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Sustainability and Competitiveness of Thailand's Natural Rubber Industry in Times of Global Economic Flux

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Abstract

This study assesses economic, legal, and environmental conditions that Thai rubber farmers face, and evaluates actions they can take to increase incomes. Statistical analyses determine relationships between prices of oil, natural and synthetic rubber. Pearson correlation tests found a strong positive relationship (r = 0.887) between the price of Brent crude and Thai ribbed smoked sheets, and a moderate positive relationship between price changes in Brent and synthetic rubber (r = 0.648). Regression analysis showed Brent oil price is a good predictor of natural rubber prices. Moderate to strong positive relationships were also found between natural rubber price and gross domestic product of Japan, China, and the United States. Criminal antitrust behavior in rubber industries appeared to interfere with normal pricing in rubber markets. No significant bivariate correlation was found between rainfall in Thailand and natural rubber price, production, or export although flooding and other environmental issues clearly affected rubber farms. A survey of options showed Thai rubber farmers can improve livelihoods best through collective purchase and use of new technologies, and by integrating into downstream supply chain industries. At very least, farmers are urged to abandon monocrop methods and supplement incomes with fruit, fish, livestock, or pigs.

Keywords: Natural rubber; agronomics; southeast Asia; international trade

1. Introduction

"Rubber is an indispensable resource," according to Thailand's Board of Investment (2017). Rubber products, from auto parts to medical supplies, are vital to the world's businesses and consumers. Regardless of the product or where it is manufactured, there is a good chance that the raw material came from Thailand – the world's top natural rubber (NR) producer and exporter. Thailand, Indonesia, and Malaysia account for about 70 percent of the world's NR, with Thailand contributing more than half of their combine 8.36 million tons in 2015 (Thailand Board of Investment, 2016). Synthetic rubber (SR) holds a slightly larger market share than NR, but NR is more resilient and longer lasting, making it irreplaceable for various products such as aircraft tires (Emspak, 2014).

Almost all NR comes from a single species of tree, *Hevea brasiliensis*, which is native to humid tropical climates like Thailand, especially the southern region. In 2015, Thailand exported $6.6 billion worth of standard Thai rubber (STR) blocks, ribbed smoked sheets (RSS), and other rubber products (Thailand Board of Investment, 2016). Despite the gargantuan numbers, rubber farming is still a family business. More than 85 percent of the world's and 90 percent of Thailand's rubber plantations are operated by smallholders whose farms are as modest as 0.3ha (Yamamoto, 2016). Whereas Malaysia has transitioned from farming to higher value finished products, Thailand still largely specializes in raw materials, STR and RSS (Doner & Abonyi, 2013). Thailand is now seeking to create opportunity, value, and income for NR farmers, but challenges persist.

1.1 Background Research

Chawananon (2014) studied interrelationships between rubber production and price, rainfall, THB/USD exchange rate, rice price, rainfall, US vehicle sales, and GDP per capita in China, Japan, and the United States. The study found a positive relationship between rubber demand and US GDP per capita; when GDP per capita rises, automotive sales generally rise, creating greater demand for rubber. While rubber demand does not change significantly with price changes, rainfall can affect supply and, in turn, producer incomes.

Farmers' decisions to monocrop rubber or intercrop are influenced by market prices of alternative crops just as natural rubber consumers' decisions are affected by the price of its main competitor: synthetic rubber. As a

petroleum product, synthetic rubber prices are impacted by oil prices. High oil prices result in higher SR prices, making NR a more viable option for consumers. Alternatively, low oil prices make SR prices more competitive and NR demand suffers (Romprasert, 2009; Petchseechoung, 2016).

Synthetic rubber does not create an existential threat to NR production considering NR is a renewable resource whereas petroleum is nonrenewable and may likely fall into shortage within the 21st century (OPEC; Murray, 2016). Thus, NR is inherently sustainable and competitive to some extent in the long term, but how efficiently shareholders manage their industry in perpetuity will determine the direction and magnitude of impacts to surrounding economic and ecological spheres. The immediate problems that farmers face relate to income and price stability; in the medium and long term, environmental responsibility will probably gather more attention.

Financial survival is the instant issue for small farm owners, and thus for nearly every rubber farmer in Thailand. Average rubber farm sizes in Thailand are between four and five hectares, and nearly all of these smallholders monocrop, resulting in less than $500 net income per year per ha (Jongrungrot et al.,, 2014; Poungchompu et al., 2015). Meager household incomes among rubber farmers help explain how roughly one-third of the Thai workforce is employed in agriculture, but agriculture contributes only 8-9 percent to GDP (World Bank, 2017a). While two to three thousand USD per year puts Thai rubber farmers well above the global poverty threshold, it does little to provide them and their families opportunity to develop themselves and their communities.

Viswanathan (2008) found rubber plantations in Songkhla, Thailand were significantly less profitable per hectare than plantations in Northeast India due primarily to Thai farmers shifting output from conventional RSS to lower-priced latex or STR. Farmers in Songkhla who had the highest incomes intercropped fruit and other foods, livestock and fisheries on their landholdings; their incomes were more than one-third higher than monocrop plantation owners. Studies consistently recommend addition of other crops alongside rubber trees to supplement income (Jalloh, et al, 2009; CIRAD, 2013; Wang, et al, 2014; Yu & Langenberger, 2016; Cadisch, 2016). However, smallholder farms like most in Thailand usually face significant difficulty diversifying their crops. Jongrungrot, Thungwa & Snoeck (2014) found small farm owners could mitigate rubber price volatility by adding other cash crops to lands, but they are consistently unable to undertake such changeovers due to lack of knowledge, skills, and labor.

Labor is ubiquitous in Asia, but knowledge and skills are often at a deficit in agricultural communities. In Thailand, only 65 percent of people aged 25 or older had completed primary school in 2016; those educational attainment rates fall to 45 percent, 32 percent, and 15 percent for lower secondary, upper secondary, and undergraduate university, respectively (World Bank, 2017a). A glut of laborers with low education has translated to short-sighted, inefficient, and inadvisable decisions in rubber industries throughout the region. Since 2000, for example, the area of land in southeast Asia under rubber farms has increased by more than 50 percent; much of the growth came from clearing natural forest. The preferred method for clearing throughout the region is slash-and-burn, which generates mammoth amounts of greenhouse gases (Ketterings, 1999; Palm et al, 2005).

Transition into NR farming entails massive-scale landscape alteration, which if done arbitrarily can seriously affect hydrology, soil quality, streams and other elements of once-thriving ecosystems (Giambelluca, Chen, & Ziegler, 2016). By 2050, rubber farming in mountainous regions is expected to increase fourfold and across the southeast Asian region, NR farming could double or triple in the same time frame (Ziegler, Fox, & Xu, 2009; Fox, et al, 2014a). Growth in NR plantations is fueled by increasing demand for rubber, generally for tires in China, Japan, the United States, and Europe. In the short term, farmers who convert other croplands to NR may earn a higher income, but due to poor selection of farmlands and inferior monoculture methods, their long term future may be jeopardized. Ahrends et al. (2015) found more than half of rubber plantations in southeast Asia are "unsustainable" due to marginal lands where low yields are likely. In addition to environmental degradation (i.e. surface erosion, loss of soil quality, risk of landslides, increased carbon emissions, etc.), the poorly-planned rubber boom could result in severe, negative economic repercussions (Fox, et al, 2014b; Van de Moortel, 2016).

As demonstrated by the number of smallholder plantations, subsistence farming is a longstanding tradition in Southeast Asia. However, the antiquated techniques that small agro-businesses often employ resemble what the Thai government has called "Thailand 1.0." The current vision is to move into "Thailand 4.0" and thereby ensure sustainability, competitiveness, inclusive prosperity, and escape from the middle income trap (Royal Thai Embassy, 2017). Adaptation in the agriculture sector is fundamental to achieving national goals not only because one in three Thais work in the industry, but also because farming is central to the Thai identity – technological and scientific evolution of small farms would provide social and psychological boosts alongside economic gains.

1.2 Research Objectives

This research is designed to understand factors currently limiting the sustainability and competitiveness of

Thailand's rubber farming industry, particularly smallholder operations. In this research, the term "sustainability" is defined as the ability to be maintained at a certain rate or level. Sustainability has both economic and environmental implications; it refers to continuing growth in economic terms, and avoidance of depletion of natural resources in order to maintain an ecological balance. "Competitiveness" is defined as the quality of being as good or better than others. In this research, competitiveness refers to price and quality of Thai rubber products, and efficiency of related industries.

Existing literature on the subject provides significant insight on environmental and economic factors, but prior research is generally compartmentalized and incomplete. Environmental research lacks detailed economic and business analysis. Likewise, studies that weigh in heavily on economics typically fail to consider social, environmental, legal or other factors. Literature commonly reviews, analyzes, and recommends policy relating to tax, subsidies, and land-use but fails to comment on antitrust in rubber industries which can severely distort markets. Researchers also routinely recommend government expenditures to upgrade agricultural operations while overlooking financial details.

This article aims to address multiple issues together, shedding light on interrelationships among factors. First, the author intends to independently confirm or disconfirm prior research on the price and production of natural rubber, and their relationships with other marketplace variables such as oil price, world consumption of synthetic rubber, exchange rate, rainfall, foreign GDP and GDP per capita. Next, the strength and direction of those relationships lead to discussion of interfering forces including natural disasters, antitrust, protests and government price intervention. Then, considering the complex matrix of factors influencing the price of NR and therefore incomes among Thai farmers, the researcher provides analysis and recommendation that promote sustainability and competitiveness in Thai NR industries. For example, growth and stability may require formation of farming cooperatives that function as juristic persons, and domestic forward integration into downstream supply chain businesses. Additionally, the research explores measures that farmers can take under the classic "sufficiency economy" model for cases where adoption of costly technologies is not an option. Conclusions implore all interested stakeholders to engage a long-term collective process of modernization in Thai rubber industries; research, revised policy, education and training, and investment are all fundamental to ensuring sustainability and competitiveness in Thai rubber industries.

2. Methodology

Data were retrieved electronically from various public databases. The Bank of Thailand (2015), Thai Rubber Association (2016), US Bureau of Labor Statistics (2017), US Federal Reserve Bank of St. Louis (2017), and Quandl (2017) provided statistics on NR and SR production, consumption, export, and price. The St. Louis Federal Reserve (2017) also provided exchange rate data. The US Energy Information Administration (2017) provided price data for Brent and WTI oil. Data were formatted into Excel and SPSS for graphical representation and statistical testing.

Data assumptions were tested prior to interpreting results. Data was normally distributed as assessed by normal Q-Q plots and Shapiro-Wilk tests. Scatterplots showed the data met assumptions of homogeneity of variance and linearity. Normal P-P plots confirmed the homoscedasticity assumption.

3. Results & Discussion

3.1 Oil & Rubber

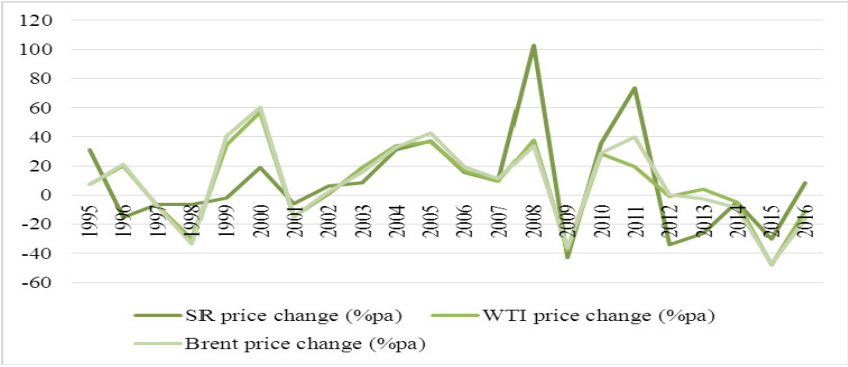

Figure 1. Oil price and SR price

Average price fluctuations for SR and oil appear to follow one another when represented graphically. For the period between 2001 and 2007, price changes are nearly identical. In other periods, the relationship is not as

strong, but peaks and troughs still correspond with one another.

To examine the relationship between these variables more closely, a Pearson correlation test was conducted which showed moderate statistically significant positive linear relationships between year-on-year (YoY) price changes in SR and both WTI ($r = 0.629$, $p = 0.002$) and Brent ($r = 0.648$, $p = 0.001$). No significant relationship was found between SR price change and changes in production or consumption of SR, showing that SR is relatively price inelastic.

Table 1: Pearson bivariate correlations for oil, SR price, production, and consumption

Despite SR's relative price inelasticity, we assume that the law of demand holds true and that as price rises, consumers will attempt to substitute products when they are available in order to minimize costs and maximize their profits as rubber passes down the supply chain. Upon examining a graphical representation of YoY price change for RSS and SR, we see local minima and maxima do not align; rather, they are nearly opposite each other. Even though both prices may be rising over time, one rises faster than the other, which creates a perfect opportunity for consumers to switch based on price.

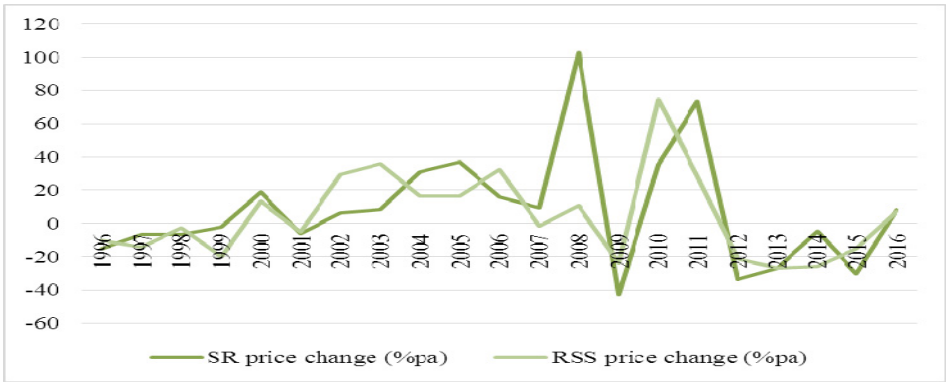

Figure 2. SR and RSS price change, percent per annum

Figure 2 supports prior research on the relationship between SR and NR, and when combine with correlations presented in Table 1, prior research on relationships between oil price, SR and NR price are supported. Further examination via Pearson bivariate correlations showed a strong significant positive linear relationship between WTI and RSS prices ($r = 0.868$, $p < 0.0005$) and Brent and RSS prices ($r = 0.887$, $p < 0.0005$). The correlation analysis found a moderate negative relationship between STR price and oil, which raised questions of an interfering factor given that STR is a NR product whose price should follow a similar curve as RSS.

Table 2. Pearson bivariate correlations for oil, STR, & RSS

		WTI Oil Price ($/bbl)	Brent Oil Price ($/bbl)	TH RSS Price (THB/kg)	STR Price (THB/kg)
WTI Oil Price ($/bbl)	Pearson Correlation	1	.991**	.868**	-.645**
	Sig. (2-tailed)		.000	.000	.001
	N	22	22	22	22
Brent Oil Price ($/bbl)	Pearson Correlation	.991**	1	.887**	-.660**
	Sig. (2-tailed)	.000		.000	.001
	N	22	22	22	22
TH RSS Price (THB/kg)	Pearson Correlation	.868**	.887**	1	-.686**
	Sig. (2-tailed)	.000	.000		.000
	N	22	22	22	22
STR Price (THB/kg)	Pearson Correlation	-.645**	-.660**	-.686**	1
	Sig. (2-tailed)	.001	.001	.000	
	N	22	22	22	22

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3. Partial correlations oil, STR, & RSS

Control Variables			WTI Oil Price ($/bbl)	Brent Oil Price ($/bbl)	STR Price (THB/kg)	TH RSS Price (THB/kg)
TH RSS Price (THB/kg)	WTI Oil Price ($/bbl)	Correlation	1	0.965	-0.136	
		Significance (2-tailed)	.	0	0.556	
		df	0	19	19	
	Brent Oil Price ($/bbl)	Correlation	0.965	1	-0.151	
		Significance (2-tailed)	0	.	0.515	
		df	19	0	19	
	STR Price (THB/kg)	Correlation	0.136	-0.151	1	
		Significance (2-tailed)	0.556	0.515	.	
		df	19	19	0	

A partial correlation test confirmed presence of a confounding factor. Correlations between RSS, WTI and Brent prices almost completely explain bivariate correlations between STR, WTI and Brent. The partial correlation between both variables is very weak and not significant ($r = 0.136$, $p = 0.556$). One possible explanation for this scenario is that STR is a lower-quality, lower-price product than RSS. When oil price rises, RSS price likewise rises and that may cause changes in production; producers may switch from STR to RSS when RSS prices are higher, or there may be a relative scarcity of NR products in the market as oil prices drive up SR prices and consumers choose NR as a substitute.

Brent and RSS shared a stronger correlation ($r = 0.887$) than RSS and WTI ($r = 0.868$). The strength of their correlation implies that, regardless of causative direction, the price of Brent has predictive value for the price of RSS. A linear regression analysis ($r = 0.887$, $F = 74.154$, $p < 0.0005$) produced an R-squared value of 0.788, indicating the regression explains 77.8 percent of variance in the data. The regression equation is,

RSS price in THB = 14.051 + 0.873*(Brent price in USD)

Tables 4-6: Linear regression analysis for RSS & Brent oil price

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.887[a]	.788	.777	15.92097
a. Predictors: (Constant), Brent Oil Price ($/bbl)				

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18796.238	1	18796.238	74.154	.000[b]
	Residual	5069.543	20	253.477		
	Total	23865.781	21			
a. Dependent Variable: TH RSS Price (THB/kg)						
b. Predictors: (Constant), Brent Oil Price ($/bbl)						

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	14.051	6.448		2.179	.041
	Brent Oil Price ($/bbl)	.873	.101	.887	8.611	.000
a. Dependent Variable: TH RSS Price (THB/kg)						

Oil price affects SR price, which affects NR demand and price, but oil price is also a reflection of global economic conditions. During periods of growth, incomes rise and people buy more cars, more oil is consumed for electricity generation and transportation, and oil stocks cannot grow significantly, which maintains a higher price per barrel. In times of economic hardship, economies contract or grow slowly and oil surpluses accumulate, pushing prices down in periods of oversupply. When there is too much oil in the marketplace, SR producers can purchase raw materials cheaply, which leads to lower SR prices. Conversely, when oil is in higher demand than supply, SR prices rise and NR becomes a more precious commodity.

3.2 GDP, Exchange Rate, & Government Policy

NR is mainly produced in southeast Asia, but it is consumed in every country; thus, the livelihoods of family farms in rural Thailand are constrained by circumstances entirely out of their reach. When market prices for RSS fall to near or below production cost, Thai farmers have oft threatened or moved to protest, demanding the Thai government intervene (Campbell, 2013; Kaewjinda, Thepgumpanat, & Niyomyat, 2014; Peel, 2016). The government has on many occasions artificially propped up the price of rubber in order to support struggling farmers, but each time it is only a temporary fix which possibly causes more harm than good in the long term.

In 2001—02, Thailand's then-Prime Minister Thaksin Shinawatra sought an "acceptable" price of 1 USD/kg for RSS, which amounted to 43—45 THB/kg (Moore, 2002). Thailand, Malaysia, and Indonesia formed the International Tripartite Rubber Organization (ITRO) around the same time in attempts to exert upward pressure

on the price of rubber, but less than one year into the agreement, the group was not adhering to its quotas (Economist, 2003), and so while prices overcame the one-dollar threshold, they failed to remain stable through years. The exchange rate also fluctuated, so the price paid to farmers in Thailand did not reflect the increasing USD-based global price. By 2010—2013, the once-fair price of 1 USD/kg only amounted to 30—31 THB/kg. Meanwhile, inflation increased the production costs for farmers who would demand 60 THB/kg by 2016 (Reuters, 2016). In 2017, the government had intervened again, hoping to push the price to 70 THB/kg, worth about 2 USD (Thaicharaoen, Hariraksapitak, & Thepgumpanat, 2017).

Table 7. Pearson bivariate correlations for RSS price, exchange rate, and GDP

		TH RSS Price (THB/kg)	THB/USD Ave Rate
TH RSS Price (THB/kg)	Pearson Correlation	1	-.408
	Sig. (2-tailed)		.059
	N	22	22
THB/USD Ave Rate	Pearson Correlation	-.408	1
	Sig. (2-tailed)	.059	
	N	22	22
CN GDP per capita	Pearson Correlation	.584**	-.323
	Sig. (2-tailed)	.004	.143
	N	22	22
US GDP per capita	Pearson Correlation	.654**	-.101
	Sig. (2-tailed)	.001	.656
	N	22	22
JP GDP per capita	Pearson Correlation	.755**	-.614**
	Sig. (2-tailed)	.000	.002
	N	22	22
CN GDP	Pearson Correlation	.576**	-.320
	Sig. (2-tailed)	.005	.147
	N	22	22
US GDP	Pearson Correlation	.652**	-.125
	Sig. (2-tailed)	.001	.580
	N	22	22
JP GDP	Pearson Correlation	.780**	-.592**
	Sig. (2-tailed)	.000	.004
	N	22	22

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Exchange rate fluctuations seriously impact import and export economies. Thailand, which relies on exports and tourism as macroeconomic staples, benefits from a high THB/USD ratio. Like the Chinese Yuan, the Thai Baht has been called "undervalued" (Danielsen, 2017). Cumperayot & Kouwenberg (2016) found developing nations sometimes use strategic policy to undervalue their currencies, resulting in limited domestic growth. In the case of rubber, undervaluation is the sort of magic that turns 50 Baht into 70 Baht, regardless of external consequences. Prior research on rubber pricing found significant correlations between exchange rate and NR price, but this research did not support those historical studies. A Pearson bivariate correlation test showed no relationships between RSS price and exchange rate significant to the 0.05 level.

Analysis confirmed moderate to strong positive correlations between RSS price and GDP indicators for China, the United States, and Japan. Whereas prior research focused on GDP per capita, the present study included both aggregate GDP and per capita statistics in analyses, finding only slight differences between the two measures. GDP per capita shared a slightly higher correlation with RSS price in the US (r = 0.654) and China (r = 0.584) than GDP (US, r = 0.652; CN, r = 0.576) whereas in Japan, RSS was more highly correlated with GDP (r = 0.780) than GDP per capita (0.755).

3.3 Anticompetitive Behavior

GDPs of the world's largest economy and biggest auto parts market, and the world's largest producer of rubber products were only moderately correlated to RSS price. At the macro-level, myriad mitigating factors could be present. One possible explanation is the influence of price fixing and anticompetitive behavior in rubber markets. As the Thai government and ITRO attempt to keep NR prices high through supply side measures, it is logical that similar attempts to keep NR prices low could occur on the demand side. And there is some evidence of such activity as billions of dollars in fines have been levied in recent years against major corporations whose actions severely distorted market prices of rubber products.

Automotive parts suppliers, and tire manufacturers in particular, have been caught fixing prices and rigging bids. Federal Courts in the United States fined Yamashita Rubber $11 million (US v. Yamashita Rubber, 2013), Toyo Tire $120 million (US v. Toyo Tire & Rubber, 2013), Bridgestone $425 million (US v. Bridgestone, 2014), and Nishikawa $130 million (US v. Nishikawa Rubber, 2016). Tire manufacturers continue to face prosecution for

anticompetitive behavior in South Africa, India and elsewhere (Goodyear & Continental South Africa v. Competition Commission, 2016; Patel, 2016). Conspiracies to fix prices and control markets have also been found in synthetic rubber industries. In 2007, the European Union imposed nearly $700 million in fines for price fixing and market sharing against an SR cartel consisting of Bayer, Dow, Eni, Shell, Unipetrol, and Trade-Stormil (De Luca & List, 2007). Just prior, US Courts fined DuPont Dow $84 million for price fixing in SR markets (US v. DuPont Dow, 2005).

Companies stand to make hundreds of millions or billions of dollars from criminal activity, and in many cases their rewards are greater than the fines imposed, so there is no reason to suspect such anticompetitive behavior will cease. Precisely how much the price of NR or SR is affected by each individual case or the collection of cases together over time is unknowable, but the difference is certainly nonzero. There is also a less elegant way that prices are being distorted. Unlike oil, rubber is a perishable commodity, so producers cannot stockpile surpluses during down periods while they wait for prices to rise; farmers could be forced to sell at low prices out of desperation. In Thailand, millions of farmers and middlemen trade agricultural commodities (rubber, rice, sugar, etc.), but farmers lack significant power in the supply chain and are largely subject to the demands of export purchasing agents. Anticompetitive practices could be rife within the hoard of producers, wholesalers, distributors, and exporters but the Thai government has remained inactive in pursuit of antitrust claims. Instead, the government merely intervenes and artificially increases the price of rubber every year or so, which may be incentive for exporters and global purchasers to maintain artificially low bids.

Thailand's government intervention programs also have had a sordid history, drawing complaints of excessive government spending and presence of corruption (Economist, 2003). Former Prime Minister Yingluck Shinawatra was fined $1.4 billion for criminal negligence in a costly, corruption-laden rice subsidy program that aimed to pay farmers 50 percent above market prices in order to raise production without concern for quality, leaving the government to pick up the enormous tab and deal with warehouses full of perishable rice (Chantanusornsiri & Yuthamanop, 2012; Yee, 2016). While the present research has no evidence supporting any claim against the integrity of the rubber subsidy scheme, it is clear that market dysfunction is intrinsic to the process. Kampan (2016) recommended integrated supply chain logistics throughout the ASEAN rubber farming regions in efforts to streamline efficiencies and help minimize price volatility. If the Thai government simply monitored potential collusion and bid rigging among middlemen in their domestic markets, and investigated and prosecuted cases involving price fixing and other anticompetitive behavior, a missing link could be unearthed between Thai exporters and global firms like those fined in the United States and Europe. While it is impossible to determine the degree to which corruption and other criminal business behavior jeopardizes fair pricing for farmers, there is reason to suspect impacts are significant.

3.4 Environment

Rubber farming has a natural advantage in that it requires planting of trees, which can help reverse the trend of deforestation and improve atmospheric quality. In Thailand, rubber production has increased alongside both the forest area and agricultural land area since the early 2000s (Bank of Thailand, 2015; World Bank, 2017a), suggesting the rubber industry may have had a net positive effect on forestry. On the other hand, when natural forests are cleared and replaced with NR plantations, as in the cases of China and Indonesia, carbon emissions can skyrocket and biodiversity can be decimated (Arifin, 2013; Source Intelligence, 2016).

Table 8. Agricultural and forest land growth 1995-2014, % of total land area

Agricultural land growth	4.24%
Forest area growth	5.55%

Carbon emissions, like those from Indonesian forest fires, have been linked to climate change. Climate change may increase or reduce rainfall, which logically affects the health of trees. News and industry reports suggest periods of severe rainfall negatively impact rubber production and lead to periods of increased prices (Farchy, 2010; Japan Ministry of Economy, Trade and Industry 2012, p. 317-384). This research tested correlations between rainfall and NR price, production, and exports to assess the association between rain and rubber that prior research has shown.

Correlational analysis did not find any statistically significant relationship between annual rainfall and rubber production, exports, or price. These results contradicted prior research. One possible explanation is that Pearson tests in the present study attempted to pair rainfall across all of Thailand whereas rubber production is largely localized in the southern region. Unfortunately, data was not available for rainfall data in Songkhla province alone. The nature and volume of reports demonstrating a relationship between rain and NR price or production

suggest the present correlation probably has unexplained variables, and may not be reliable.

Table 9. Pearson bivariate correlations for rainfall and NR data

		TH annual rainfall
TH annual rainfall	Pearson Correlation	1
	Sig. (2-tailed)	
	N	21
STR Prod (Met Ton)	Pearson Correlation	-.101
	Sig. (2-tailed)	.709
	N	16
TH RSS Price (THB/kg)	Pearson Correlation	.196
	Sig. (2-tailed)	.395
	N	21
STR Price (THB/kg)	Pearson Correlation	.156
	Sig. (2-tailed)	.500
	N	21
TH Tot NR Prod (Met Ton)	Pearson Correlation	-.293
	Sig. (2-tailed)	.270
	N	16
TH Tot NR Exports (Met Ton)	Pearson Correlation	-.325
	Sig. (2-tailed)	.220
	N	16

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

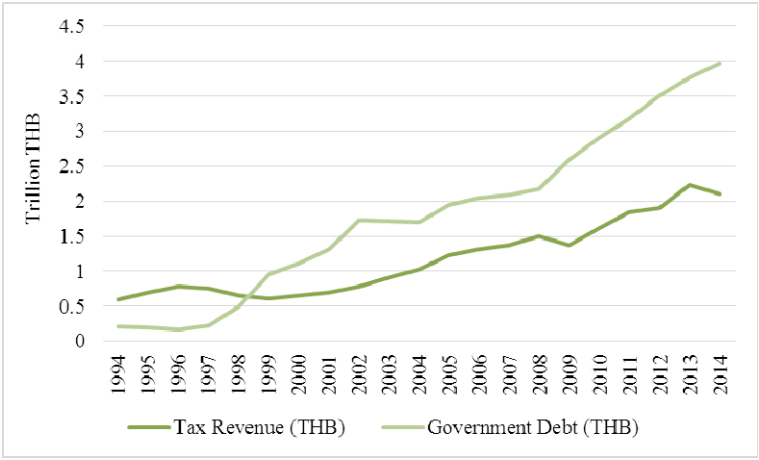

Figure 3. Thailand tax revenue and government debt

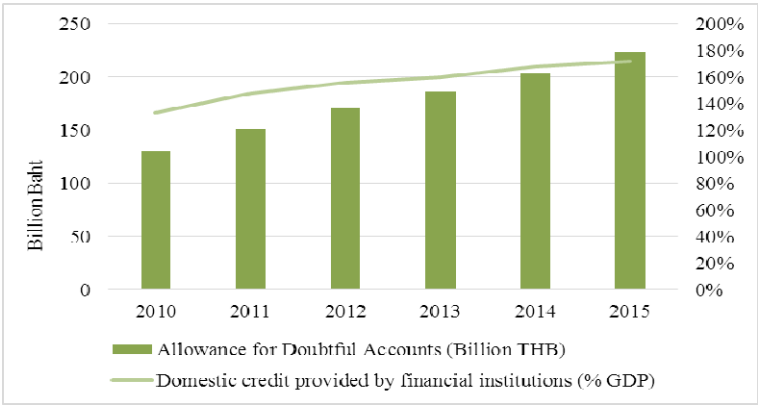

Figure 4. BAAC Allowance for Doubtful Accounts

Periods of high rubber prices like those between 2010 and 2012 can lead to a surge in new plantations, many of which are poorly planned and located. Prior research criticized suboptimal selection of rubber plantation lands for increasing environmental risks. Farms born out of desperation can also lead to lower NR prices when oversupply occurs following the 5 to 7-year gestation period for new trees. Meanwhile, farmers who fail to remove trees over age 30 reduce efficiency of their lands (Rubber Board, 2002). Thus, land management is an integral part of the science of farming that has been overlooked, which has detrimental environmental and economic effects.

3.5 Evolution of Sufficiency Economy

Thailand 4.0 aims to create "smart farmers" who use technology and manage efficiencies more precisely (Royal Thai Embassy Washington DC, 2017). Several authors on the subject recommended Thailand expand its rubber industry into downstream industries so the country can capitalize on what appears could be a natural comparative advantage in export-quality rubber products (Kampan, 2016; Yamamoto, 2016). Updated and upgraded farming methods would undoubtedly improve sustainability and competitiveness, however, it remains uncertain how farmers can fund any elaborate improvements.

3.5.1 Financing Technology Acquisition

Saidur & Mekhilef (2010) discussed energy usage in the rubber industry in Malaysia, where about 90 percent of domestically-farmed NR is consumed and processed domestically. By comparison, roughly 90 percent of Thai

NR is exported (Doner & Abonyi, 2013), thus increasing energy consumption along the supply chain. Yamamoto (2016) recommended locally washing, processing, drying and packaging RSS rather than selling STR directly from farms. Forward integration via technology adoption would reduce transportation costs and emissions, provide farmers with greater income, and improve quality but at a cost that smallholders usually cannot afford.

Thailand's debt has exceeded its revenues for nearly two decades and the margin has only increased since the economy turned volatile following the global financial crisis. With budgets already stretched, farmers cannot rely on the government to foot the bill. The government already subsidizes interest rates for farmers at the state-sponsored Bank for Agriculture and Agricultural Cooperatives (BAAC), where the number of accounts in delinquency and default has steadily risen for years (BAAC 2014, 2015).

Domestic credit has also risen consistently for over a decade (World Bank, 2017a), but most of it appears to have gone toward car loans and consumer credit rather than small business expansion. Considering that small farmers can most often only qualify for a loan from the state-owned BAAC, personal loans and credit are not a feasible option for the mainstream smallholder. The World Bank (2017b, p. 55) found only one in ten SMEs in Thailand has a loan or line of credit, further showing that private lending is not an appropriate solution. Yamamoto (2016) suggested institutional support or cooperative purchasing for community use. While farmers usually lack the legal knowhow to construct corporations, the collective juristic person appears the most attractive option for raising capital. To accomplish any sort of scaled objectives on cooperatives, local government organization and oversight would be essential as subsistence farmers are not capable of such enterprise without guidance.

3.5.2 The Base Case: Better Agronomics

To take advantage of legal, financial, and technological options available in the marketplace, farmers or their agents need to be well-informed and able to make sound business decisions. Ideally, farmers themselves should have a bachelor's degree in a related field. In Thailand, however, they are more likely to have finished at most primary school. Currently, people of all ages in Thailand are undereducated, lacking the basic skills and knowledge required to function in a competitive economy whether agricultural, technological, financial or other. Maybe after several generations, something resembling universal secondary education can be achieved, but that goal is far from reality today.

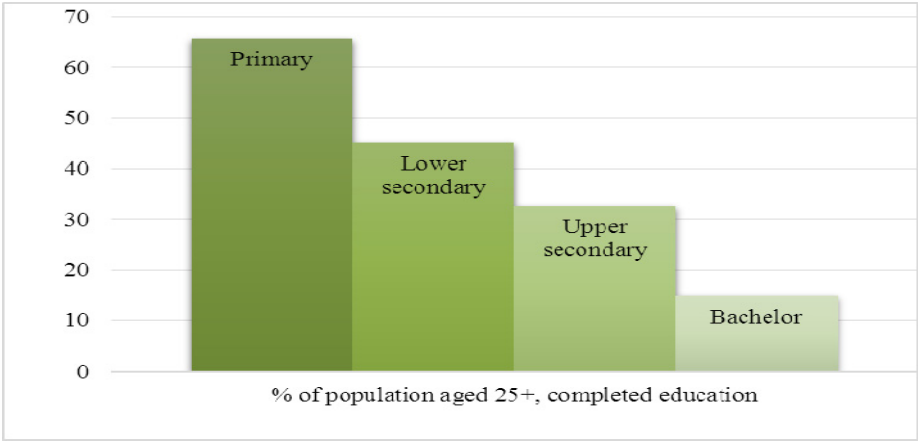

Figure 5. Thailand education deficit

Of course, in today's wired and connected world, everybody has access to knowledge for only the price of a mobile phone subscription. In Thailand, where there were an average 1.53 mobile phone connections per person in 2015, there is potential. However, while the percent of Thai people using the internet grew by more than 1100 percent between years 2000 and 2015, still less than half of the population uses it (World Bank, 2017a). In a global survey, Kemp (2015) found that although social media penetration in Thailand is roughly 50 percent, internet use rates are lower than global averages and growth is flat while e-commerce activity is low compared to other nations surveyed. Thais ranked fifth globally in time spent on social media, but one can safely assume that time spent sharing photos and liking posts on social network feeds will not translate to improved rubber farming techniques.

One of the key facts that farmers would find if they were using the internet for work-related research is that rubber has a long history of being a low-priced crop. In fact, the average price of NR was only over $1/lb for 79 months between January 1980 and May 2017, and all of those months were since May 2006. There was a price spike in the aftermath of the 2008 financial crisis where NR price rose to a peak of nearly $3/lb in early 2011 and

then steadily fell back down to 55 cents/lb by early 2016. Coincidentally, the area of land under rubber plantations grew significantly during the upswing in prices, and after about 5 years of gestation for new trees, oversupply helped bring the price of rubber down. Graphing NR price gives us a linear trendline equation where the slope is only 0.0066x, meaning the average price of rubber increases a mere 0.66 cents per month, nowhere near enough to cover rises in costs.

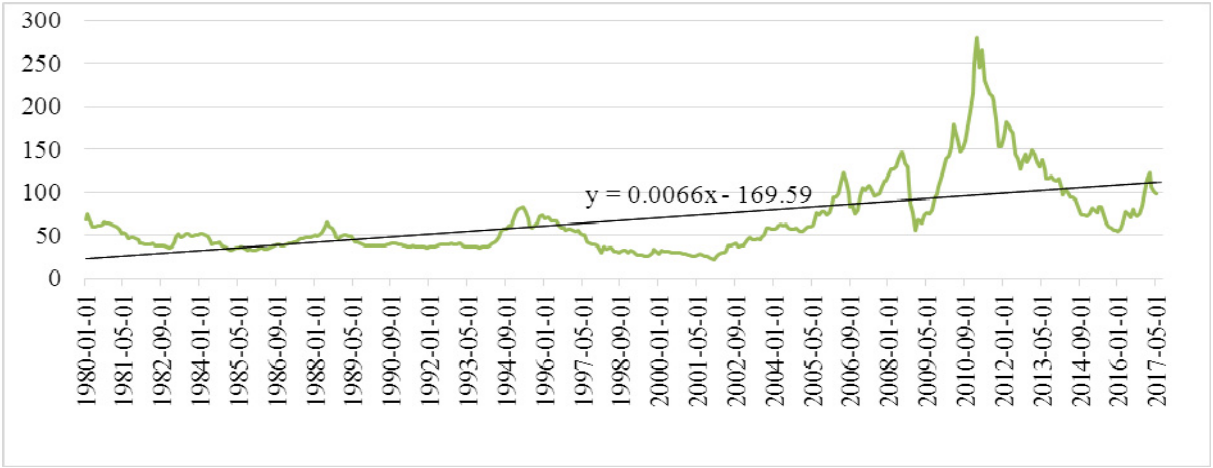

Figure 6. Price of rubber with linear trendline ($0.01/lb)

Options for farmers to improve income and quality of life are few and far between without technical knowledge or pursuit of education, and lacking financial support. One thing is clear, though, the way forward is not to haphazardly plant more rubber trees in hopes of a nearly-miraculous surge in prices. Instead, smarter maintenance of existing farms is essential. Pragmatic analysis of the farming situation that takes into account the type of social and financial austerity of the people yields few alternatives other than government promotion of better farming practices under the sufficiency economy. Poungchompu & Chantanop (2015) recommended the Thai government, probably via the military and BAAC, make site visits to farms and demonstrate tapping and land management methods. Empirical studies have shown NR farmers who also tended fruit, fish, livestock, and pigs had incomes that were one-third or more greater than monocrop NR farmers (Cherdchom, Prommee & Somboonsuke, 2002; Jongrungrot, Thungwa & Snoeck, 2014). Monocropping offers farmers a sense of simplicity, but studies have shown there is no economic justification for limiting the number of income sources to only rubber; still, disseminating such information and making it understood in practice could present significant challenges.

4. Conclusion

This research confirmed that the price of synthetic and natural rubber changes with the price of oil. Since SR can be a substitute for NR, and vice versa, their prices alternate with one higher while the other is lower. This study supported prior research and demonstrated when the price of oil rises, so does the price of SR, which drives increased demand for NR that in turn leads to higher NR prices. Statistical analyses showed the price of Brent crude oil is a very good predictor of the price of RSS. The research also showed that GDP and GDP per capita in China, Japan, and the United States share moderate to high significant positive correlations with RSS price. Considering the mass of data and commentary on the subject, one can deduce that oil price is a corollary to GDP, or conversely that GDP growth changes are responses to oil price changes, all of which affects rubber commodity prices.

Unlike prior research, this study did not find any significant relationship between exchange rate (THB/USD) and NR price. A multitude of interfering factors are considered present in the NR macro-environment, so it was impossible to isolate variables and pinpoint exactly what causes price fluctuations over time. One area of particular concern is antitrust in rubber industries as billions of dollars in fines have been levied against multinational corporations in recent years, which if viewed in the context of abnormal volatility in NR markets appears to suggest pervasive market manipulation. Whether or not Thai government subsidies and price intervention is helping or harming NR price stability and growth in the long term remains unknown. Also unknown is any extent to which domestic Thai middlemen, wholesalers and exporters have engaged in price fixing, but due to the relatively high likelihood of anticompetitive and predatory behavior in domestic Thai NR

trades, the Thai government should stay vigilant of suspicious activity and prosecute offenses when possible to deter such conduct.

Unlike prior research, this study did not find a significant relationship between annual rainfall and NR price, production, or export. Given the palpable manner in which heavy rainfall negatively impacts agriculture in general, the present findings regarding rainfall may be unreliable. Flooding in particular has become a threat to sustainable and competitive NR farming in parts of southern Thailand, so further research should be conducted on that subject focusing only on local plantations. Frequency of extreme weather events like flooding hinted at the potentially disastrous effects that climate change could manifest in the future. To help prevent climate change, farmers in the region should reduce or abandon carbon-intensive activities like slash-and-burn farming and clear-cutting natural forest. Literature found improper land management contributed to increased carbon emissions, soil degradation, erosion, and generally had negative impacts on waterways in the surrounding ecosystem.

Individual farmers were found to be poorly educated, which makes them unlikely to discover and implement improvement plans such as technology adoption or usage of optimal farming methods without government or other outside support. Ideally, smallholder farmers should form cooperatives which collectively borrow investment capital from BAAC to purchase drying, kneading, pressing and other processing technologies. Meanwhile, other industry shareholders with more access to funding should integrate forward into downstream rubber industries, ultimately making Thailand a one-stop shop for NR products from farmed raw materials to export quality finished goods. At the same time, farmers who are unable to engage in higher industrial pursuits should at very least stop monocropping; instead, they should incorporate fruits, fish, livestock, or pigs into their operations to increase and stabilize incomes.

Ensuring the sustainability and competitiveness of Thailand's NR industry is a multifaceted undertaking. While sustainability generally refers to environmental conditions, in Thailand there are human aspects to the term since a family simply cannot sustain a profession whose income does not exceed its costs. As inflation increases farm-related costs and NR prices fail to rise concurrently, farmers feel the pinch while downstream industries like tire manufacturers continue to improve their profit margins. Time and again, the burden has fallen on the Thai government to intervene and pay farmers a price for NR that at least covers their costs, but such an arrangement is inherently unsustainable. A true remedy to the problems Thai NR farmers have faced in the past couple decades includes an upgrade to their operations, whether by adopting advanced technologies or by simply applying more precise agronomics to their plots. More scientific methods at the farm and in the supply chain will improve quality, which in turn increases the competitiveness of Thailand's rubber industry, and a more competitive industry is a more profitable industry. With assistance from the Thai government, industry groups, academics, and other stakeholders, Thai farmers can undoubtedly overcome the obstacles in their way and secure the livelihoods of their families for generations to come.

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