Philippines, 2016.

Source	Address/Location
Rubber Nursery A	Kidapawan City
Rubber Nursery B	San Vicente, Makilala
Rubber Nursery C	Malasila, Makilala
Rubber Nursery D	Poblacion, Makilala
Rubber Nursery E	Malasila, Makilala
Rubber Nursery F	Poblacion, Makilala
Rubber Nursery G	Katidtuan, Kabacan
Rubber Nursery H	Poblacion, Makilala
Rubber Nursery I	Kidapawan, City
Rubber Nursery J	Pigcawayan
Rubber Nursery K	Aleosan

Distribution Flow of Rubber Cup Lumps and By-products in Cotabato Province, Philippines, 2016.

Figure 2 shows the distribution flow of cup lumps and rubber by-products from the major sources of rubber seedlings to the processors. The product flow begins with the inputs of production: rubber farming, trading of products, and processing of rubber byproducts. Rubber farmers obtain seedlings, fertilizer, and pesticides from nursery operators and agricultural supplies in the area. In the fifth to seventh years after planting, rubber trees reach their productive stage and latex can be harvested (Rodrigo et al., 2005), until up to 30 years after planting (Darmawan et al., 2014). During this time, individual farmer-producers bring their products, such as rubber sheets and cup lumps, directly to traders/processors, and some are picked up by area consolidators. After cup lumps are processed, local processors sell their finished product in Standard Philippine Rubber (SPR) form to the different manufacturers in the country.

Some processors directly export cup lumps because they can be exported without processing, even though this reduces economic efficiency due to high water content. Some processors/traders are also inclined to export raw rubber cup lumps due to the high cost of processing, the region's unstable power supply, and the stringent quality standards of direct buyers (typically tire companies). Traders/consolidators process their cup lumps and sell these to the big processors (local and international) in the form of rubber sheets. If demand is high, processors may sell cup lumps; otherwise, some processors sell SPR to Thailand and Malaysia.

Traders or agents are the main sources of raw materials, and they transport the accumulated cup lumps to the processors within the locality. As in the case of Thailand (Werathamrongsak & Wongsurawat, 2013), processing facilities are located close to latex production to secure access to raw materials and reduce transportation costs. Current market rates and the estimated dry rubber content determine the price. Furthermore, relationships between industry players are established through spot transactions and the "suki" system. The entire trade is formalized through contracts and memorandums of understanding between and among the actors in the chain. Commonly in the Philippines, agri-marketing relationships, mutual trust, and verbal agreement rather than formal documentation form the basis of the flow of goods and services and can make or break the reputation of growers/tappers and traders (Department of Agriculture PRDP, 2014).

On the other hand, along with the distribution flow of rubber by-products, several problems have been encountered by the players in the rubber industry. For instance, processors encountered difficulties in marketing and consuming cup lumps. Among these issues are the low price of cup lumps and low quality of cup lumps (i.e. dirty appearance and some have stone inside). These issues affect large processors because they incur significant losses and waste because of adulteration in the quality of cup lumps. Further, some village-type processors lacked technical know-how and capability to implement sustainable production practices, product standardization, and value addition of rubber cup lumps into rubber sheets or crumbs.

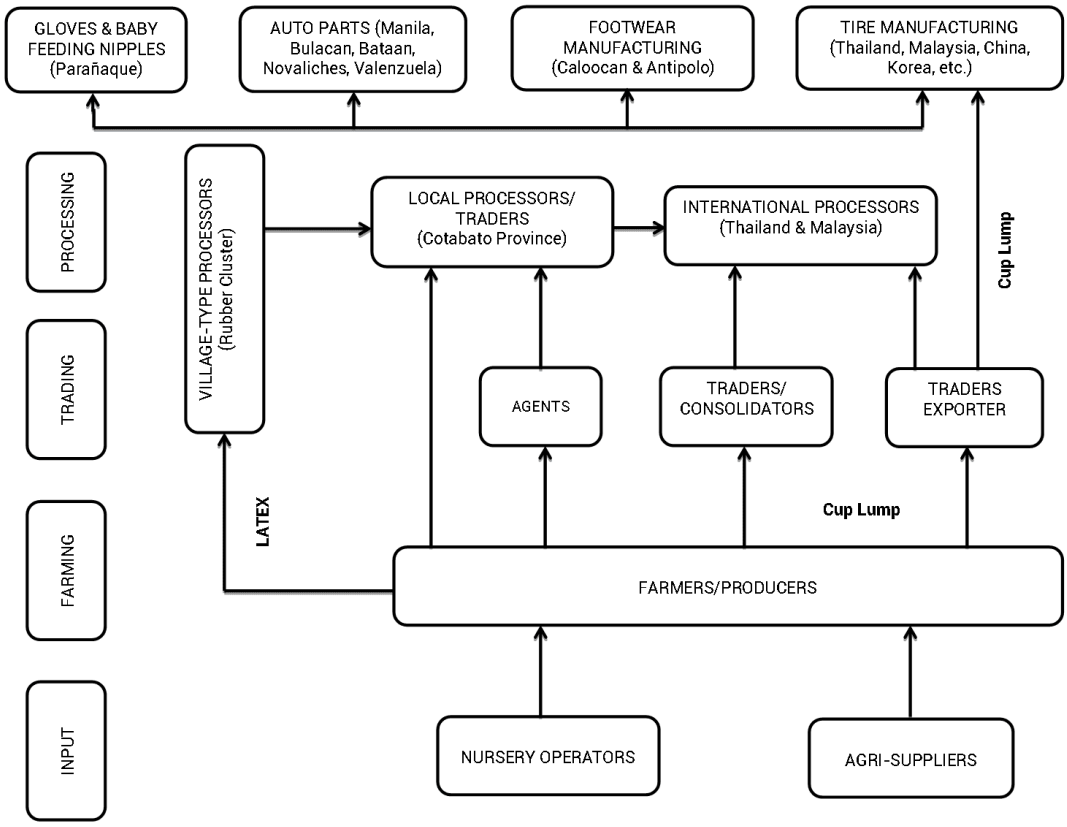

Figure 2. Distribution flow of the rubber by products from the major sources to processors in Cotabato Province, Philippines, 2016.

Major Consumers of Rubber Sheet/Crepe and Crumbs in Cotabato Province, Philippines, 2016

Table 2 shows the major consumers of crepe/sheet and crumb rubber in the major areas, the consumption volume (in bales), and the desired prices. One bales is equivalent to 35kg. Based on this study, there are two kinds of crumb rubber produced by the five processors in Cotabato Province—SPR 10 and SPR 20. Consumers of these crumb rubber are the local manufacturers in Caloocan, Antipolo, Parañaque, Bulacan, Bataan, Novaliches, Valenzuela, Yokohama, and Ozone Tire and the international manufacturers in Thailand, Malaysia, China, and Korea. Among the five processors, only two firms (labelled Firm 1 and Firm 2 in Table 2) provided their volume consumption of SPR 10 (32,200 bales) and SPR 20 (42,000 bales), respectively. The remaining three processors were not able to provide the volume consumption data

because their data are kept in their marketing offices in Manila and Davao. The price per kilogram of SPR 10 is PhP40.00 and PhP41.00 for SPR 20. The major consumers of the village-type produced sheets were the processors.

Table 2. Major consumers of crepe/ sheet and crumb in the major areas, indicating the consumption volume and the prices.

Product	Consumers	Consumption volume	Price/kg (bale)
Crumb:			
SPR 10	International and local	32,200 bales (Firm 1)	40
SPR 20	International and local	42,000 bales (Firm 2)	41
Sheet	Processors		

Note: The data is only available for two out of five processors.

Estimated Volume of Supply and Demand of Cup Lumps in Cotabato Province, Philippines, 2016

From the total area of 239.35 ha managed by the farmers in this study, results revealed that the total volume of production reached 48.434 MT in 2016. This volume was less than the demand for cup lumps which was 4,558.08 MT, or 379.84 MT per month. Thus, there was a recognizable shortage of supply of cup lumps in the local market in 2016.

The demand is further categorized into demand from processors and traders in Table 3. Among the 33 processors/traders-consolidators of raw rubber in Cotabato Province, 5 (15.2%) were processors, 25 (75.8%) were traders/consolidators, and 3 (9.1%) were traders/village level. Data show that processors handled most of the volume of cup lumps in the province (300 MT per month).

The price of raw rubber during the conduct of the study was Php18.00/kg. This price provides income to rubber farmers especially if they are engaged in an integrated rubber-based farming system with banana, cacao, or coconut (Mag-aso & Garcia, 2021). Although rubber farming can be profitable, it is also risky due to the volatility of the rubber price (Min et al., 2015).

In terms of rubber industry-related employment, 56 out of 150 (37.3%) respondents were dependent on the industry as their main source of income. Of this, 34 were processors, while 9 and 13 workers were employed at the traders/consolidators and traders/village level, respectively. The implication is that rubber processors have the largest potential to contribute to economic activities both locally and internationally and create a multiplier effect on the economy. Rubber industries increase employment and income while increasing output in other sectors of the economy (Nair, 2010). It can also increase rural income and decrease poverty (Gao et al., 2012).

Table 3. The demand for cups lumps by the traders and processors, its corresponding price, and the number of workers in the industry,2016.

Processors/traders	Frequency	The average demand for cup lumps/month, tons	Price/kg	The average number of workers in the industry
Processors	5	300	18	34
Traders/consolidators	25	17.34	18	9
Traders (village-level)	3	62.5	18	13
Total	33	379.84		56

Note: Among the 8 processors in Cotabato Province, 5 of them were interviewed; no data were obtained from other respondents due to the rules and regulations of their respective companies.

Estimated Volume of Supply and Demand of Cup Lumps in Cotabato Province, Philippines, 2016

Originally, the model included the 13 variables: price of seedlings, cost of land preparation, cost of planting, cost of fertilizer application, cost of herbicide application, cost of harvesting, farm size, age of crop, price of cup lump, variety of seedling, number of trees planted per hectare, planting distance, and age of farmers, while production/yield served as the dependent variable. However, after data transformation and analysis, the researchers included only variables that were statistically significant up to 10% in the final model. The result of the log-lin regression model estimates for the factors affecting the supply of cup lumps in Cotabato province is presented in Table 4.

Table 4. Estimation of the factors affecting the supply of cup lumps in Cotabato Province, Philippines, 2016.

Supply	Coef.	Std. Err.	*t*	*p*
Cost of land preparation, PhP	–0.000085**	0.000039	-2.18	0.031
Cost of planting, PhP	–0.000062*	0.000035	-1.77	0.079
Cost of harvesting, PhP	0.00005***	0.000017	3.01	0.003
Farm Size	0.45456***	0.052819	8.61	0.000
Planting distance	0.11710*	0.060044	1.95	0.053
Constant	5.10347***	0.64675	7.89	0.000
F(13,136)	= 18.36			
Prob>F	= 0.0000			
R^2	= 0.6370			
Adj R^2	= 0.6023			
Root MSE	= 0.2845			

Note: Level of Significance: *** significant at 1% level or better
** significant at 5% level or better
* significant at 10% level or better

Sixty percent (60%) of the variables included in the study are explained in the model. The cost of land preparation (p = 0.031), cost of planting (p = 0.079), cost of harvesting (p = 0.003), farm size (p < 0.001), and planting distance (p = 0.053) are identified factors that could affect the supply of rubber cup lumps in Cotabato Province. The model shows that the value of supply for cup lumps is 5.10 kg when all the factors affecting the supply for cup lumps are equal to zero. Furthermore, for every decrease in the cost of land preparation, and cost of planting, the supply of cup lump will increase by 0.000085 kg, and 0.000062 kg, respectively, ceteris paribus. This means that as the cost of planting and land preparation for rubber farms decreases, more rubber farmers will engage in rubber farming/production. This also means that lower production costs increase the supply of rubber because farmers are more willing to engage in rubber production when production costs are low. On the other hand, for every peso increase in the cost of harvesting, the supply of cup lump will increase by 0.0005 kg, holding other variables constant. This means that there is a direct relationship between the number of tappers who work in rubber farms and the supply of cup lumps. As wages represent the cost on the part of rubber farmers, an increase in the wage of the tappers incentivizes more tappers to work, consequently increasing the supply of rubber cup lumps. However, when there is a scarcity of farm laborers, there will be an expected increase in wages[1], leading to an increase in cost on the part of the rubber farmers.

The model also shows that the farm size and planting distance are factors that could affect the productivity of rubber. This means that the larger the land area planted with rubber, the larger the supply of cup lumps. This is consistent with the study conducted by Purcell (1993) which showed that the rubber supply was affected by the area planted with rubber. Further, for every meter increase in the distance between rubber trees, the higher the supply of cup lumps. This is due to less competition for soil nutrients and sunlight. For every 1-meter increase in the distance between rubber trees, the production of cup lumps will increase by 0.18 kg, ceteris paribus.

Estimation of the Factors Affecting Demand of Cup Lumps in Cotabato Province, Philippines, 2016

The variables included in the regression analysis were volume handled by the processor as the dependent variable, and price of cup lump, years in operation, and the number of workers as independent variables. However, after the model transformation and regression analysis, only those variables with statistically significant effect were included. The final model which includes only two independent variables is presented in Table 5. The model shows that the variables affecting the quantity demanded for cup lumps among the traders/ processors are the years in operation and the number of workers in the rubber processing industry. This implies that firms that have been in business for a longer period have a higher demand for cup lumps. This is due to already established connections and links with local and international markets for rubber crepe/sheets and crumbs. As a result, established rubber processors' demand for cup lumps rises. Furthermore, the number of workers employed in the rubber industry influences the number of cup lumps demanded by processors. Rubber processors produce value-added rubber products ranging from cup lumps to rubber crepe/ sheets and crumbs. Hence, these value adding activities resulted in increased demand for additional manpower.

[1] Wages represent the tappers' share of the total cup lumps produced. The estimated share is around 30%-40% of the total produced cup lumps.

Table 5. Estimation of the factors affecting demand of cup lump in Cotabato Province, Philippines, 2016.

Demand		Coef.	Std. Err.	*t*	*p*
Years in operation		0.0457**	0.02171	2.19	0.036
Number of workers		0.0391***	0.0129	3.04	0.005
F(3,32)	= 8.73				
Prob>*F*	= 0.0002				
R^2	= 0.4500				

Note: Level of Significance: *** significant at 1% level or better
** significant at 5% level or better

Conclusion

The majority of the rubber seedlings planted by farmers came from various municipalities in Cotabato province, particularly from Makilala. As a result, most rubber processors are concentrated in this area. In addition to rubber farmers, processors also play an important role in the rubber industry. Rubber by-products are typically added to the value of latex and cup lumps, and can command a higher price. Of all the actors in the rubber supply chain, processors have the highest demand for cup lumps. Further, processors/traders contribute significantly to the local economy by creating jobs, generating tax revenue, and providing employment opportunities for the community. These middlemen play an important role in the distribution of rubber byproducts, adapting their form to meet the specific requirements of clients and buyers. Maintaining a good reputation and ensuring product quality are essential factors in the buying and selling of rubber byproducts.

Recommendations

In addition to being the region's leading producer of rubber by-products, the rubber industry in Cotabato Province shows great promise. It has been found that the supply of cup lumps in Cotabato is less than the demand for cup lumps, resulting in a cup lump shortage in the area. Because the market for cup lumps in the area is stable due to the presence of processors, farmers can be encouraged to grow rubber.

Investment in rubber plantations in the province is vital, especially in areas with favorable climatic conditions and agricultural practices, to increase supply and close the demand-supply gap and achieve balance. To ensure price stability and further reduce poverty levels in the region, there is a need to maintain consistent supply and good quality produced. To achieve this, the government should formulate strategic initiatives aimed at boosting rubber production. Additionally, comprehensive plans and programs tailored to rubber farmers should be implemented to enhance overall rubber productivity. These include policies and programs to help farmers improve rubber productivity. The government may invest in R&D to produce high-yielding rubber varieties, improve rubber production, cup lump quality, and the development of new varieties of rubber trees that are more productive, more resilient in adverse climatic conditions, and have a lower environmental impact. The government may provide technical assistance to small-scale rubber farmers, especially on proper rubber tapping and harvesting, rubber tree care and maintenance, as well as value-adding activities such as providing technology for processing cup lumps into rubber sheets and crumbs, aimed at increasing farmer's income.

It is also advantageous to encourage collaboration among industry participants to exchange knowledge and advance technology. Rubber producers, processors, and traders must work together to develop innovative rubber-based products that meet changing market demands. Finally, this study focused on demand and supply of rubber cup lumps. A further study on quality assessment and breakeven analysis as well as on the supply and value chain traceability of rubber is highly recommended.

Disclosure Statement

No potential conflict of interest was declared by the authors.

References

Agence France Presse. (2009). *Rubber plantations could Have a "devastating" impact in Asia*. Retrieved June 28, 2023, from http://phys.org/news/2009-05-rubber-plantations-devastating-impact-asia.html#nRlv

Bureau of Plant Industry (2016). *HVCDP – Rubber commodity profile*. Retrieved June 28, 2023, from https://www.buplant.da.gov.ph/images/PDF_file/Rubber%20Elements%20Paper%202016.pdf

Chawananon, C. (2014). *Factors affecting the Thai natural rubber market equilibrium: Demand and supply response analysis using two-stage least squares approach*. Unpublished Master's Thesis, California Polytechnic State University.

Darmawan, M.A., Putra, M.P.I.F., & Wiguna, B. (2014). Value chain analysis for green productivity improvement in the natural rubber supply chain: A case study. *Journal of Cleaner Production*, *85*, 201-211.

Department of Agriculture Philippine Rural Development Project [PRDP] (2014). *Value chain and analysis competitiveness strategy: Bulb onion*. Luzon A Cluster. Retrieved May 1, 2023, from https://dokumen.tips/download/link/philippine-rural-development-project-prdp-i-plan-drive-vca-clusterwide-.html

Department of Science and Technology-Philippine Council for Industry, Energy, and Emerging Technology. (2020). *Strengthening the Philippine rubber industry towards a sustainable economy*. Retrieved June 5, 2023, from https://pcieerd.dost.gov.ph/images/policy_advocacy/Policy-Brief-on-Rubber.pdf

Department of Science and Technology-Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development [DOST-PCAARRD]. (n.d.). *Rubber: Industry strategic science and technology program*. Retrieved May 1, 2023, from https://ispweb.pcaarrd.dost.gov.ph/isp-commodities/rubber/

Dwyer, M. (2007). Turning land into capital. A review of recent research on land concessions for investment in the Lao PDR. Retrieved September 15, 2023, from https://data.opendevelopmentmekong.net/dataset/931d3a70-aa3b-4ac9-915d-657249f242ed/resource/1a267036-b3cd-4cd6-8364-074a025cac74/download/turning-land-into-capital-a-review-of-recent-research-on-land-concessions-for-investment-in-lao-.pdf

Fertilizer and Pesticide Authority. (n.d.). *SOCCSKSARGEN*. Retrieved July 15, 2023, from https://fpa.da.gov.ph/NW/index.php/information-resources/regional-profile/region-xii

Food and Agriculture Organization of the United Nations. (2023). Crops and livestock products. Retrieved October 15, 2023, from https://fenixservices.fao.org/faostat/static/bulkdownloads/Production_Crops_ Livestock_E_All_Data.zip

Fox, J. & Castella, J.-C. (2013). Expansion of rubber (*Hevea brasiliensis*) in Mainland Southeast Asia: What are the prospects for smallholders? *The Journal of Peasant Studies*, *40*(1), 155-170.

Gao, T., Shen, L., Liu, L., & Xue, J. (2012). The socio-economic and eco-environment impacts of rubber plantation in Jinghong City. *Resources Science*, *34*, 1200-1206.

Mag-aso, J. & Garcia, F.G. (2021). Productivity from the different rubber-based farming system models in Cotabato Province, Philippines. *IOP Conference Series: Earth and Environmental Science, 892*, 012019.

Min, S,. Huang, J., Bai, J., & Waibel, H. (2015). Adoption of intercropping among smallholder rubber farmers in Xishuangbanna, China. Paper presented at the 29th Triennial Conference of the International Association of Agricultural Economists (IAAE), August 9-14, Milan.

Nair, K.P. (2010). *The agronomy and economy of important tree crops of the developing world*. Amsterdam, the Netherlands: Elsevier.

National Statistical Coordination Board. (2012). *List of provinces*. Retrieved June 30, 2023, from https://web.archive.org/web/20130117174921/http://nscb.gov.ph/activestats/psgc/listprov.asp

Philippine Rubber Technical Working Group. (2017). Philippine Rubber Industry Roadmap. Retrieved September 15, 2023, from https://www.da.gov.ph/wp-content/uploads/2019/06/Philippine-Rubber-Industry-Roadmap-2017-2022.pdf

Philippine Statistics Authority (2020). *Other crops: Volume of production, by region and by province, by quarter and semester*. Retrieved December 1, 2020, from https://rsso08.psa.gov.ph/sites/default/files/Other%20Crops_Volume%20of%20Production,%20by%20Region%20and%20by%20Province%20by%20Year,%201990-2018.xlsx

Philippine Statistics Authority (2022). *Magnitude of poor families with measures of precision, by region and province: 2015, 2018, and 2021p*. Retrieved October 15, 2023, from https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/search/?searchquery=1E3DF050

Philippine Statistics Authority (2023). *Other crops: Volume of production, by region and by province, by quarter and semester*. Retrieved October 15, 2023, from https://openstat.psa.gov.ph/PXWeb/pxweb/en/DB/search/?searchquery=2E4EVCP1

Purcell, T. (1993). *The factors affecting the long run supply of rubber from Saramak, East Malaysia, 1900-1990- An historical and econometric analysis*. Unpublished Master's Thesis, The University of Queensland.

Rodrigo, V.H.L., Stirling, C.M., Silva, T.U.K., & Pathirana, P.D. (2005). The growth and yield of rubber at maturity are improved by intercropping with banana during the early stage of rubber cultivation. *Field Crops Research*, *91*(1), 23-33.

Statista Research Department. (2023). *Global production of natural rubber 2000-2022*. Retrieved October 15, 2023, from https://www.statista.com/statistics/275387/global-natural-rubber-production/

Sturgeon, J. (2010). Governing minorities and development in Xishuangbanna, China: Akha and Dai rubber farmers as entrepreneurs. *Geoforum*, *41*, 318-328.

Warren-Thomas, E., Dolman, P.M., & Edwards, D.P. (2015). Increasing demand for natural rubber necessitates a robust sustainability initiative to mitigate impacts on tropical biodiversity. *Conservation Letters*, *8*(4), 230-241.

Weerathamrongsak, P. & Wongsurawat, W. (2013). The rubber industry of Thailand: a review of past achievements and prospects. *Journal of Agribusiness in Developing and Emerging Economies*, *3*(1), 49-63.

Ziegler, D., Fox, M., & Xu, J. (2009). The rubber juggernaut. *Science*, *324*, 1024-1025.