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An Equation of Oil Palm Plantation Areas in Thailand

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Abstract

Thailand's oil palm plantation areas have increased continuously in response to rising demand for food and non-food products. This quantitative research aims at presenting situations of oil palm production areas and their relevant variables, and analyzing factors determining these areas. Annual time-series data were analyzed using appropriate descriptive statistics and multiple regression analysis. The results revealed that Thai oil palm plantation areas have substantially increased for over the past three decades. Statistically significant variables determining oil palm plantation areas were domestic demand for crude palm oil per capita, farm prices of oil palm fresh fruit bunch and unsmoked rubber sheet grade 3, and prices of diesel. The results are useful for agricultural policy makers to formulate guidelines for oil palm policy and management plans.

Keywords: oil palm, plantation areas, multiple regression

1. Introduction

Oil palm is a notably important oil crop throughout the world. It thrives in wild, semi-wild and cultivated areas in the regions of equatorial tropics including Africa, America and South-east Asia (Salunkhe and Desai, 1986; Hartley, 1988). In Thailand, oil palm is one of the significantly economic oil crops since the ancient times due to its multiple utilities. Palm oil is used in a wide variety of products such as food items (cooking oil, margarine, sweet), commodities (cosmetics, soap, candle), and an alternative fuel source (biodiesel).

Oil palm has a high oil content and the highest potential of yield per unit area when compared to other oil crops (Hartley, 1988; Maiti *et al.*, 1988 quoted by Salunkhe *et al.*, 1992; Gascon et al, 1989 quoted by Salunkhe *et al.*, 1992; Barison, 1996; Anyane, 1961 quoted by Bergert, 2000; Mattsson *et al.*, 2000 and Corley and Tinker, 2003). For example, oil palm provides an average yield of 3,622 kg/ha, over ten times more than yield from soybean (322 kg/ha) (Mielke, 1991 quoted by Fairhurst and Mutert, 1999).

Thailand is the world's third largest palm oil producer after Malaysia and Indonesia because of its topographical natural advantages. In 2011, Indonesia and Malaysia produced palm oil of approximately 25.40 and 18.70 million tons, respectively; 50.13 and 36.91 percents of the world palm oil production whereas Thailand produces about 1.55 million tons, accounting for 3.05 percent of the world palm oil production (Foreign Agricultural Service, 2012).

Research and development, and technological advancement in oil palm production have helped raise yields and reduce input costs. These have made oil palm become the most attractive choice for planters investing in a profitable oil crop. In addition, prices of palm oil are currently higher than a few years ago. Consequently, oil palm is the best alternative for many farmers and investors as compared to other candidates such as rubber, fruit trees and rice. The expansion of oil palm plantation areas has been boosted by both primary and derived demand from domestic industries. Palm oil is a major source of sustainable and renewable raw material for food, oleochemical and biodiesel industries (Barison, 2007).

Increasing local demand for biodiesel is expected to promote a rapid expansion of oil palm plantation areas in natural forest, saline and acidic soils and peat swamp forest. Environmental groups and industry representatives have debated on the extent to which the oil palm area expansion has impacts on deforestation, public land encroachment, tropical biodiversity loss, and consequently more adverse environmental and social impacts. Furthermore, the oil palm expansion affects food security owing to its competitive nature between other food crops (or economic crops) and oil palm. Some of the agricultural lands for cash crops (rubber and fruit tree) are replaced by oil palm mainly because of its price competitiveness, better responses to soil properties, changing climate conditions, and other factors limiting crop production.

This research is an attempt to utilize econometric method for analyzing factors determining oil palm plantation areas as the expansion is visible and imposing an alarming sign of competition with food crops and natural forest. The specific objectives are;

(1) to present situations of areas under oil palm production and relevant variables, and

(2) to analyze factors determining areas under oil palm plantation.

The results are expected to be used in create guidelines for appropriate policy and plans of oil palm management as well as to optimize the use of land for differently and equally important purposes of agricultural development.

2. Research methods

Annual time-series data from 1988 to 2011 were used. The variables used in this research are derived from related published researches, i.e., Poomthong (2000), Paksuchol (2005) and Boontongmai (2007), and theories, i.e., supply theory (Tomek and Robinson, 1981; Samuelson and Nordhaus, 2005; Puttikorn *et al.*, 2006; Mankiw, 2007; Netayarak, 2007), agricultural production theory with respect to competition (Snodgrass and Wallace, 1964; Netayarak, 2007), supply response theory regarding partial adjustment model (Nerlove, 1956 and 1958), and Cobweb theory (Goodwin, 1994; Netayarak, 2007).

The data were collected from both published and unpublished reports of Thai Office of Agricultural Economics (2010, 2011, 2012a, 2012b, 2012c and 2012d), Meteorological Department (2011), Bank of Thailand and Petroleum Authority of Thailand (PTT) Public Company websites.

Data analyses are divided into two parts in the following details:

(1) to achieve the first objective, annual time-series, data from 1977 to 2011 were used, and

(2) to achieve the second objective, annual time-series, data from 1988 to 2011 were used.

The data were analyzed using appropriate statistical and econometric tools as follows:

(1) Descriptive analysis using basic statistics including mean, variance and percentage to describe oil palm plantation areas in Thailand, and other specified variables.

(2) Multiple regression analysis to analyze factors determining oil palm plantation areas in Thailand. Ordinary least squares (OLS) method was employed to estimate the coefficients. The log-log functional form appropriately fit well with the data, leading to the following model,

$$\ln(PPA_t) = \ln(b_o) + b_1\ln(PPA_{t-1}) + b_2\ln(DPO_t) + b_3\ln(PDO_t) + b_4\ln(PPF_t) + b_5\ln(PPF_{t-1}) + b_6\ln(USS_t) + b_7\ln(USS_{t-1}) + b_8(BIP_t) + U_t$$

Where

PPA_t is Thai oil palm plantation areas (ha),

PPA_{t-1} is Thai oil palm plantation areas in previous year (ha),

DPO_t is domestic demand for crude palm oil per capita (ton),

PDO_t is an average price of diesel (baht per litre),

PPF_t is an average farm prices of oil palm fresh fruit bunch (baht per kg),

PPF_{t-1} is an average farm prices of oil palm fresh fruit bunch in previous year (baht per kg),

USS_t is an average farm prices of unsmoked rubber sheet grade 3 (baht per kg),

USS_{t-1} is an average farm prices of unsmoked rubber sheet grade 3 in previous year (baht per kg),

BIP_t is a dummy variable representing government policy before and after action plan on the development and promotion of biodiesel production and consumption, BIP = 0 representing years before the action plan (1989 to 2004), and BIP = 1 representing years after the action plan (2005 to 2011),

U_t is stochastic disturbance term or error term, and

$t = 1,2,3,\ldots,24$.

Multicollinearity test using variance inflation factor (VIF) revealed that VIF values for some independent variables, i.e., Thai oil palm plantation areas in previous year, an average farm prices of oil palm fresh fruit bunch in previous year, an average farm prices of unsmoked rubber sheet grade 3 in previous year, and a dummy variable representing government policy were greater than 10. These regressors might be related to

each other and could cause multicollinearity problem (Wetherill, 1986; Bowerman and O' Connell, 1990; Myers, 1990; Lee *et al.*, 2000; Nissapa, 2004; Lomax, 2007 and Ryan, 2009). Therefore, some selected regressors, proven to be less beneficial to the model, were removed using Frisch' s confluence analysis. Autocorrelation test using Breusch-Godfrey serial correlation LM test and Durbin-Watson statistics revealed that the disturbance terms in different periods were uncorrelated. Heteroscedasticity test using White heteroscedasticity test revealed that the variance of the disturbance terms were constant for all values of independent variables (homoscedasticity). Unit root test using Augmented Dickey-Fuller revealed that independent variables were stationary.

3. Results and discussion

The results of this research are presented in the following sections.

3.1 Present situations of oil palm plantation areas in Thailand and relevant variables

Oil palm was first introduced to Thailand before the Second World War (Thiam and Thongpan, 1986). It came a promising economic crop since palm oil and its products are important commodities for Thailand as a major food, materials for several processing industries, an ingredient in a number of items, in addition to raw material for biodiesel production. Therefore, it can be considered that the oil palm has become a significant economic crop of the Thai economy.

Based on the report of the Office of Agricultural Economics (2010, 2011 and 2012a) as presented in Figure 2, oil palm plantation areas for ten-year intervals were 11,140, 91,612, 217,092 and 512,044 ha in 1977, 1987, 1997 and 2007 with annual growth rates of 24.68, 9.20, 9.02 percent, respectively. The area increased to 661,629 ha in 2011. Increasing Thai population and rising standard of living in terms of income per capita are two major pressures on the food and energy supplies. The needs for a reserve supply of palm oil and its potential allocation from energy to food use are important to ensure Thai food and energy securities in the future. Figure 2 shows that over the past 35 years (1977-2011), oil palm plantation areas in Thailand have increased continuously. The upward trend exhibits an average annual growth rate of 13.41 percent or about 59 times more than the area in 1977.

Sustainable availability of raw material (palm oil) for biodiesel production is important to support success in the biodiesel program. A key element of the government's strategic plan for biodiesel is to promote an expansion of oil palm plantation areas. The government plans to develop domestic oil palm plantation areas to cover a total area of 640,000 ha. Theoretically, the production of palm-oil based biodiesel is estimated at 1.2 litre per day from 0.16 ha of oil palm plantation. Hence, 640,000 ha of oil palm plantation areas are expected to provide 4.8 million litre biodiesel daily. Moreover, the oil palm plantation covering a total area of 160,000 ha will be invested in Thailand's neighboring countries, such as Vietnam, Laos and Malaysia. This will yield an additional biodiesel production capacity of 1.2 million litre per day. Finally, the government plans to cultivate more oil palm and physic nut (*Jatropha curcas Linn.*) to produce 2.5 million litre per day of biodiesel. As a result, the total daily biodiesel production will be 8.5 million litre in 2012 (Sujjakulnukit, 2005 and Gonsalves, 2006).

Based on the publication of the Office of Agricultural Economics (2012a) as illustrated in Figure 3, most oil palm plantation areas were in the south of Thailand. In 2010, about 565,703 ha or 86.70 percent of the total oil palm plantation areas were in southern Thailand, and increased to 571,056 ha (86.31 percent)

in 2011. Surat Thani province had the largest oil palm plantation areas (24.49 percent), followed by Krabi (23.41 percent), Chumporn (19.21 percent), Nakhon Si Thammarat (5.53 percent) and Prachuab Khiri Khan provinces (5.10 percent).

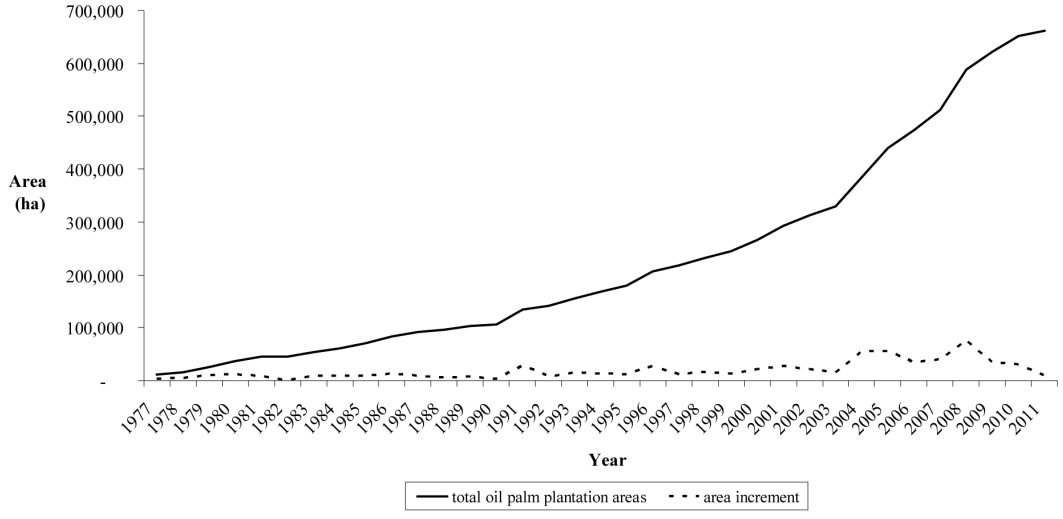

Figure 2 Oil palm plantation areas in Thailand from 1977 to 2011
Source: Office of Agricultural Economics (2010, 2011 and 2012a)

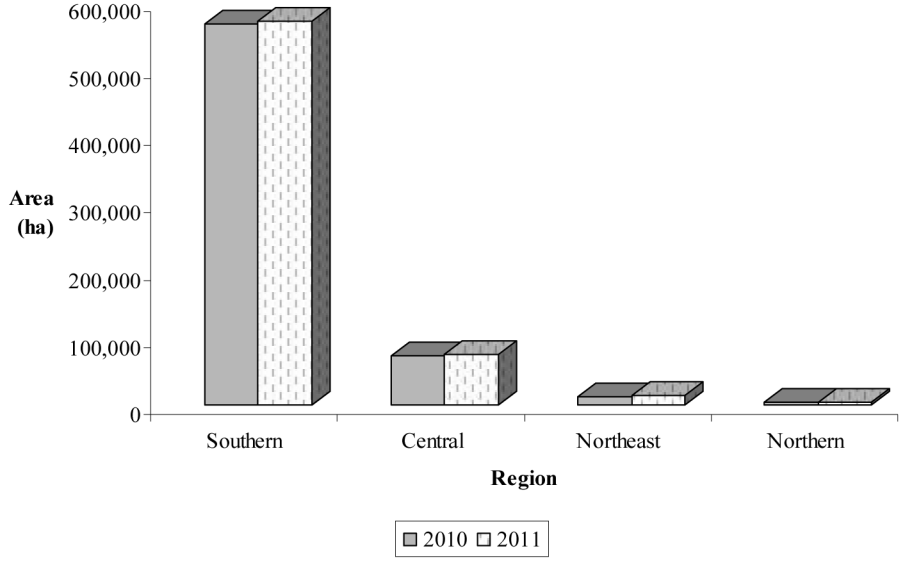

Figure 3 Oil palm plantation areas by regions in Thailand from 2010 to 2011
Source: Office of Agricultural Economics (2012a)

3.2 Factors determining oil palm plantation areas in Thailand

Multiple regression analysis result before solving a problem is shown in Table 1. It indicates that the Thai oil palm plantation areas in previous year, the domestic demand for crude palm oil per capita, the price of diesel and farm prices of oil palm fresh fruit bunch are statistically significant at 0.10 level.

Table 1 Multiple regression analysis result of factors determining Thai oil palm plantation areas (PPA_t) before solving a problem

Variable	Estimated coefficient	Standard error	P-value
C	7.35***	0.64	0.01
PPA_{t-1}	0.58***	0.13	0.01
DPO_t	0.32**	0.13	0.05
PDO_t	0.15*	0.08	0.10
PPF_t	0.11*	0.07	0.10
PPF_{t-1}	-0.05	0.05	n.s.
USS_t	-0.08	0.06	n.s.
USS_{t-1}	0.01	0.07	n.s.
BIP_t	0.01	0.07	n.s.

$R^2 = 0.9967$ Adjusted $R^2 = 0.9949$ Durbin-Watson statistics = 2.3513 F-statistic = 560.1434***

Note: n.s. is not sifnificant, *** $p \leq 0.01$, ** $p \leq 0.05$ and * $p \leq 0.10$

PPA_{t-1} is Thai oil palm plantation areas in previous year

DPO_t is domestic demand for crude palm oil per capita

PDO_t is an average price of diesel

PPF_t is an average farm prices of oil palm fresh fruit bunch

PPF_{t-1} is an average farm prices of oil palm fresh fruit bunch in previous year

USS_t is an average farm prices of unsmoked rubber sheet grade 3

USS_{t-1} is an average farm prices of unsmoked rubber sheet grade 3

BIP_t is a dummy variable representing government policy before and after action plan on the development and promotion of biodiesel production and consumption

Multiple regression analysis result after solving a problem is shown in Table 2. It indicates that the domestic demand for crude palm oil per capita, the price of diesel, farm prices of oil palm fresh fruit bunch and unsmoked rubber sheet grade 3 are statistically significant at 0.10 level. The coefficient of multiple determination (R^2) is 0.99. That is, the included independent variables explain correctly 99 percent of the total variation in Thai oil palm plantation areas. In addition, as a rule of thumb, R^2 is less than Durbin-Watson statistics indicating that the estimated regression doesn't suffer from spurious (or nonsense) regression as suggested by Granger and Newbold (Gujarati and Porter, 2010). F-statistic shows that at least one or all of the independent variables significantly determines Thai oil palm plantation areas.

Table 2 Multiple regression analysis result of factors determining Thai oil palm plantation areas (PPA_t) after solving a problem

Variable	Estimated coefficient	Standard error	P-value
C	2.41***	0.64	0.01
DPO_t	0.72***	0.06	0.01
PDO_t	0.32***	0.08	0.01
PPF_t	0.22***	0.06	0.01
USS_t	-0.12*	0.06	0.10

$R^2 = 0.9919$ Adjusted $R^2 = 0.9901$ Durbin-Watson statistics = 1.7983 F-statistic = 553.4714***

Note: *** $p \leq 0.01$ and * $p \leq 0.10$

DPO_t is domestic demand for crude palm oil per capita

PDO_t is an average price of diesel

PPF_t is an average farm prices of oil palm fresh fruit bunch

USS_t is an average farm prices of unsmoked rubber sheet grade 3

The result also reveals that the domestic demand for crude palm oil per capita has the positive strongest impact on Thai oil palm plantation areas, similar to the price of diesel and the farm price of oil palm fresh fruit bunch. The farm price of unsmoked rubber sheet grade 3, on the contrary, has the least and negative impact.

The findings imply that the domestic demand for crude palm oil per capita, the price of diesel and farm price of oil palm fresh fruit bunch either increase decrease by 1 percent, oil palm plantation areas tend to either increase or decrease respectively by 0.72, 0.32 and 0.22 percent, keeping other independent variables constant. The farm price of unsmoked rubber sheet grade 3 is negatively related with the oil palm plantation areas, implying that the farm price of unsmoked rubber sheet grade 3 either increases or decrease by 1 percent, oil palm plantation areas tend to either decrease or increase by 0.12 percent, keeping other independent variables constant.

The results are consistent with the supply of agricultural product theory. It is well known that palm oil is used as cooking oil for both edible purposes/ food applications and non-edible purposes/non-food applications. In addition, it can also be consumed as substitute for other vegetable oils such as soybean, canola, and coconut oils, so Thai demand for crude palm oil has increased continuously.

Rising domestic demand for diesel and its high price in 2008 (average price of diesel was 31.75 baht per litre) has driven Thailand to consider producing biodiesel from renewable resources, especially the palm oil. This application opens up a potentially large market outlet for palm oil as well as for other major oils. A large-scale biodiesel production is an opportunity for Thailand to lessen its dependence on import of petroleum. In 2007, Thailand started to use palm oil as raw material for biodiesel production, quantity of crude palm oil for biodiesel production was 62,182 tons. It increased to 379,657 tons in 2011, about 6 times the quantity of crude palm oil for biodiesel production in 2007.

Thai population and market for oils have grown, so they have brought along expectations of higher farm price of oil palm fresh fruit bunch that motivate farmers to invest more in oil palm production because it is expected that it is profitable for a long-term investment due to an economic life cycle of more than twenty-five years. However, the planters can only partially adjust for oil palm production due to some restrictions such as lands, labor (knowledge and skill), capital, technology, information, climate condition, and government policy as supply response theory regarding partial adjustment model. There is a trend of oil palm fresh fruit bunch price to increase in the future. In 1989, farm price of oil palm fresh fruit bunch was just 2.86 baht per kg while the price increased to 5.34 baht per kg in 2011, almost 2 times the price in 1988.

The oil palm cultivation has been also regarded as a lucrative alternative to planting rubber because they are competitive products as agricultural production theory with respect to competition. That is, if farmers use their lands for oil palm cultivation, smaller land area is required as compared to rubber cultivation, considering the price as an important factor determining farmers' decision making. Moreover, rubber production, in particular tyre producer attempt to develop synthetic rubber technologies as substitute for natural rubber owing to fluctuation of prices of natural rubber, and supply of synthetic rubber can meet demand and hence replacing supply of natural rubber.

4. Conclusion

The oil palm is considered as a major agricultural commodity in Thailand owing to its socio-economic importances. This quantitative research aims at presenting situations of oil palm production area and the relevant variables, and analyzing factors determining the area change. The results of the research could be concluded that Thai oil palm plantation areas have increased for more than three decades. Most of them are significantly increased in southern Thailand. Statistically significant variables determining Thai oil palm plantation areas are domestic demand for crude palm oil per capita, farm prices of oil palm fresh fruit bunch and unsmoked rubber sheet grade 3, prices of diesel.

5. Recommendations

The results of the research lead to some important recommendations that the expansion of oil palm plantation areas is an important policy to meet the primary and derived demands for palm oil. The recommendations include:

(1) It is obvious that price of diesel tends to increase, with positive impact on Thai oil palm plantation areas. Ministry of Energy (MOE) should establish biodiesel consumption as national agenda by encouraging biodiesel production and consumption, and research and development be conducted to improve its quality to fulfill the international standard requirements. These are to ensure the energy security.

(2) The results indicate that farm price of oil palm fresh fruit bunch tends to increase and has positive impact on Thai oil palm plantation areas. Ministry of Commerce (MOC) should control the appropriate and stable farm prices of oil palm fresh fruit bunch as an incentive for farmers to maintain their current level of oil palm production. In addition, MOAC should survey to ensure that farmers receive parity prices for their oil palm fresh fruit bunch, reflecting the most realistic rate of its production cost.

(3) The results indicate that farm price of unsmoked rubber sheet grade 3 tends to increase and has negative impact on Thai oil palm plantation areas.

Ministry of Agriculture and Cooperatives (MOAC) should consider availability of lands that are suitable for either planting oil palm or rubber and encourage land zoning as national agenda.

(4) The results indicate that oil palm plantation areas have increased continuously. MOAC should promote more efficient land use planning to encourage the conservation of natural forest coverage and biodiversity, to ensure that oil palm are planted only in suitable areas and cause less external diseconomies. Furthermore, MOAC should consider availability of abandoned paddy fields and areas with emphasis on studying soil properties to optimally improve oil palm production. Also, MOAC should provide appropriate knowledge, know-how and technologies of oil palm production to farmers for a better management of oil palm production.

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