UNIVERSITI PUTRA MALAYSIA

TECHNICAL EFFICIENCY AND RISK OF SMALLHOLDERS' RUBBER PRODUCTION IN SOUTH SUMATRA, INDONESIA

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By

LINA FATAYATI SYARIFA

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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November 2019

Chairman : Professor Datuk Mad Nasir Shamsudin, PhD
Faculty : Agriculture

In Indonesia, particularly in South Sumatra, rubber production is characterised by risks that result production variability. The presence of risks not only affected rubber output but also farmer's decision with regard to input use. Another problem is that the productivity of smallholders' rubber was lowest compared to that of private and government estates. The general objective of this study is to determine the technical efficiency and to estimate production risk in smallholders' rubber in South Sumatra. The specific objectives are: (1) to estimate the level of technical efficiency of smallholders' rubber production by applying Parametric (Stochastic Frontier Analysis integrated with Just and Pope Model) and Non-parametric (Bootstrap DEA) approaches; (2) to identify and determine factors affecting technical efficiency of smallholders' rubber production; and (3) to estimate the level of production risk in smallholders' rubber production

The data collected covered the yields obtained of rubber, technological inputs and farmers' demographic/socio-economic characteristics. The selection of 384 respondents was conducted through the combination of the purposive, multi-stage and random sampling techniques. The study was carried out in South Sumatra Province, Indonesia. This study employed the parametric approach (Stochastic Frontier Model integrated with Just-Pope model) and the non-parametric approach (bootstrap DEA analysis).

Results of Stochastic Frontier Analysis indicated that, on average, the sampled farms in this study had the technical efficiency score at 0.72 while when applied to data envelopment analysis (DEA), the mean technical efficiency estimate was 0.80. Then, bootstrap DEA was applied to correct bias estimation of DEA. Under bootstrap DEA, the mean technical efficiency reduced to 0.76. The finding also showed that production input factors of Weighted Rubber Trees (WRT), fertiliser, herbicide and labour were essential in rubber production development. All those production inputs increased the mean output in the production process. The sum of all of inputs elasticities indicated that rubber farms had decreasing return to scale (0.82). In this study, production risk was jointly explained by fertiliser, herbicide and labour. Fertiliser and herbicide were not statistically significant concerning production risk. Meanwhile, labour was estimated statistically significant to be risk reducing-input. It implies that an increase in labour input will reduce output risk. Farmer's age, family size and education were found to be not significant concerning inefficiency effect model. Extension visit, farming experience, and recommended tapping system were significants to increase production efficiency. Lastly, adopting planting material of rubber clone was also evident to increase production efficiency.

This study concludes that production efficiency was explained by technical inefficiency and production risk. But the effect of inefficiency was greater than production risk. This implies that it is necessary to pay more attention to farmers' practices and the existence of production risk. In particular, the estimation of technical efficiency without accounting the risk effect on production output may cause incorrect estimation results.

The results of the study showed that labor was risk-reducing input and some factors (experience, extension visit, recommended tapping system and planting material of rubber clone) had significant contributions to increase technical efficiency. Thus, it is suggested that farmers are encouraged to use more labour input on rubber farm to reduce risk. Then, the farmers should also be encouraged to apply recommended tapping system S/2 d2 and rubber clone. The government should also intensify research and development activities to produce new high yielding rubber clones and intensify extension visit by involving experienced farmers in order to improve farmer's knowledge on farming management.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KECEKAPAN TEKNIKAL DAN RISIKO PENGELUARAN GETAH OLEH PEKEBUN KECIL DI SUMATERA SELATAN, INDONESIA

Oleh

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Di Indonesia, khususnya di Sumatera Selatan, pengeluaran getah adalah dicirikan oleh risiko yang mengakibatkan kepelbagaian dalam hasil pengeluaran. Kehadiran risiko-risiko ini bukan sahaja menjejaskan pengeluaran getah tetapi turut mempengaruhi keputusan pekebun dalam mengambil kira penggunaan input. Masalah lain pula ialah, produktiviti oleh pekebun kecil adalah paling sedikit berbanding dengan estet milik swasta dan juga estet milik kerajaan. Objektif umum kajian ini dijalankan adalah untuk menentukan kecekapan teknikal dan juga menganggarkan risiko pengeluaran getah oleh pekebun kecil di Sumatera Selatan. Objektif-objektif khusus ialah: (1) untuk menganggarkan tahap kecekapan teknikal pengeluaran getah oleh pekebun kecil dengan mengaplikasikan Parametrik (model sempadan stokastik dengan integrasi model Just-Pope) dan pendekatan bukan parametrik (analisis bootstrap DEA); (2) untuk mengenalpasti dan menentukan faktor-faktor yang menjejaskan kecekapan teknikal pengeluaran getah oleh pekebun kecil; dan (3) untuk menganggarkan tahap risiko pengeluaran dalam pengeluaran getah oleh pekebun kecil.

Data yang telah dikumpul meliputi hasil yang diperoleh daripada getah, input teknologi, demografi pekebun/kriteria sosioekonomi. Pemilihan seramai 384 responden telah dilakukan melalui kombinasi teknik pensampelan iaitu secara pemilihan, secara pelbagai peringkat, dan secara rawak. Kajian ini telah dijalankan di Daerah Sumatera Selatan, Indonesia. Kajian ini melibatkan penggunaan pendekatan parametrik (model sempadan stokastik dengan integrasi model Just-Pope) dan pendekatan bukan parametrik (analisis bootstrap DEA).

Hasil daripada analisis sempadan stokastik menunjukkan bahawa, pada keseluruhannya, lading-ladang yang telah digunakan sebagai sampel dalam kajian ini mempunyai skor kecekapan teknikal pada 0.72 manakala apabila digunakan pada

analisi penutupan data (DEA), anggaran purata skor kecekapan teknikal ialah 0.80. Kemudian bootstrap DEA digunakan untuk membetulkan anggaran berat sebelah DEA. Dibawah bootstrap DEA, purata kecekapan teknikal telah berkurang kepada 0.76. Penemuan ini juga menunjukkan bahawa faktor input pengeluaran Pokok Getah Berat (WRT), baja, herbisida dan tenaga buruh adalah penting dalam pembangunan pengeluaran getah. Semua input pengeluaran meningkatkan purata output dalam proses pengeluaran. Jumlah semua keanjalan input menunjukkan bahawa ladang getah telah menurun kembali ke skala (0.82). Dalam kajian ini, risiko pengeluaran telah dijelaskan secara bersama oleh baja, herbisida dan juga tenaga buruh. Baja dan herbisida tidak ketara secara statistik melibatkan risiko pengeluaran. Sementara itu, buruh dianggarkan secara statistik sebagai penting sebagai input pengurangan risiko. Ini menunjukkan bahawa peningkatan input buruh akan mengurangkan risiko pengeluaran. Umur petani, saiz keluarga dan tahap pendidikan didapati tidak signifikan dalam melibatkan kesan ketidakcekapan model. Lawatan lanjutan, pengalaman pertanian dan sistem penorehan yang disyorkan adalah signifikan dalam meningkatkan kecekapan pengeluaran. Akhir sekali, mengamalkan bahan penanaman getah klon juga jelas meningkatkan kecekapan pengeluaran.

Kajian ini menyimpulkan bahawa kecekapan pengeluaran dijelaskan oleh ketidakcekapan teknikal dan risiko pengeluaran. Tetapi kesan ketidakcekapan adalah lebih besar berbanding risiko pengeluaran. Ini menunjukkan bahawa perhatian yang lebih perlu diberikan kepada amalan petani dan kewujudan risiko pengeluaran. Secara khususnya, anggaran kecekapan teknikal tanpa mengambil kira kesan risiko ke atas output pengeluaran boleh menyebabkan keputusan anggaran yang salah.

Hasil kajian menunjukkan bahawa buruh adalah input pengurangan risiko dan beberapa faktor (pengalaman, lawatan lanjutan, sistem penoreh yang disyorkan dan bahan penanaman getah klon) mempunyai sumbangan yang signifikan dalam meningkatkan kecekapan teknikal. Oleh itu, adalah dicadangkan agar para pekebun digalakkan menggunakan lebih banyak input buruh di ladang getah untuk mengurangkan risiko. Kemudian, petani juga harus digalakkan untuk mengaplikasikan sistem penunjuk yang disyorkan S/2 d2 dan getah klon. Pihak kerajaan juga harus meningkatkan aktiviti penyelidikan dan pembangungan untuk menghasilkan getah klon baru yang dapat mengeluarkan getah dengan banyak dan memperhebatkan lawatan lanjutan dengan melibatkan para petani berpengalaman untuk meningkatkan pengetahuan petani mengenai pengurusan pertanian.

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This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) were adhered to.

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BCC	Banker, Charnes, and Cooper
BC-CRS	Bias Corrected- Constant Return to Scale
BC-VRS	Bias Corrected- Variable Return to Scale
CCR	Charnes, Cooper and Rhodes
CLRM	Classical Linear Regression Model
CNLRM	Classical Normal Linear Regression Model
COLS	Corrected Ordinary Least Square
CRS	Constant Return to Scale
DEA	Data Envelopment Analysis
DGP	Data Generating Process
DMUs	Decision making Units
FOB	Free on Board
HES	Hicks Elasticity of Substitution
ITRC	International Tripartite Rubber Council
JB	Jarque-Bera
J-P Model	Just and Pope Model
LR	Likelihood Ratio
MLE	Maximum Likelihood Estimation
NES	Nucleus Estate-Smallholder
OLS	Ordinary Least Square
RREEC	Replanting-Rehabilitation and Extension of Export Crops
RSS	Ribbed Smoked Sheets
WRT	Weighted Rubber Trees

SFA	Stochastic Frontier Analysis
SIR	Standard Indonesian Rubber
SMS	Supply Management Scheme
SRDP	Smallholder Rubber Development
TE	Technical Efficiency
TI	Technical Inefficiency
TCSDP	Tree Crop Smallholder Development Projects
TCSS	Tree Crop Smallholder Sector
TWT	Total Weighted Trees
VIF	Variance Inflation Factor
VRS	Variable Return to Scale

CHAPTER 1

INTRODUCTION

This chapter provides background of the study, problem statement, research questions, objectives and significance of the study. The background of the study was presented in Section 1.1. In Section 1.2, problem statement was explained. Research questions were presented in Section 1.3. Objectives of the study were presented in Section 1.4. Section 1.5 presented significance of the study. Finally, the organisation of the thesis was given in Section 1.6.

1.1 Background of the Study

In Indonesia, natural rubber was an important commodity as it contributed to the country's revenue (US$3.7 billion) and acted as a source of income for more than 2.4 million households in the rural areas in 2015 (Directorate General of Estate Crops, 2016). The world's production and consumption of rubber continued to increase in 2017. During the 2011-2016 periods, the production of natural rubber increased by 2.95% per year, i.e. from 11.24 million tonnes in 2011 to 13.38 million tonnes in 2017. Similarly, rubber consumption also rose by 2.89% per year, i.e. from 11.03 million tonnes in 2011 to 13.09 million tonnes in 2017 (Table 1.1).

Table 1.1 : World natural rubber production and consumption, 2011-2017

Year	Production ('000 tonnes)	Consumption ('000 tonnes)
2011	11,239	11,034
2012	11,658	11,046
2013	12,282	11,430
2014	12,142	12,181
2015	12,271	12,140
2016	12,451	12,587
2017	13,380	13,090

(Source: The International Rubber Study Group IRSG, 2018)

Currently, there are seven major natural rubber producing countries in the world, namely, Thailand, Indonesia, Vietnam, China, Malaysia, India and Cambodia. In 2017, Thailand was the leading producer with 4.76 million tonnes, followed by Indonesia in the second place with 3.41 million tonnes and Vietnam with 1.09 million tonnes (Table 1.2). However, yields produced by Indonesia were the lowest compared to other natural rubber producing countries (Table 1.3).

Table 1.2 : Major producing countries of natural rubber, 2011-2017

Country	Production ('000 tonnes)						
	2011	2012	2013	2014	2015	2016	2017
Thailand	3,569	3,778	4,170	4,324	4,473	4,519	4,755
Indonesia	2,990	3,012	3,237	3,153	3,145	3,208	3,409
Vietnam	789	877	949	954	1,013	1,032	1,086
China	727	802	865	840	794	774	779
Malaysia	996	923	827	669	722	674	739
India	893	919	796	705	575	624	714
Cambodia	51	65	85	97	127	145	194

(Source: The International Rubber Study Group IRSG, 2018)

Table 1.3 : Rubber productivity in main rubber producing countries, 2011-2017

Country	Productivity (Kg/Ha)						
	2011	2012	2013	2014	2015	2016	2017
Vietnam	1,716	1,720	1,728	1,692	1,688	1,680	1,697
India	1,818	1,823	1,676	1,576	1,471	1,434	1,455
Malaysia	1,500	1,462	1,400	1,370	1,410	1,400	1,420
Thailand	1,557	1,560	1,561	1,487	1,395	1,333	1,327
Cambodia	1,135	1,166	1,086	1,069	1,140	1,122	1,125
China	1,174	1,232	1,261	1,208	1,117	1,075	1,100
Indonesia	1,095	1,073	1,082	1,052	1,043	1,039	1,040

(Source: The Association Natural Rubber Producing Countries ANRPC as cited in *Dewan Karet Indonesia*, 2017)

1.1.1 Performance of the Indonesian Rubber Area

In general, the development of total rubber area in Indonesia showed an increase from 1980-2016 with an average growth of 1.18 percent per year i.e. from 2.38 hectares in 1980 to 3.64 million hectares in 2016 (Figure 1.1).

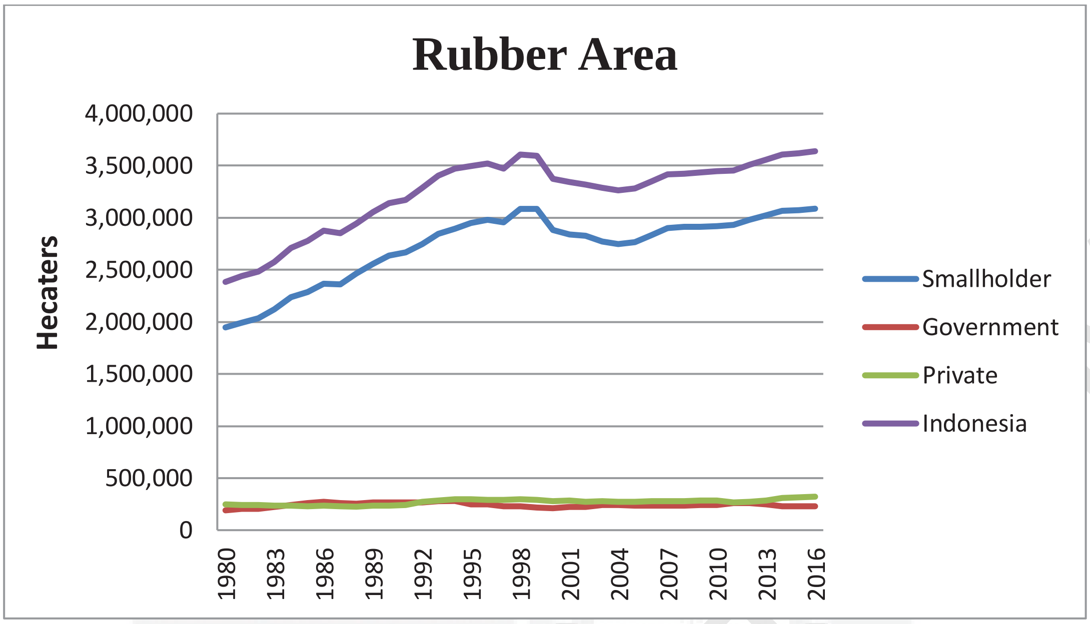


Figure 1.1 : Growth of Rubber Area in Indonesia, 1980-2016
(Source**:** Directorate General of Estate Crops, 2015; 2016)

Based on Figure 1.1, rubber plantations in Indonesia consist of smallholders' rubber, private estates and government estates. The mainstay of rubber plantations in Indonesia was smallholders' rubber which covered an area of about 85 percent (i.e. 3.09 million hectares) of the total area of rubber planted in Indonesia, followed by government estate (6 percent of total area) and private estate (9 percent of total area) in 2016. The development of smallholders' rubber area had increased from 1980 until 2016, with an average growth of 1.18 percent per year. However, it experienced a decrease of about 0.82 percent per year between 2000 and 2004 before it increased again from 2005 until 2016 (Directorate General of Estate Crops, 2015; 2016; *Pusat Data dan Informasi Pertanian*, 2016).

1.1.2 Performance of the Indonesian Rubber Production and Productivity

In line with the growth of total rubber area, rubber production had increased by 3.19 percent per year between 1980 and 2016. In 2016, total rubber production in Indonesia was about 3.16 million tonnes. Indonesian rubber production was intended to meet both local demand and export demand. As with total area, rubber production in Indonesia was also dominated by smallholders' rubber with a contribution of 82 percent of total Indonesian rubber production in 2016. This was followed by private estate at 11 percent of total national rubber production and government estate at 7 percent of the total national rubber production. Therefore, smallholders' rubber plays an important role in determining rubber productivity in Indonesia. Since smallholders' rubber dominated the national rubber production, the growth of national rubber production was a reflection of the growth of smallholders' rubber production. The average growth of national rubber production in the period 2012-2016 was 1.19 percent per year, which was smaller than the average growth of national rubber production in the period 1980-2011 which was 3.53 percent per year (Directorate General of Estate Crops, 2015; 2016; *Pusat Data dan Informasi Pertanian*, 2016). The average growth of national rubber production in the period 2012-2016 can be described in Figure 1.2.

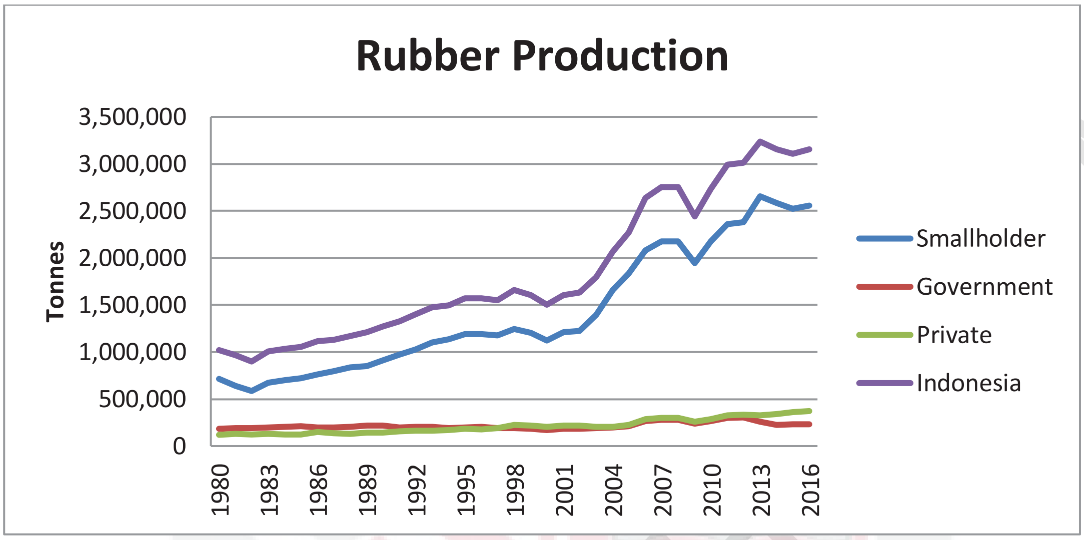


Figure 1.2 : Growth of Indonesian Rubber Production, 1980-2016
(Source**:** Directorate General of Estate Crops, 2015; 2016)

In general, the growth of rubber productivity in Indonesia had fluctuated over the years. During the period 2003-2016, the average growth of rubber productivity in Indonesia was 2.46 percent per year. In 2013, rubber productivity reached 1,083 kilogram per hectare despite a decline in rubber productivity by 9.36 percent in 2009 caused by climate anomalies that occurred in that year (Directorate General of Estate Crops, 2016; *Pusat Data dan Sistem Informasi Pertanian*, 2016).

In Indonesia, smallholders' rubber had been characterised by much lower yields compared to estates. In period 2003-2016, on average, private estates had the highest productivity i.e. about 1,499 kilogram per hectare, followed by government estates with a productivity of 1,287 kilogram per hectare while the productivity of smallholders' rubber reached about 909 kilogram per hectare (Figure 1.3). During the thirteen-year period, rubber productivity of smallholders was still lower than that of private estates and government estates. The growth of Indonesian rubber productivity which consisted of smallholders, private and government estates in 2003-2016 is presented in Figure 1.3.

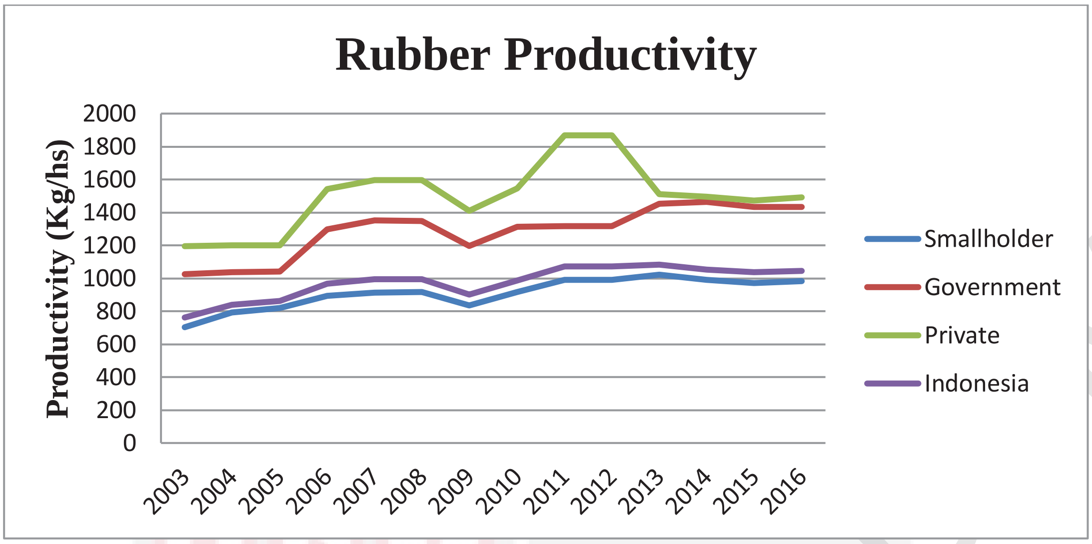


Figure 1.3 : Growth of Indonesian Rubber Productivity, 2003-2016
(Source**:** Directorate General of Estate Crops, 2016)

1.1.3 Centre of Rubber Production in Indonesia

Indonesia has 26 natural rubber producing provinces. Most rubber plants were planted in Sumatra and Kalimantan. Table 1.4 shows the natural rubber producing provinces in Indonesia and that South Sumatra Province was the largest rubber producing province in the country with a total area of 838.749 hectares.

Table 1.4 : Natural rubber producing provinces in Indonesia, 2015

No	Province	Total Area (Ha)	Farmers and labor Numbers
1	Aceh	114,544	119,172
2	North Sumatra	427,409	229,382
3	West Sumatra	129,847	151,587
4	Riau	348,140	217,973
5	Riau Islands	23,733	16,771
6	Jambi	379,011	213,455
7	South Sumatra	838,749	485,565
8	Bangka Belitung	46,850	42,580
9	Bengkulu	96,474	84,683
10	Lampung	152,809	126,224
11	West Java	61,840	51,880
12	Banten	15,537	30,177
13	Central Java	35,941	29,123
14	D.I. Yogyakarta	21	358
15	East Java	25,562	10,208
16	Bali	493	247
17	West Kalimantan	365,296	269,247
18	Central Kalimantan	280,351	155,878
19	South Kalimantan	189,985	160,695
20	East Kalimantan	69,223	54,458
21	North Kalimantan	816	1,066
22	Central Sulawesi	5,097	3,356
23	South Sulawesi	7,660	5,227
24	South East Sulawesi	225	352
25	Maluku	2,136	1,068
26	Papua	3,357	3,810
	Total Indonesia	3,621,106	2,464,542

(Source**:** Directorate General of Estate Crops, 2016)

The average data of national rubber production in 2012-2016, showed that there were six (6) rubber producing provinces in Indonesia that had produced 76.77 percent of the national rubber production, namely South Sumatra, North Sumatra, Riau, Jambi, West Kalimantan and Central Kalimantan (Directorate General of Estate Crops, (2013); (2014); (2015); (2016); *Pusat Data dan Sistem Informasi Pertanian*, 2016). South Sumatra was the largest producer which contributed to about 867.91 thousand tonnes or 27.62 percent of the national rubber production. This was followed by North Sumatra which produced 436.89 thousand tonnes (13.91 percent). Riau, Jambi, Kalimantan Barat, Central Kalimantan were among big producers of natural rubber in Indonesia with a total production of 343.81 thousand tonnes, 299.25 thousand tonnes, 272.58 thousand tonnes, and 191.44 thousand tonnes respectively, and these accounted for 10.94 percent, 9.52 percent, 8.68 per cent, and 6.09 percent of the Indonesian rubber production, respectively (Figure 1.4).

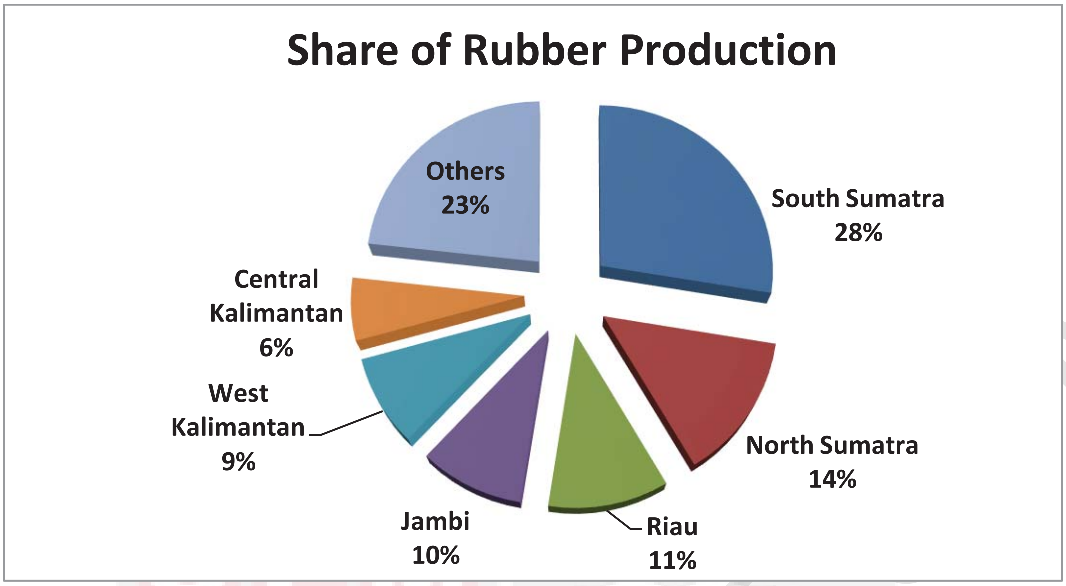
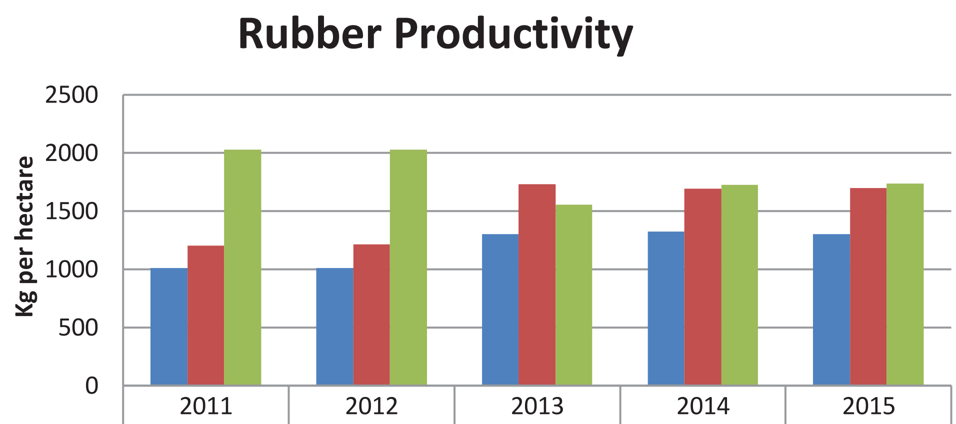


Figure 1.4 : Share of Rubber Production by Province, 2012-2016
(Source**:** Directorate General of Estate Crops, 2013; 2014; 2015; 2016)

Rubber production area in South Sumatra was dominated by smallholder's rubber which covered an area of 791.187 hectares or about 94 percent of total area in South Sumatra. Smallholder's rubber contributed about 884.166 tonnes or 94 percent of the total production in 2015. Approximately, more than 485 thousand households in South Sumatra relied on rubber production. If it is assumed that each household consisted of four (4) family members, thus, rubber provided livelihood for more than 1.94 million people or about 24 percent of the total population in South Sumatra in 2015 (Directorate General of Estate Crops, 2016; BPS-Statistics of *Sumatera Selatan* Province, 2016).

In South Sumatra, productivity of smallholder's rubber was lower than the productivity of private estates and government estates. In 2015, private estates had the highest productivity, about 1,736 kilogram per hectare, followed by government estates with 1,697 kilogram per hectare and rubber smallholdings with 1,302 kilogram per hectare in 2015. The growth of rubber productivity in South Sumatra in 2011-2015 is presented in Figure 1.5.



	2011	2012	2013	2014	2015
Smallholdings	1012	1011	1302	1324	1302
Government	1204	1214	1732	1692	1697
Private	2026	2028	1554	1727	1736

Figure 1.5 : Growth of Rubber Productivity in South Sumatra
(Source: Directorate General of Estate Crops, 2013; 2014; 2015; 2016)

Some improvement efforts to increase smallholders' rubber productivity had been carried out by the government since the 1980s through government's rubber development projects such as the Nucleus Estate-Smallholder (NES), Replanting-Rehabilitation and Extension of Export Crops (RREEC), Smallholder Rubber Development (SRDP), Tree Crop Smallholder Development Projects (TCSDP) and Tree Crop Smallholder Sector (TCSS) projects. However, the increase in rubber productivity was still slow (Budiman and Penot, 1997).

Furthermore, smallholders' rubbers in South Sumatra were still facing some problems. These included the use of rubber clone at the farmers' level which remains approximately at 59%; and the lack of implementation of recommended technology and farm maintenance (Syarifa, et al., 2012).

Since smallholders' rubber in South Sumatra has low productivity compared to that of the estates, they will not provide sufficient income levels in the future unless productivity is improved substantially. A workable strategy to improve productivity of smallholders' rubber is important to be conducted so that increasing the smallholders' rubber productivity can be an important engine of growth and poverty alleviation (Budiman and Penot, 1997).

1.1.4 Performance of the Indonesian Rubber Domestic Demand

The demand for domestic rubber in Indonesia was calculated in which the total production was reduced by export volume and added by import volume. In the period 1980-2015, the growth of domestic demand for rubber fluctuated over the years with an average growth of 7.35 percent per year. However, in 2013, 2014 and 2015, they decreased by 5.83 per cent, 0.27 percent and 1.94 per cent, respectively. This was due to a decline in rubber production in 2014 and 2015 by 2.60 percent and 0.25 per cent, respectively (Directorate General of Estate Crops, 2015; 2016; *Pusat Data dan Sistem Informasi Pertanian*, 2016). The decline in rubber prices since 2012 had caused many farmers to leave rubber farms and to work in other sectors, which in turn had led to a decline in rubber production in 2014 and 2015. Growth of Domestic Demand of Indonesian Rubber, 1980-2015 is shown in Figure 1.6.

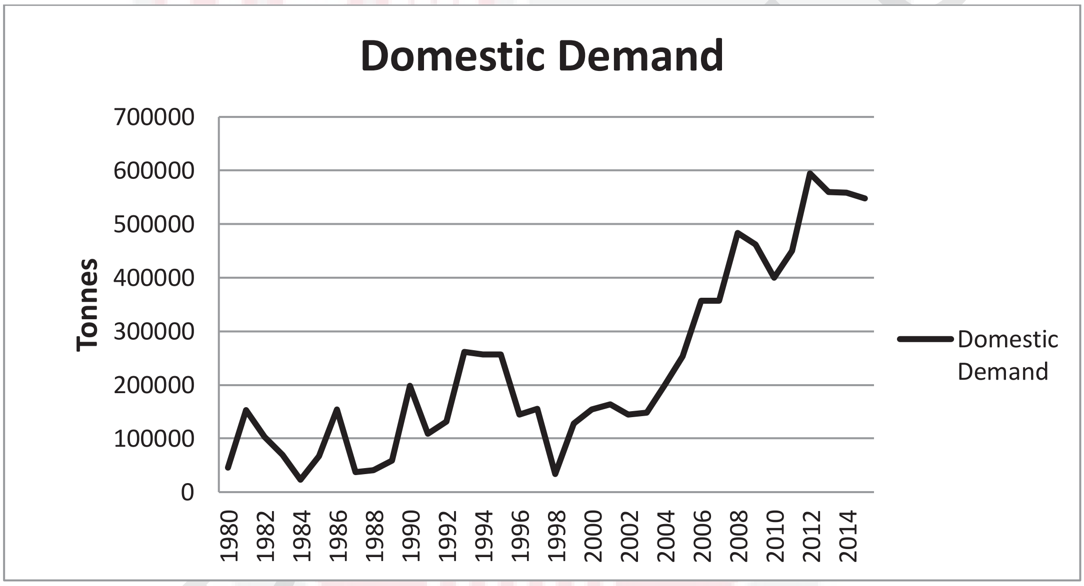


Figure 1.6 : Growth of Domestic Demand of Indonesian Rubber, 1980-2015
(Source**:** Directorate General of Estate Crops, 2015; 2016)

Based on the data, the price of natural rubber (lump) in the Indonesian domestic market also fluctuated. From 2008, prices increased by 17.4 percent to Rp. 6,584 per kilogram in 2009. The price continued to increase and reached Rp. 12.814 per kilogram until 2011. Furthermore, rubber prices decreased by 12.37 percent to Rp. 11,229 per kilogram in 2012 and continued to decrease gradually until 2014 (Figure 1.7). When rubber price increased, it was easier for smallholders to increase production efficiency, since they were able to buy production inputs such as fertilizer, herbicide, pesticide and good planting material and also more focused in managing rubber farm to get higher production, which in turn led to increase rubber productivity. In contrast, when rubber price decreased, production efficiency tended to be decreased since smallholders could not afford to buy production inputs. Besides, smallholders tended to leave rubber farm and worked in other sectors, which eventually caused poor rubber productivity.

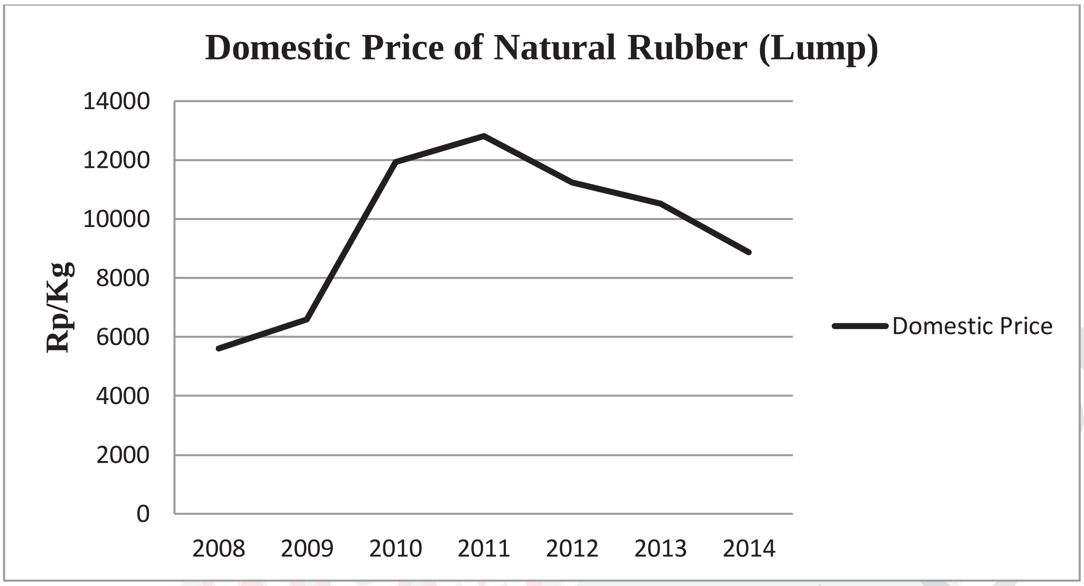


Figure 1.7 : Growth of Domestic Natural Rubber Price in Indonesia, 2008-2014
(Source: Directorate General of Estate Crops, 2015)

1.1.5 Performance of the Indonesian Rubber Export

Besides supplying for domestic use, Indonesia also exports natural rubber to other countries. The growth of volume of Indonesian rubber exports increased from 1980 to 2015 despite experiencing fluctuations. Indonesia had exported the highest volume of rubber that was about 2.70 million tons in 2013 (Figure 1.8). Indonesian rubber had the highest decline in the export volume in 2009, which was about 12.77 percent. This was due to an 11.40 percent decline in natural rubber production in 2009. In addition, about 80 percent of Indonesian natural rubber production was intended for exports in the form of semi-finished products during the 1980-2015 since Indonesia's rubber downstream industry had been underdeveloped (Directorate General of Estate Crops, 2016; *Pusat Data dan Sistem Informasi Pertanian*, 2016). Therefore the absorption of rubber production for export market was higher compared to domestic market.

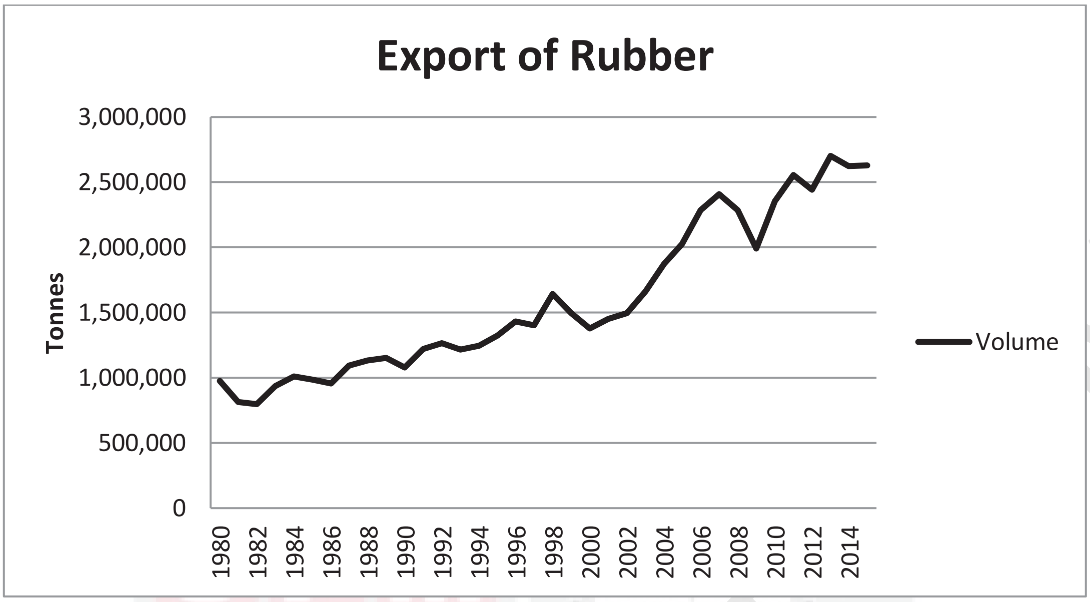


Figure 1.8 : Growth of the Indonesian Rubber Export, 1980-2015
(Source**:** Directorate General of Estate Crops, 2016)

The main rubber categories produced by Indonesia are: 1) standard Indonesian rubber (SIR); 2) ribbed smoked sheets (RSS); and 3) latex concentrate. Recently, Indonesia exported Standard Indonesian rubber (SIR) and Ribbed Smoked Sheets (RSS) in large volumes. The SIR was the largest type of natural rubber exported by Indonesia which was about 94.34 percent of the total export of natural rubber in 2016. This was followed by Ribbed Smoked Sheet (RSS) with 2.53 percent of total export. Generally, there was an increase in the total export of SIR, i.e. about 0.22 percent per year between 2011 and 2016. However, there was a slightly decrease in the volume of RSS exported during 2011-2016. The export volume of RSS also depended on the demand from rubber downstream industry in the world market (Table 1.5).

Table 1.5 : Exports of natural rubber by grades, 2011-2016

Year	**Latex**		**RSS**		**SIR**		**Others**		**Total (Tonnes)**
	Volume (Tonnes)	**%**	**Volume (Tonnes)**	**%**	**Volume (Tonnes)**	**%**	**Volume (Tonnes)**	**%**	
2011	9,501	0.37	67,333	2.63	2,478,904	96.99	0	0.00	2,555,739
2012	7,620	0.31	66,682	2.73	2,370,136	96.96	0	0.00	2,444,438
2013	5,908	0.22	69,324	2.57	2,625,137	97.16	1,626	0.06	2,701,995
2014	5,410	0.21	68,307	2.60	2,549,733	97.19	20	0.00	2,623,471
2015	6,411	0.24	80,357	3.06	2,539,112	96.53	4,433	0.17	2,630,313
2016	4,512	0.17	67,272	2.53	2,506,237	94.34	78,446	2.95	2,656,467

(Source: *Gabungan Perusahaan Karet Indonesia Gapkindo* as cited in *Dewan Karet Indonesia*, 2017)

The export price of Indonesian natural rubber was proxied as export value divided by export volume. Rubber export price was determined by the Free on Board Price (FOB), meaning that the price only included delivering cost of rubber to the board, but excluded shipping and other fees. Figure 1.9 shows the export price of natural rubber. It indicates that the price was fluctuating over the years. From 2006-2008, the export price of natural rubber increased to US$ 2.64 in 2008. However, in 2009, the price of natural rubber decreased. Then the price started to increase in 2010 to 2011. In 2011, rubber price reached its highest price i.e. US$ 4.60 before it experienced a downward trend until 2016. Indonesia is only price taker since Indonesian rubber price is controlled by rubber price in the world market. The fluctuation of rubber price was related to the fluctuation of natural rubber demand in the world market. Rubber price increased when natural rubber demand in the world market increased, and vice versa.

The efforts to increase rubber prices in the world market had been carried out through reducing the amount of rubber exports by members of the International Tripartite Rubber Council such as Indonesia, Malaysia and Thailand as the main rubber producers. Efforts to reduce the amount of rubber exports were done through the instrument of Supply Management Scheme (SMS) (*Departemen Perdagangan Republik Indonesia*, 2008). By reducing the amount of rubber export, rubber prices in the world market increased.

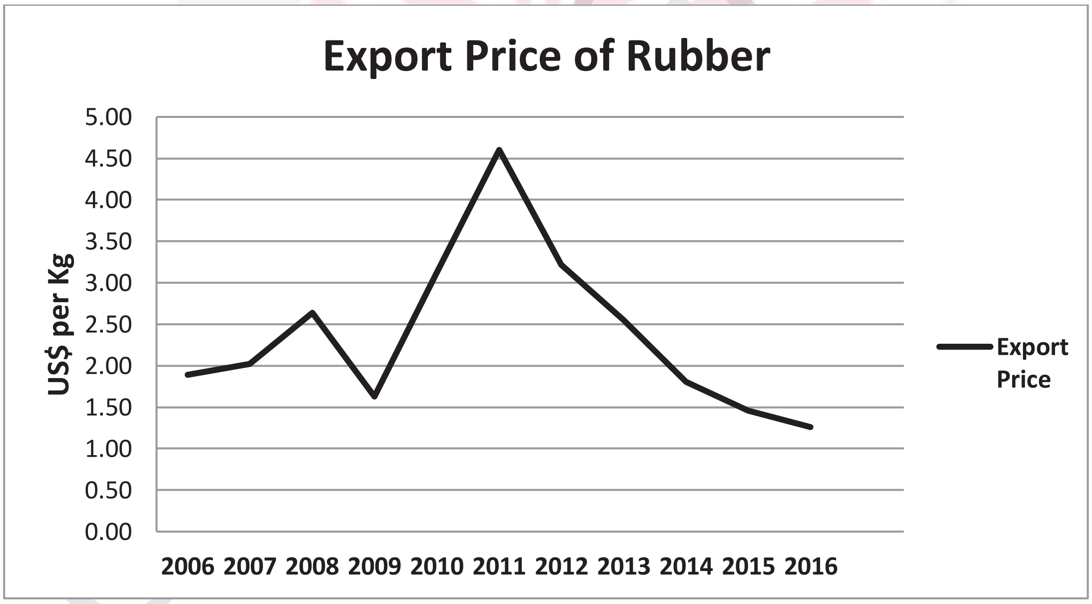


Figure 1.9 : Growth of Export Rubber Price, 2006-2016
(Source**:** Directorate General of Estate Crops, 2016)

There were six (6) largest destination countries in which Indonesian rubber was exported to in the 2011-2016 periods. In 2016, USA was the largest importer for Indonesian natural rubber with volumes reaching 577,683 tonnes or 22 percent of the total export of the Indonesian natural rubber. This was followed by Japan as the second largest market for Indonesian natural rubber. In 2016, the total export volume to Japan was 421,305 tonnes or 16 percent of the total natural rubber exported by Indonesia. China, India, Korea and Brazil were also big markets for Indonesian natural rubber with the total exports of 368,145 tonnes, 230,949 tonnes, 179,348 tonnes and 96,084 tonnes respectively, and these accounted for 14 percent, 9 percent, 7 percent and 4 percent of the Indonesian natural rubber total export, respectively (Table 1.6). The increasing of rubber exports to the world market could be supported by the availability of local rubber production. If rubber production decreases, the volume of rubber exports will also decrease. Therefore, some efforts are necessary to be conducted to support rubber smallholders in increasing rubber productivity.

Table 1.6 : Indonesia's export of natural rubber by destination countries, 2011-2016

Countries	2011 (tonnes)	(%)	2012 (tonnes)	(%)	2013 (tonnes)	(%)	2014 (tonnes)	(%)	2015 (tonnes)	(%)	2016 (tonnes)	(%)
USA	607,870	24	572,278	23	609,744	23	597,848	22	624,733	24	577,683	22
Japan	387,655	15	389,234	16	425,869	16	409,024	15	425,073	16	421,305	16
China	409,377	16	437,760	18	511,700	19	367,032	14	289,490	11	368,145	14
India	68,769	3	107,848	4	144,489	5	195,811	7	204,598	8	230,949	9
Korea	120,059	5	142,690	6	147,308	5	158,739	6	182,874	7	179,348	7
Singapore	104,282	4	63,460	3	21,768	1	18,289	1	31,543	1	22,670	1
Brazil	94,426	4	71,086	3	87,700	3	103,478	4	95,508	4	96,084	4
Canada	77,262	3	76,700	3	71,982	3	74,274	3	76,832	3	74,043	3
Germany	60,757	2	59,764	2	72,124	3	74,847	3	70,428	3	70,153	3
Turkey	71,555	3	55,060	2	71,646	3	75,800	3	73,024	3	70,781	3
Others	553,747	22	468,568	19	537,662	20	633,175	23	556,210	21	545,306	21
Total	2,555,739	100	2,444,438	100	2,701,995	100	2,623,471	100	2,630,313	100	2,656,467	100

(Source : *Badan Pusat Statistik* and *Gapkindo* as cited in *Dewan Karet Indonesia*, 2017)

The volume of total rubber exports came from various export ports in Indonesia including South Sumatra, North Sumatra, West Sumatra, Riau, Jambi, Bengkulu, Lampung, Jakarta, Central Java, East Java, West Kalimantan, Central Kalimantan and South Sulawesi. In 2016, the largest volume of rubber exports was contributed by export port of South Sumatra, which reached 998, 341 tonnes or 37.6 percent of the total national rubber export. This was followed by North Sumatra as the second largest contributor to Indonesian rubber export. In 2016, the total export volume from North Sumatra was 562,843 tonnes or 21.2 percent of the total exported natural rubber by Indonesia. West Sumatra, Jambi, East Java and West Kalimantan exported 278,238 tonnes, 232,348 tonnes, 229,366 tonnes and 191,044 tonnes of rubber, respectively, and these account for 10.5 percent, 8.7 percent, 8.6 percent and 7.2 percent of the total national rubber export, respectively (Table 1.7).

South Sumatra was the largest rubber export port in Indonesia since it had the largest volume of raw rubber materials to be processed in rubber factories. In 2016, South Sumatra had 27 crumb rubber factories which had an installed production capacity of 1,648,288 tonnes per year with the availability of raw rubber material of 946,031 tonnes per year. This was followed by North Sumatra which had 35 units of crumb rubber factories with availability of raw rubber material of 412,314 tonnes per year (Table 1.8).

Table 1.7 : Exports of total natural rubber by provinces, 2011-2016

Provinces	2011		2012		2013		2014		2015		2016	
	(tonnes)	(%)	(tonnes)	(%)	(tonnes)	(%)	(tonnes)	(%)	(tonnes)	(%)	(tonnes)	(%)
North Sumatra	681,298	26.7	626,048	25.6	693,877	25.7	625,527	23.8	597,445	22.7	562,843	21.2
West Sumatra	227,736	8.9	230,428	9.4	241,499	8.9	238,086	9.1	258,634	9.8	278,238	10.5
Riau	57,745	2.3	53,391	2.2	21,781	0.8	16,630	0.6	30,069	1.1	32,960	1.2
Jambi	242,219	9.5	190,976	7.8	199,319	7.4	230,636	8.8	232,619	8.8	232,348	8.7
South Sumatra	851,976	33.3	903,112	36.9	1,065,976	39.5	1,048,156	40.0	1,016,166	38.6	998,341	37.6
Bengkulu	14,592	0.6	10,037	0.4	1,719	0.1	101	0.0	130	0.0	183	0.01
Lampung	28,114	1.1	37,820	1.5	49,004	1.8	51,390	2.0	57,469	2.2	56,711	2.1
Jakarta	11,563	0.5	14,023	0.6	16,436	0.6	17,944	0.7	24,691	0.9	49,405	1.9
Central Java	16,544	0.6	13,110	0.5	14,178	0.5	16,742	0.6	20,045	0.8	19,972	0.8
East Java	197,616	7.7	158,693	6.5	175,284	6.5	181,476	6.9	199,281	7.6	229,366	8.6
West Kalimantan	216,233	8.5	198,124	8.1	215,163	8.0	191,518	7.3	187,663	7.1	191,044	7.2
Central Kalimantan	3,053	0.1	3,090	0.1	3,081	0.1	1,950	0.1	2,936	0.1	3,726	0.1
South Sulawesi	6,451	0.3	5,524	0.2	4,677	0.2	3,316	0.1	3,165	0.1	1,327	0.05
Total	2,555,739	100	2,444,438	100	2,701,995	100	2,623,471	100	2,630,313	100	2,656,467	100

(Source**:** *Gapkindo* as cited in *Dewan Karet Indonesia*, 2017)

Table 1.8 : Total crumb rubber factory and availability of raw material by province

No	Provinces	Total Factory (unit)	Installed Production Capacity (tonnes/year)	Availability of Raw Material (tonnes/year)
1	North Sumatra	35	876,879	412,314
2	West Sumatra	7	263,000	120,268
3	Riau	9	295,000	324,143
4	Jambi	9	580,200	262,429
5	South Sumatra	27	1,648,288	946,031
6	Bengkulu	4	64,000	95,597
7	Lampung	9	246,205	131,196
8	West Kalimantan	17	524,400	234,608
9	South Kalimantan	17	520,500	165,183
10	Java	14	184,204	122,605
	Total	148	5,202,676	3,157,780

(Source: Directorate General of Estate Crops, 2016; *Gapkindo* as cited in *Dewan Karet Indonesia*, 2017)

1.1.6 Production Risk in Rubber Farm

Production risks exist in the production processes of most primary industries like agriculture, aquaculture and fishing. Output risk had become a significant concern in developing countries since in these countries, farming is dominated by subsistence agriculture (Asche & Tveterås, 1999).

In Indonesia, particularly South Sumatra, rubber production was characterised by risk, which was indicated by yield variability due to biophysical factors, such as rainfall, drought, pests and diseases. During high rainfall intensity, especially in the morning, farmers cannot tap rubber trees since tapping activity may causes damaging of rubber bark. Conversely, during drought season, the yield produced by rubber trees is low. It decreased rubber production collected by farmers. Further, the presence of diseases in rubber plantation also caused great production losses, which eventually causes a decrease in rubber productivity and export. Plant diseases that commonly attack rubber plants included white root disease, Moldy Rot, tapping panel dryness (TPD) and leaf fall disease caused by the fungus corynespora cassiicola and colletotrichum, etc.

White root disease attacks the roots of rubber plants which causes significant mortality to plants at aged 2 years to 6 years. In Indonesia, the intensity of white root disease attack could reach 5% in smallholders' rubber, and 3% in estates (Gunawan, 2004). Moldy Rot disease is caused by fungus which causes damage to the tapping panel area. Meanwhile, tapping panel dryness (TPD) disease can cause damage to the bark of tapped rubber tree. Leaf fall disease in rubber can cause the plants shed their leaves continuously, which then causes rubber plants can not be able to produce latex and eventually die. In addition, the presence of pests also can reduce rubber productivity. Pests that commonly attack rubber plants include pig, monkey, goat, and termites.

The existence of production risk not only affect production but also farmers's decision regarding to the level of input used (Villano and Fleming, 2006). Production inputs used can give different influence on the mean output and on the variability of output. Producers in agricultural sector are generally risk-averse, they will attempt to reduce the risk by input combination and output choices. The risk-averse farmers will consider the effect of the level of inputs used on output variance (Tveteras, et.al., 2011).

1.2 Problem Statement

Based on background of the study, in Indonesia, South Sumatra was one of centres for rubber production which has the largest contribution to the total area, total production, total exports and total availability of raw rubber material for crumb rubber factories compared to other provinces. Thus, South Sumatra played an important role in the development of rubber industry in Indonesia.

In Indonesia, particularly in South Sumatra, rubber production was characterised by risks which caused a wide variability in production. This variability was reflected by the fluctuations in Indonesian rubber production, productivity, and export due to biophysical factors, such as rainfall, drought, pests and diseases. Plant diseases that commonly attack rubber plants include white root disease, Moldy Rot, tapping panel dryness (TPD) and leaf fall disease. Meanwhile, pests that commonly attack rubber plants include pig, monkey, goat, and termites.

Another problem was the low productivity of smallholders' rubber compared to the productivity of the estates. The problem of low productivity among rubber smallholders has been a concern for Indonesian government since its independence. Some improvement efforts to increase the productivity of smallholders' rubber have been carried out by the government since the 1980s through rubber development projects such as the Nucleus Estate-Smallholder (NES), Replanting-Rehabilitation and Extension of Export Crops (RREEC), Smallholder Rubber Development (SRDP), Tree Crop Smallholder Development Projects (TCSDP) and Tree Crop Smallholder Sector (TCSS) projects. However, the increasing of productivity is still slow. The low productivity on smallholders' rubber results in low income for smallholders. Therefore, the productivity of smallholders' rubber should be improved substantially, so that it can be an important engine of welfare growth and poverty alleviation (Budiman and Penot, 1997).

However, the effort to increase rubber production through expansion of rubber area is not possible to be carried out at the moment. Due to the decline in rubber price, Indonesia, together with Thailand and Malaysia, incorporated in the International Tripartite Rubber Council (ITRC), agreed to implement the Supply Management

Scheme (SMS). According this agreement, these countries have to conduct decelerating rubber new planting in order to increase rubber price in the world market (Departemen Perdagangan Republik Indonesia, 2008).

Since the expansion of rubber area could not be conducted in order to increase rubber production, therefore an alternative to be considered is how to increase rubber productivity by managing resources (production inputs) more efficiently. Rubber production very depends on production inputs, such as number of the trees, age of the trees, fertiliser, herbicide and labor. According to Yahaya, et.al, (2016), the best and effective way to improve productivity is to use production inputs more efficiently. This effort can be implemented if the empirical knowledge regarding the technical efficiency of resource allocation, production risk and the factors affecting technical efficiency are provided. Output risks are shown to be an important influence on farmers' decisions related to input allocation and production supply (Villano & Fleming, 2006). Therefore, the performance of farmers' technical efficiency could be changed significantly as the existence of risk (Bokusheva & Hockmann, 2006). Taking this into consideration, it is necessary to measure the technical efficiency level of farms to estimate output losses resulting from output risks and inefficiencies. It is suggested that production risk and technical inefficiency are integrated into a single framework by incorporating the stochastic frontier model into the Just-Pope Model. Empirical studies by Kumbhakar, (1993); Battese, et.al. (1997); Kumbhakar, (2002), revealed that it is possible to incorporate the stochastic frontier model into the Just-Pope production function.

Based on the data, rubber price was fluctuating over the years. From 2006-2008, natural rubber price increased. However, in 2009, natural rubber price decreased. Then the price started to increase in 2010 to 2011 before it experienced a downward trend until 2016 (Directorate General of Estate Crops, 2016). When rubber price increased, it was easier for smallholders to increase production efficiency, since they were able to buy production inputs such as fertiliser, herbicide, pesticide and good planting material and also more focused in managing rubber farm to get higher production, which in turn led to increase rubber productivity. In contrast, when rubber price decreased, production efficiency tended to be decreased since smallholders could not afford to buy production inputs. Besides, smallholders tended to leave rubber farm and worked in other sectors, which eventually caused poor rubber productivity.

Studies on technical efficiency in agricultural production in Indonesia have been performed rather extensively; however, most of these studies examined technical efficiency on the production of annual crops. Few studies have examined technical efficiency on the production of perennial crops, particularly rubber. In addition, most of these studies only described the level of technical efficiency achieved and focused on socio-economic characteristics as determinants of inefficiency, but none included the risk effect on technical efficiency estimates. Denying the existence of risk can lead to biased estimations of production and technical efficiency (Bokusheva & Hockmann, 2006). Therefore, this study bridges the research gap by including the effect of output risk on technical efficiency estimates of rubber production. This study is also meant to contribute to the limited literature on the technical efficiency and risk analysis of perennial tree crops production, in this case, rubber in Indonesia.

1.3 Research Questions

Based on the problem statement, this study attempts to answer the following research questions:

1) What is the level of technical efficiency of smallholders' rubber production?
2) What are the factors affecting production efficiency of smallholders' rubber production?
3) What is the level of production risk in smallholders' rubber production?

1.4 Objectives of the Study

The general objective of this study is to determine the technical efficiency and production risk of smallholders' rubber production in South Sumatra.

The specific objectives are:

1) To estimate the level of technical efficiency of smallholders' rubber production by applying Parametric (Stochastic Frontier Analysis integrated with Just and Pope Model) and Non-parametric (Bootstrap DEA) approaches;
2) To identify and determine factors affecting technical efficiency of smallholders' rubber production; and
3) To estimate the level of production risk in smallholders' rubber production.

1.5 Significance of the Study

This study is necessary to be conducted to measure the technical efficiency level of farms in estimating output losses resulting from output risks and inefficiencies. The results estimation of technical efficiency scores will show the level of technical efficiency achieved by smallhoders rubber. It will indicate whether there are still possibilities to increase rubber production through improvement of technical efficiency or not. If the estimation results of technical efficiency show that there is a potential improvement of technical efficiency, thus, the factors that may affect technical efficiency should be identified and determined. Since risks have an important influence to farmers in making decision concerning input allocation and production supply at agriculture production process, which in turn change the performance of tehnical efficiency, thus it is needed to take into account the risks in estimating technical efficiency. The results of output risk components will provide information on how inputs allocation affects output variability.

Therefore, the estimation of technical efficiency concerning output risk and technical inefficiency would help farmers and policy makers to make improvements of risk management and productivity at the rubber farming. This will increase their knowledge on technical efficiency and risk effects of input allocation; hence they can manage the given inputs in order to increase production efficiency by reducing inefficiency and risk effects. This research will also be a useful reference for other researchers who plan to conduct a research on technical efficiency which accounted risk and inefficiency effect for rubber production.

1.6 Organisation of the Study

This thesis is organised into five chapters. The first chapter provides the introduction of the study, and the remainder of the thesis is organised as follows:

Chapter 2 provides the definitions of productivity, technical efficiency and production risk based on several scientific literatures. It also presents the measurement approach of technical efficiency and production risk and determines important factors of technical efficiency as well as reviews previous empirical studies on technical efficiency and production risk.

Chapter 3 provides the theoretical framework. It also explains the methodology used in this thesis i.e. method of Stochastics Frontier Analysis (SFA) integrated with Just and Pope model to estimate frontier production function, production risk function and technical inefficiency simultaneously. Data Envelopment Analysis (DEA) and Bootstrap DEA methods used to estimate technical efficiency are also justified in this chapter. The description of study area, data collection and sampling technique are also presented.

Chapter 4 presents the summary of the statistics on input and output data and the demographic and socio-economic characteristics of farmers. It also discusses the result analysis of technical efficiency, production risk and determinants affecting technical efficiency of rubber smallholders. The comparisons made on the efficiencies for the different analysis methods used are discussed.

Chapter 5 provides the summary and conclusion of the study. The recommendations arising from the finding of the study are also presented.

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