Sustainability and Competitiveness in Thai Rubber Industries

ADAM TANIELIAN

Abstract

This article assesses the 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 price. Moderate to strong positive relationships were also found between natural rubber price and the gross domestic products of Japan, China and the United States. Criminal antitrust behaviour in the 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 that Thai rubber farmers can best improve their livelihoods through the collective purchase and use of new technologies and by integrating into downstream supply chain industries. At the very least, farmers are urged to abandon monocrop methods and supplement their incomes with fruit, fish, livestock or pigs.

Keywords: *Natural rubber, agronomics, southeast Asia, international trade*

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 comes from Thailand – the world's top natural rubber (NR) producer and exporter. Thailand, Indonesia and Malaysia account for about 70 per cent of the world's NR, with Thailand contributing more than half of their combined 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 tyres (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 these gargantuan numbers, rubber farming is generally still conducted as a family business. More than 85 per cent of the world's and 90 per cent of Thailand's rubber plantations are operated by smallholders whose farms are as modest as 0.3ha (Jongrungrot, Thungwa and Snoeck 2014; Yamamoto 2016). Whereas Malaysia has transitioned from farming to higher value finished products, Thailand still largely specializes in raw materials, STR and RSS (Doner and Abonyi 2013). Thailand is now seeking to create opportunity, value, and income for NR farmers, but challenges persist.

Research Objectives and Value

This research is designed to understand factors currently limiting the sustainability and competitiveness of Thailand's rubber farming industry, particularly smallholder operations. Literature on the subject provides significant insight into environmental and economic factors, but the research to date is generally compartmentalized and incomplete. Environmental research lacks detailed economic and business analysis (e.g. Fox et al. 2014a, 2014b; Giambelluca, Chen and Ziegler 2016; Ives 2013). Likewise, studies that weigh in heavily on economics typically fail to consider social, environmental, legal or other factors (e.g. Chawananon 2014; Petchseechoung 2016; Romprasert 2009; Thailand Board of Investment 2016; Yamamoto 2016). The literature commonly reviews, analyses and recommends policies 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 expenditure in order to upgrade agricultural operations while they overlook financial constraints.

Prior research has shown associations between market variables (i.e. oil price, synthetic rubber price, natural rubber price, rainfall), but single studies rarely assess multiple or complex relationships. This article aims to independently evaluate interrelationships between and among

disparate factors such as oil price, world consumption of synthetic rubber, exchange rate, rainfall, foreign gross domestic product (GDP) and GDP per capita. The strength and direction of those relationships lead to discussion of interfering forces including natural disasters, antitrust, protests and government price intervention. Considering the complex matrix of factors influencing the price of NR, and therefore incomes of smallholders in Thailand, analyses and recommendations are provided that promote sustainability and competitiveness in Thai NR industries. The formation of farming cooperatives that function as juristic persons, together with domestic forward integration into downstream supply chain businesses, are considered essential for growth and stability. This research also explores measures that farmers can take under the classic 'sufficiency economy' model for cases where adoption of costly technologies is not an option.

The article also offers insights into Thai rubber markets via novel analysis of multiple forces in rubber markets – political, economic, environmental and social. The uncommon scope of the research propounds multifaceted results and recommendations. Rather than focusing on one small part of the Thai rubber market, the research provides an original, holistic examination of the industry from diverse angles, resulting in eclectic guidance for all stakeholders in Thailand. Due to the comprehensive nature of the study, results and recommendations may be scalable or relevant to smallholder farmers in other countries, or in developing economy rubber industries.

Literature Review

Chawananon (2014) studied the interrelationships between rubber production and price, rainfall, THB/USD exchange rates, rice prices, 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, which creates greater demand for rubber. Chawananon also found that the demand for rubber is generally not affected by changes in price – that is, rubber demand is price inelastic. Several authors have found rainfall negatively affects production of rubber (Mesike and Esekhade 2014; Much, Tongpan and Sirisupluxana 2013; Chawananon 2014).

Just as farmers' decisions to monocrop rubber or intercrop are influenced by market prices of alternative crops, natural rubber consumers' decisions are affected by the price of its main competitor, synthetic

rubber. Being a petroleum product, synthetic rubber prices are affected 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 (Khin, Mohamed, and Hameed 2012; Petchseechoung 2016; Romprasert 2009).

Synthetic rubber does not create an existential threat to NR production since NR is a renewable resource whereas petroleum is nonrenewable and may become a scarce commodity in the 21st century (IEA 2017; Murray 2016; OPEC 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 on 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 immediate issue for small farm owners, and thus for nearly every rubber farmer in Thailand. Average rubber farm sizes in Thailand are between 4 and 5 hectares, and nearly all of these smallholders monocrop, resulting in less than USD 500 net income per year per ha (Cherdchom, Prommee and Somboonsuke 2002; Jongrungrot, Thungwa and Snoeck 2014; Ketterings et al. 1999; Poungchompu and Chantanop 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 per cent to the country's GDP (World Bank 2017a). While USD 2,000–3,000 per year puts Thai rubber farmers well above the global poverty threshold, it does little to provide them and their families with an 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 (Viswanathan 2008). Studies consistently recommend addition of other crops alongside rubber trees to supplement income (Cadisch 2016; CIRAD 2013; Jalloh et al. 2009; Langenberger and Yu 2016; Wang et al. 2014); however, smallholders face significant difficulty in crop diversification (Yamamoto 2016). Jongrungrot, Thungwa and 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 and skills.

Labour is ubiquitous in Asia, but knowledge and skills are often at a deficit in agricultural communities. In Thailand, only 65 per cent of people aged 25 or older had completed primary school in 2016; those educational attainment rates fall to 45 per cent, 32 per cent and 15 per cent for lower secondary, upper secondary and undergraduate university, respectively (World Bank 2017a). A glut of labourers with low education has translated into short-sighted, inefficient, and inadvisable decisions in rubber industries throughout the region. Since 2000, for example, the area of land in south-east Asia under rubber farms has increased by more than 50 per cent; 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 et al. 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 (Ahrends et al. 2015; Giambelluca, Chen and Ziegler 2016; Ives 2013). By 2050, rubber farming in mountainous regions is expected to increase fourfold (Fox et al. 2014a), and across the south-east Asian region NR farming could double or triple in the same time frame (Ziegler, Fox and Xu 2009). Growth in NR plantations is fuelled by increasing demand for rubber, generally for tyres 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, Washington DC 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 – the technological and scientific evolution of small farms would provide social and psychological boosts alongside economic gains.

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 US Federal Reserve Bank of St Louis (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.

Limitations

The study is limited by the quantity and quality of data available. Although various institutions make data publicly available, other data are only available via subscription services. The research budget limited the amount and detail of data retrieved.

Pearson correlations, while useful in showing relationships between two variables, do not control for interfering factors. Considering the complexity of the data and number of potential restricting variables, Pearson coefficients may not provide a complete representation of relationships among the data. Where the presence of confounding variables was obvious, partial correlations provide more accurate details of associations.

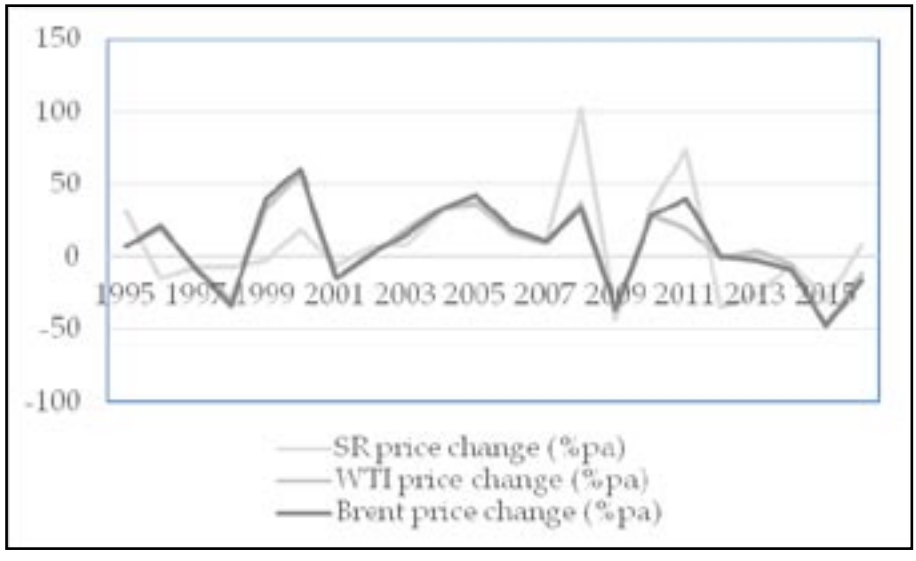
Results and Discussion

Price and Economic Indicators

Oil and Rubber

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.

FIGURE 1. Oil price and SR price



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.

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

TABLE 1. Pearson bivariate correlations for oil, SR price, production and consumption

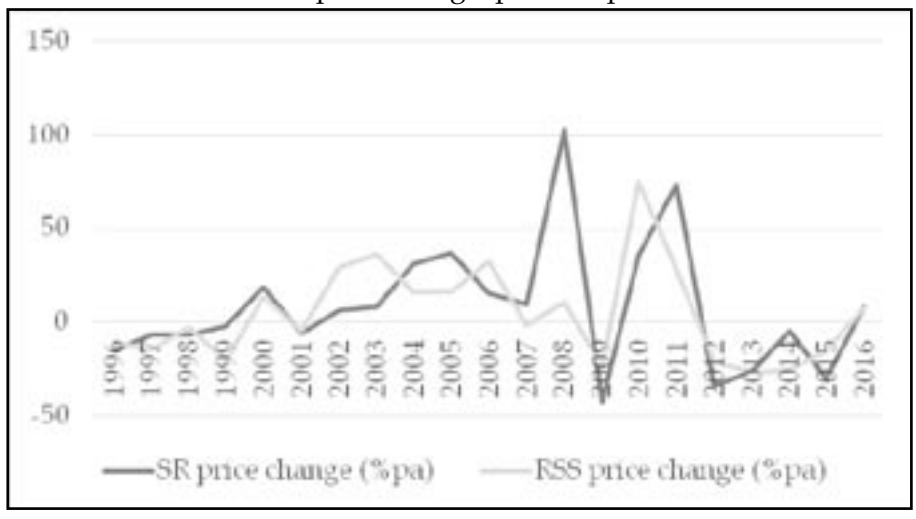
Correlations						
		SR Price YoY% Change	Brent Oil Price YoY% Change	WTI Oil Pr YoY% Change	World SR Prod YoY% Change	World SR Cons YoY% Change
SR Price YoY% Change	Pearson Correlation	1	.648**	.629**	.282	.253
	Sig. (2-tailed)		.001	.002	.216	.268
	N	22	22	22	21	21
Brent Oil Price YoY% Change	Pearson Correlation	.648**	1	.982**	.483**	.447**
	Sig. (2-tailed)	.001		.000	.027	.042
	N	22	22	22	21	21
WTI Oil Pr YoY% Change	Pearson Correlation	.629**	.982**	1	.463*	.444*
	Sig. (2-tailed)	.002	.000		.034	.044
	N	22	22	22	21	21
World SR Prod YoY% Change	Pearson Correlation	.282	.483*	.463*	1	.970**
	Sig. (2-tailed)	.216	.027	.034		.000
	N	21	21	21	21	21
World SR Cons YoY% Change	Pearson Correlation	.253	.447*	.444*	.970*	1
	Sig. (2-tailed)	.268	.042	.044	.000	
	N	21	21	21	21	21

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

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 supports prior research on the relationship between SR and NR, and when combined with correlations presented in Table 1, prior research

FIGURE 2. SR and RSS price change, per cent per annum



on relationships between oil prices, SR and NR prices are supported. Further examination via Pearson bivariate correlations showed a strong significant

TABLE 2. Pearson bivariate correlations for oil, STR and RSS

		WTI Oil Price ($/bbl)	Brent Oil Price ($/bbl)	TH RSS Price (THB/kg)	STR Price (THB/kg)
WTI Oil Price ($/bbl)	Pearson Correlation	1	.991**	.868**	-.645**
	Sig. (2-tailed)		0.000	0.000	.001
	N	22	22	22	22
Brent Oil Price ($/bbl)	Pearson Correlation	.991**	1	.887**	-.660**
	Sig. (2-tailed)	0.000		0.000	.001
	N	22	22	22	22
TH RSS Price (THB/kg)	Pearson Correlation	.868**	.887**	1	-.686**
	Sig. (2-tailed)	0.000	0.000		0.000
	N	22	22	22	22
STR Price (THB/kg)	Pearson Correlation	-.645**	-.660**	-.686**	1
	Sig. (2-tailed)	.001	.001	0.000	
	N	22	22	22	22

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

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 the STR price and oil, which raised questions of an interfering factor given that STR is a NR product whose price should follow a curve similar to RSS.

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, the 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 positive 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 per cent of variance in the data.

TABLE 3. Partial correlations oil, STR and RSS

Control Variables		WTI Oil Price ($/bbl)	Brent Oil Price ($/bbl)	STR 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

The regression equation is, *RSS price in THB = 14.051 + 0.873*(Brent price in USD)*

Oil prices affect SR prices, which affects NR demand and price, but oil prices are 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.

TABLES 4–5. Linear regression analysis for RSS and Brent oil price

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)

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.

GDP, Exchange Rate and Government Policy

NR is mainly produced in Southeast Asia, but it is consumed in every country in the world; 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 often threatened or taken to protest, demanding the Thai government intervene (Campbell 2013; Kaewjinda, Thepgumpanat, and

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 prime minister, Thaksin Shinawatra, sought an 'acceptable' price of US$ 1/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 US$ 1/kg only amounted to 30–31 THB/kg. Meanwhile, inflation increased the production costs for farmers who demanded 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 US$ 2 (Thaicharaoen, Hariraksapitak and Thepgumpanat 2017).

Exchange rate fluctuations seriously impact on 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' (Brereton-Fukui 2012; Danielsen 2017). Cumperayot and Kouwenberg (2016) found that 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 rates and NR prices, but this research did not support those historical studies. A Pearson bivariate correlation test showed no relationships between the RSS price and exchange rate significant to the 0.05 level.

Analysis confirmed moderate to strong positive correlations between RSS prices 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 the RSS price in the USA ($r = 0.654$) and China ($r = 0.584$) than GDP (US, $r = 0.652$; CN, $r = 0.576$) whereas in Japan, the RSS was more highly correlated with GDP ($r = 0.780$) than GDP per capita (0.755).

TABLE 6. 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).

Anticompetitive Behaviour

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 the RSS price. At the macro-level, myriad mitigating factors could be present. One possible explanation is the influence of price fixing and anticompetitive behaviour 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 tyre manufacturers in particular, have been caught fixing prices and rigging bids. Federal Courts in the United States fined Yamashita Rubber USD 11 million (*US v. Yamashita Rubber 2013*), Toyo Tire USD 120 million (*US v. Toyo Tire and Rubber 2013*), Bridgestone USD 425 million (*US v. Bridgestone 2014*), and Nishikawa USD 130 million (*US v. Nishikawa Rubber 2016*). Tyre manufacturers continue to face prosecution for anticompetitive behaviour in South Africa, India and elsewhere (*Goodyear and 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 USD 700 million in fines for price fixing and market sharing against an SR cartel consisting of Bayer, Dow, Eni, Shell, Unipetrol and Trade-Stormil (DeLuca and List 2007). Just before this, US Courts fined DuPont Dow USD 84 million for price fixing in SR markets (*US v. DuPont Dow Elastomers 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 that such anticompetitive behaviour 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 non-zero. 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 programmes also have had a sordid history, drawing complaints of excessive government spending and the presence of corruption (*Economist* 2003). Former Prime Minister Yingluck Shinawatra was fined USD 1.4 billion for criminal negligence in a costly, corruption-laden rice subsidy programme that aimed to pay farmers 50 per cent 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 and Yuthamanop 2012; Yee 2016). While the present research has no evidence supporting any antitrust claim against participants in Thai rubber markets, 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 behaviour, a missing link could be unearthed between Thai exporters and global firms such as those fined in the United States and Europe. While it is impossible to determine the degree to which corruption and other criminal business behaviour jeopardizes fair pricing for farmers, there is reason to suspect that the impacts are significant.

Environment

Sustainability is achieved when production of a product can be maintained at a certain level or rate. The term generally carries an environmental implication, so to be considered 'sustainable' the perpetuation of production must occur without depleting natural resources or damaging ecological balance. Rubber farming has a natural advantage in that it requires tree planting, 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 that 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 China and Indonesia, carbon emissions can skyrocket and biodiversity can be adversely affected (Arifin 2013; Source Intelligence 2016).

Carbon emissions, such as 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 that periods of severe rainfall negatively impact on rubber production and lead to periods of increased prices (Boonthanom 2017; Farchy 2010; Japan Ministry of Economy Trade and Industry 2012: 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.

TABLE 7. Agricultural and forest land growth 1995–2014, % of total land area in Thailand

Agricultural land growth	4.24%
Forest area growth	5.55%

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 of the whole of Thailand whereas rubber production is largely localized in the southern region. Unfortunately, data was not available for rainfall in Songkhla province alone. The nature and volume of reports demonstrating a relationship between rain and NR price or production suggest that the present correlation probably has unexplained variables and may not be reliable.

Periods of high rubber prices such as 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 five- to seven-year gestation period for new trees. Meanwhile, farmers who fail to remove trees over age 30 reduce the 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.

TABLE 8. 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).

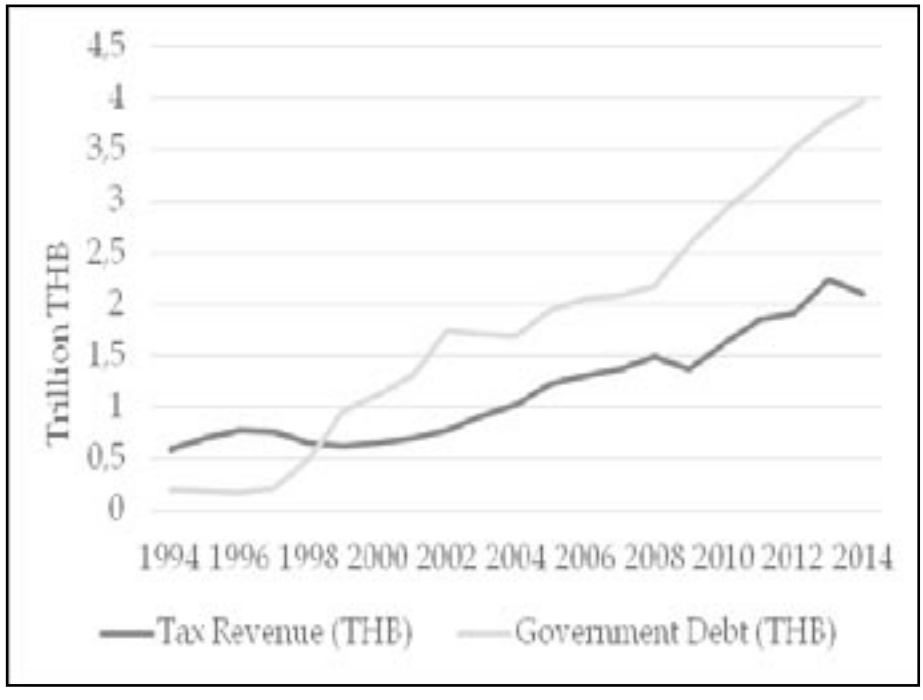
Evolution of Sufficiency Economy

Thailand 4.0 aims to create 'smart farmers' who use technology and manage efficiencies more precisely (Royal Thai Embassy, Washington DC 2017; Thailand Public Relations Department 2017). Several authors on the subject recommended that Thailand expands its rubber industry into downstream industries so that the country can capitalize on what appears could be a natural comparative advantage in export-quality rubber products (Doner and Abonyi 2013; 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.

Financing Technology Acquisition

Saidur and Mekhilef (2010) discussed energy usage in the rubber industry in Malaysia, where about 90 per cent of domestically farmed NR is consumed and processed domestically. By comparison, roughly 90 per cent of Thai NR is exported (Doner and Abonyi 2013), thus increasing energy consumption along the supply chain. Yamamoto (2016) recomm-

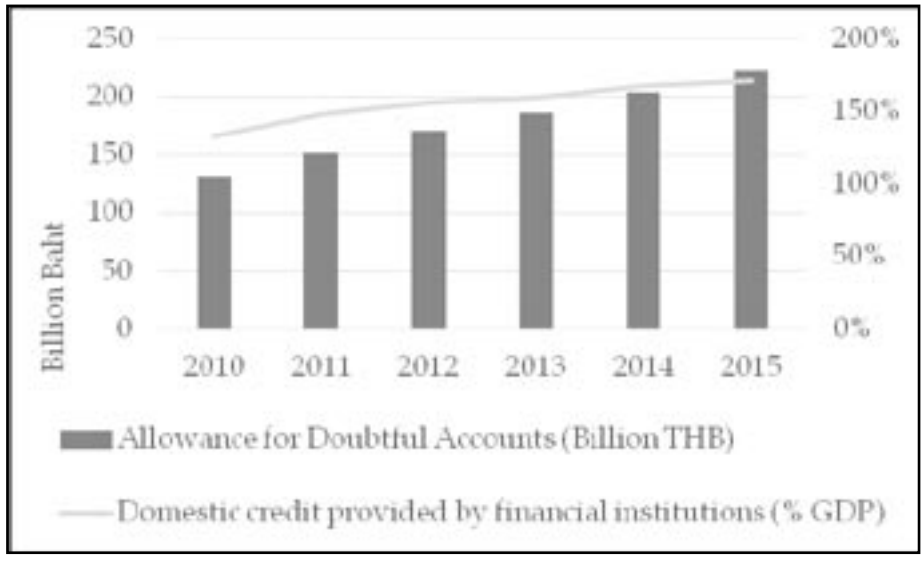
FIGURE 3. Thailand tax revenue and government debt



ended 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).

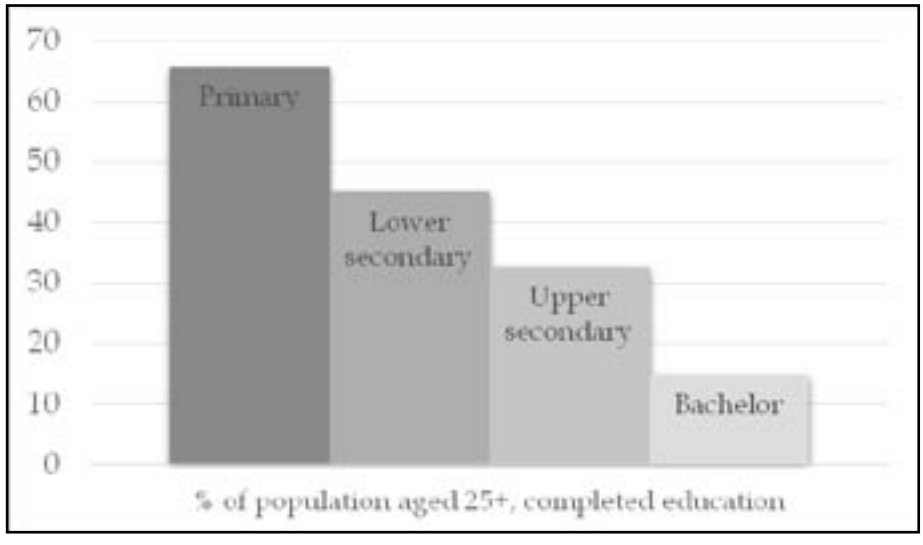
FIGURE 4. BAAC allowance for doubtful accounts



Domestic credit also rose consistently between 2007 and 2017 (World Bank 2017a), but most of it appears to have gone towards 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-sponsored BAAC, personal loans and credit are not a feasible option for the mainstream smallholder. The World Bank (2017b: 55) found that only one in ten small and medium-size enterprises 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 objective on cooperatives, local government organization and oversight would be essential as subsistence farmers are not capable of such enterprise without guidance.

FIGURE 5. 2016 Thailand's education deficit



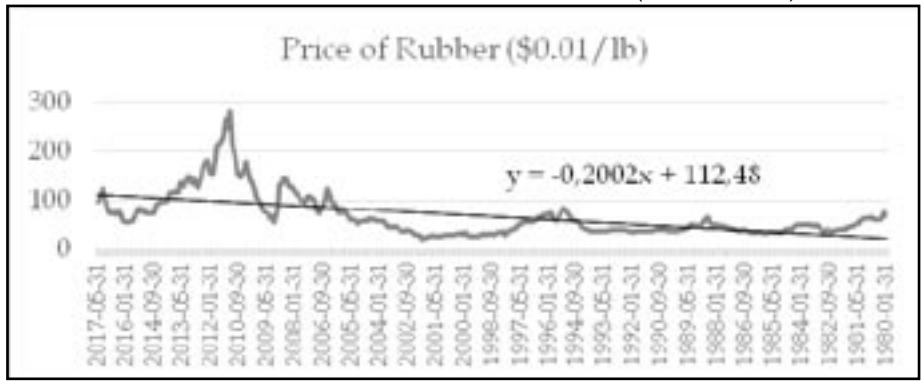
The Base Case: Better Agronomics

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.

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 was an average 1.53 mobile phone connections per person in 2015, there is potential. However, while the percentage of Thai people using the internet grew by more than 1.100 per cent between 2000 and 2015, still less than half of the population uses this facility (World Bank 2017a). In a global survey, Kemp (2015) found that although social media penetration in Thailand is roughly 50 per cent, internet use rates

are lower than global averages and growth is flat while e-commerce activity is low compared with 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 into improved rubber farming techniques.

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



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 US$ 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 US$ 3/lb in early 2011 and then steadily fell back down to US$ 0.55/lb by early 2016. Coincidentally, the area of land under rubber plantations grew significantly during the upswing in prices, and after about five 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.

Options for farmers to improve income and quality of life are few and far between without technical knowledge, pursuit of education and 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 and Chantanop

(2015) recommended that the Thai government, probably via the military and BAAC, make site visits to farms and demonstrate tapping and land management methods. Empirical studies showed that 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 and Somboonsuke 2002; Jongrungrot, Thungwa and Snoeck 2014; Viswanathan 2008). 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;yet disseminating such information and making it understood in practice could present significant challenges.

International Cooperation

Rubber is a truly global product; it is farmed mostly in the Asian-Pacific tropics, but it is used around the world in multifarious products. Virtually every human uses rubber at some point in their life; for the global middle and upper classes, rubber is part of daily life. Millions of people make a living from rubber while billions of people benefit from its uses. Rubber is as essential as any other natural resource, yet it garners relatively little attention from intergovernmental and trade organizations. Although supply and price disruptions could be detrimental to macroeconomic performance, rubber is somewhat of a cottage industry – loosely regulated with minimal institutional investment or research upstream in the supply chain. Manufacturing technologies have been honed to perfection at the end of the product manufacturing process where multinational corporations have exceptional access to capital, but technology has scarcely advanced in the past 50 years for farmers who have little to no credit.

One reason for the imbalance between raw material and manufacturing stages is that governments have coordinated efforts, harmonized policies and streamlined procedures to make things easier for importing and exporting companies, like thousands of those that make and deliver finished rubber products. In contrast, governments have been less motivated to tend to the interests of millions of rubber farmers; and in Thailand, where the government has tried to enforce price controls, the efforts have been ineffectual or counterproductive in the medium to long term. Therefore, if governments worked together on rubber issues, as they have done with oil and other natural resources, more equitable outcomes may be possible for all.

Public funding of economic research groups may well spur private interest and possibly investment. The International Rubber Study Group (IRSG), for example, has been trying to bring rubber producers and consumers together since 1944 (IRSG 2018). The IRSG's membership is strong on the consumption side with China, India and the EU, but the group has failed to attract major producing countries such asThailand, Indonesia, Malaysia, Vietnam and the Philippines. Similarly, the Association of Natural Rubber Producing Countries has been representing more than 90 per cent of the world's rubber suppliers since 1970, but has failed to bring those producers together with consumers outside South and East Asia (ANRPC 2018). Business competition and international economics are fields of intense competition where buyers and sellers can be adversaries, but their objectives are not entirely at odds. Quality and efficiency, for example, are intrinsically valued by all stakeholders. Accordingly, governments and institutional stakeholders should consider combining their efforts in support of the entire supply chain, from the tree to end consumer.

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. The study supported prior research and demonstrated that 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 con-

text of abnormal volatility in NR markets appears to suggest pervasive market manipulation. Whether or not Thai government subsidies and price intervention are helping or harming NR price stability and growth in the long term remains unknown. Also unknown is the 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 behaviour in domestic Thai NR trades, the Thai government should stay vigilant in respect of suspicious activity and prosecute offences 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 on 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 such as 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. The literature found that improper land management contributed to increased carbon emissions, soil degradation and erosion, and it 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 the 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 such as tyre 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 more reliable 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, competitiveness, and profitability in Thailand's rubber industry. With assistance from governments, 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.

ADAM TANIELIAN is an English Instructor at King Faisal University in Hofuf, Saudi Arabia, and Researcher at the Thailand National Institute of Development Administration. He holds a PhD in Law, an MA in Business Administration, and BAs in Business and Mathematics. His research interests are varied. Since 2013, he has published works on issues relating to international law, economics, energy policy, human rights and foreign language learning. Email: adam.tanielian@gmail.com

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