International Journal of Agricultural Technology 2013 Vol. 9(4): 749-767
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Price variation and factors determining prices of Thai palm oil and oil palm

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Phitthayaphinant, P., Somboonsuke, B. and Eksomtramage, T. (2013). Price variation and factors determining prices of Thai palm oil and oil palm. International Journal of Agricultural Technology 9(4):749-767.

Abstract Oil palm becomes an economically important crop for Thailand. This research was conducted to (1) present situation of production and marketing of Thai oil palm, (2) analyze price variation behaviors of Thai palm oil and oil palm through time, (3) investigate price transmissions of Thai palm oil and oil palm among different market level, and (4) construct a system of equations of price determination for Thai palm oil and oil palm. Time series data from 1988 to 2011 are obtained for data analysis. The results reveal that Thai oil palm plantation areas have increased for more than three decades. Oil palm planters are categorized into three groups: smallholders in land settlement, private smallholders and commercial companies. Prices of palm oil and prices of fresh fruit tend to increase over time. Seasonal price index of palm oil is highest in January and lowest in September, whereas seasonal price index of fresh fruit is highest in January and lowest in April. Cyclical price indices of palm oil and fresh fruit are unclear. Irregular price variations of palm oil and fresh fruit arise from Tom Yam Kung Crisis. Price transmission from prices of refined palm oil to prices of palm oil is elastic. Price transmission from prices of Malaysian palm oil to prices of palm oil is inelastic. Price transmission from prices of palm oil to prices of fresh fruit is elastic. The statistically significant variables that determine prices of palm oil are prices of refined palm oil, Malaysian prices of palm oil and farm prices of fresh fruit. The statistically significant variable in determining farm prices of oil palm fresh fruit bunch is prices of palm oil. The results are expected to enable policy-makers and concerned parties to formulate appropriate policy options. In addition, It is useful for palm oil producers as well as oil palm planters to plan their appropriate production.

Key words: Price variation, Time series decomposition, palm oil, oil palm fresh fruit bunch, Thailand

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Introduction

Oil palm (*Elaeis guineensis* Jacq.) is notably an important oil crop for Thailand. This is due to a high oil content and the highest potential of oil yield per unit area, compared to other oil producing 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; Corley and Tinker, 2003). Oil palm production has significantly increased in accordance with the trend in domestic palm oil consumption. It has been simulated by area expansion policy of oil palm to satisfy prevailing demands and become self-sufficient. This is due to high demands for vegetable oil, palm oil products and biodiesel. In addition, there is lesser risk as compared to other economic crops thus the popularity of oil palm is increased. For instance, oil palm generates benefits within 3 years (Eksomtramage, 2011) which is shorter than para rubber.

Thailand is the third largest palm oil producing country in the world after Indonesia and Malaysia. In 2011, Thailand produced 1.55 million tons representing 3.09 percent of the world palm oil production (Foreign Agricultural Service, 2012). Palm oil is versatile oil and has a wide range of applications. Palm oil is being used for food applications (Barison, 1996; I and Yusoff, 2000; Salmiah, 2000 quoted by Hai, 2002; Sambanthamurthi, 2000 quoted by Corley and Tinker, 2003). It is currently being used in food manufacturing such as cooking and frying oils, shortenings, margarines, cookies and ice-cream. It can be also consumed directly as substitute to soybean oil. Moreover, it is a raw material for non-food applications (Sambanthamurthi, 2000 quoted by Corley and Tinker, 2003). For example, it is produced either directly or through oleo-chemical routes for flavor, fragrance, soaps, candles, cosmetic products and rubber products, fatty esters for biodiesel, fatty alcohols for washing and cleaning products (Barison, 1996).

Price plays a key role in guiding production and consumption (Tomek and Robinson, 1981). Farmers' decisions are primarily governed by prices in a previous year to plan their production. This is according to the assumption of Cobweb theory (Tomek and Robinson, 1981; Netayarak, 2007). As a result, it may generally face risk of price instability due to seasonality in demand and supply and marketing or a combination of two. It can also be nature of agricultural product, its perishability, bulkiness, delicacy and probably returns from trading of frustrated marketers (Netayarak, 2007). The prices observed through time show results of a complex mixture of changes associated with trend, seasonal, cyclical, and irregular factors (Tomek and Robinson, 1981).

The research aims to (1) present situation of production and marketing of Thai oil palm, (2) analyze price variation behaviors of Thai palm oil and oil palm through time, (3) investigate price transmissions of Thai palm oil and oil palm among different market level, and (4) construct a system of equations of price determination for Thai palm oil and oil palm. The results are expected to enable policy-makers and concerned parties in determining what direction the government should take in promoting palm oil industry in Thailand. In addition, It is useful for palm oil producers and oil palm planters to plan their appropriate production program.

Materials and methods

This research used time-series data. These data were taken from both published and unpublished reports of Thai Office of Agricultural Economics (2010, 2012a, 2012b, 2012c), Department of Internal Trade (2010, 2012a), and Bank of Thailand (2012).

Time series decomposition was used as an analytical tool in order to explain the price variation behavior of Thai palm oil and oil palm through time. It consists of 4 components as follows:

1. Trend variation (T) is long term price movements associated with macroeconomic factors such as general inflation and deflation of the economy and factors specific to agricultural products (Tomek and Robinson, 1981). It was analyzed using simple linear regression analysis with ordinary least squares method. Issariyanukula (1983) mentioned that the data to be used should be at least 15 time-series observations. Annual time series data of prices of palm oil and prices of oil palm fresh fruit bunch during 1988 to 2011 were used as dependent variables, and time trend as independent variable. So, the equations to describe them are as follows:

$$PPO_t = b_0 + b_1 TIM_t$$
$$PPF_t = b_0 + b_1 TIM_t$$

Where PPO_t denotes an average prices of palm oil (baht per kilogram), PPA_t denotes an average prices of oil palm fresh fruit bunch (baht per kilogram), and TIM denotes time trend (1, 2, 3,…, 24).

2. Seasonal variation (S) is a regular repeating price pattern completed once every twelve months due to climate conditions in different season and biological growth process of crops (Tomek and Robinson, 1981). Accordingly, supply and demand for agricultural products seasonally vary. Monthly time series data of prices of palm oil and prices of fresh fruit during 1988 to 2011

were used. Ratio to simple average method was used to analyze seasonal price index (Suwanwongse, 1997). In addition, multiple regression analysis was used as an analytical tool in order to examine seasonal factors that determine prices of palm oil and prices of fresh fruit. So, the equations to describe them are as follows:

$PPO_t = b_0 + b_1JAN_t + b_2FEB_t + b_3MAR_t + b_4APR_t + b_5MAY_t + b_6JUN_t + b_7JUL_t + b_8AUG_t + b_9SEP_t + b_{10}OCT_t + b_{11}NOV_t$

$PPF_t = b_0 + b_1JAN_t + b_2FEB_t + b_3MAR_t + b_4APR_t + b_5MAY_t + b_6JUN_t + b_7JUL_t + b_8AUG_t + b_9SEP_t + b_{10}OCT_t + b_{11}NOV_t$

Where JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV are dummy variables as a proxy variable representing seasonal factors (January, February, March, April, May, June, July, August, September, October and November).

3. Cyclical variation (C) is a pattern which repeats itself regularly with a passage of time (Tomek and Robinson, 1981). Annual time series data of prices of palm oil and prices of fresh fruit from 1988 to 2011 were used. Trend and irregular variations were eliminated. It used binomial weighted moving average which is equal to 1 : 2 : 1 because influence of data in each period is different (Suwanwongse, 1997).

4. Irregular variation (I) is the pattern which is impossible and completely unpredictable to forecast price. Annual time series data of prices of palm oil and prices of fresh fruit from 1988 to 2011 were used. Trend and cyclical variations were eliminated (Suwanwongse, 1997).

Time series decomposition analysis used multiplicative method because it is commonly used in practice and is more appropriate if the characteristics interact (Lucey, 2002) as follows:

$Y_t = T_t \times S_t \times C_t \times I_t$

Where S_t, C_t and I_t are expressed as percentages

Simple regression analysis was used as an analytical tool in order to investigate vertical price transmissions of Thai palm oil and fresh fruit among the different market levels. Ordinary least squares (OLS) method was employed to estimate coefficients. Monthly time series data from 1988 to 2011 were used. The double log functional form best fit with the data leading to the following model.

$\ln(PPO_t) = \ln b_0 + b_1 \ln(PRPO_t)$

Where PPO_t denotes an average prices of palm oil (baht per kilogram) and $PRPO_t$ denotes an average prices of refined palm oil (baht per kilogram).

$\ln(PPO_t) = \ln b_0 + b_1 \ln(PPOM_t)$

Where PPO_t denotes an average prices of palm oil (baht per kilogram) and $PPOM_t$ denotes an average Malaysian prices of palm oil (baht per kilogram).

$\ln(PPF_t) = b_0 + b_1 \ln(PPO_t)$

Where PPF_t denotes an average prices of oil palm fresh fruit bunch (baht per kilogram) and PPO_t denotes an average prices of palm oil (baht per kilogram).

Multiple regression analysis was used as an analytical tool in order to examine price determination for Thai palm oil and oil palm. Weighted least squares (WLS) model was employed to estimate coefficients of a system of equations because there is heteroskedasticity, but no serial or contemporaneous correlation in the residuals. The model was developed from previous studies including Harri *et al*. (2009), Petchsuwan (2006) and Phuthep (2006) in addition to the demand theory (Tomek and Robinson, 1981; Samuelson and Nordhaus, 2005; Mankiw, 2007; Netayarak, 2007). Annual time series data from 1988 to 2011 were used. The double logarithmic functional form appropriately fits well with the data leading to the following model.

Model 1

$\ln(PPO_t) = \ln a_1 + a_2 \ln(PRPO_t) + a_3 \ln(PPOM_t) + a_4 \ln(PPF_t) + a_5 \ln(PSO_t) + U_1$;

Model 2

$\ln(PPF_t) = \ln b_1 + b_2 \ln(PPO_t) + b_3 \ln(PPOM_t) + b_4 \ln(PSB_t) + U_2$

Where PPO_t is an average prices of palm oil (baht per kilogram), representing a product obtained from oil palm fresh fruit bunch, $PRPO_t$ is an average prices of refined palm oil (baht per kilogram), representing a product made of palm oil, $PPOM_t$ is an average Malaysian prices of palm oil (baht per kilogram), representing referable prices of the second largest palm oil

producing country in the world, PPF_t is an average farm prices of oil palm fresh fruit bunch (baht per kilogram), representing a major raw material for palm oil production, PSO_t is an average prices of soybean oil (baht per kilogram), representing a substitute of palm oil, PSB_t is an average prices of soybean (baht per kilogram), representing a substitute of oil palm, U_t is stochastic disturbance term or error term, and t = 1, 2, 3,…, 24.

Results and discussion

Situation of production and marketing of Thai oil palm

Almost 10 percent of the world's permanent cropland was planted with oil palm (Koh and Wilcove, 2008). Forty-two countries only grow oil palm. In Thailand, it was said that Phraya Pradipath Phubal was the first person who brought oil palm and planted it for ornamental purposes. There was an evidence of commercial plantation in Ban Prik subdistrict, Sadao District, Songkhla province. About 160 hectares (ha) oil palm plantation was operated by M.J.Amornsamarnlak Kitiyakorn before the Second World War. However, cultivation ceased later owing to the war (Eksomtramage, 2011).

Oil palm industry was initiated by both government and private sector's effort. A key factor contributing to the establishment of oil palm sector in Thailand was the decrease in rubber prices since natural rubber products were substituted by synthetic rubber. The price of rubber was considerably low in 1967 (an average prices of smoked rubber sheet grade 1 was equal to 5.94 baht per kilogram decreasing from 9.45 baht per kilogram in 1961) (Bank of Thailand, 1973 quoted by Wiwattanakantang, 1994). Therefore, there was a concern to reduce reliance on rubber and diversify agricultural production to other commercial crops.

Oil palm became an alternative crop owing to success of palm oil sector in Malaysia who shifted from rubber to oil palm in 1960's and became the world leading producer and exporter of palm oil. It was expected that areas in southern Thailand could be utilized for oil palm cultivation and become successful in oil palm production like Malaysia because of similar climatic conditions, soil and topography. A feasibility study showed that oil palm production was profitable in comparison to rubber (Rangsaritkul, 1974 quoted by Wiwattanakantang, 1994). Accordingly, both government and private sectors paid their interest to oil palm as a promising commercial crop. Figure 1 shows that over the past 35 years (1977-2011), areas under oil palm plantation in Thailand have increased continuously. Upward trend exhibits an average annual growth rate of 13.41 percent or about 59 times more than the area in 1977.

Oil palm planters can be categorized into three groups according to type of holding (Wiwattanakantang, 1994). Firstly, smallholders in land settlement: each of them generally holds areas for oil palm plantation less than 8 ha. This is the smallest production unit. These land settlements are initiated by royal Thai government and under the assistance of royal Thai government. Most of Thai oil palm planters are smallholder farmers (Dallinger, 2011). In 2011, the number of smallholder is 121,306 household (Department of Internal Trade, 2012a). Second, private smallholders: most of them hold areas for oil palm plantation less than 160 ha. They have more money to invest in the field than smallholders in land settlement. Finally, commercial companies: most of them hold areas for oil palm plantation more than 160 ha. This is the largest production unit. Generally, commercial companies are known to be efficient because they greatly invest in all care, maintenance, research and development. Thus, there is no surprise that their yields are the highest among other planters.

The number of oil palm planters is large and mostly falls into the first two types of holding. Their oil palm yield and oil extraction rates are relatively low (Dallinger, 2011). Accordingly, improvement of oil palm yield is need owing to significant economic benefits for smallholder farmers and potentially improving competitiveness of Thai oil palm production before participating in Asean Economic Community (AEC) agreement in 2015. In contrast, the number of commercial companies is small, but their productions are greater than half of domestic production, thanks to their high oil palm yields.

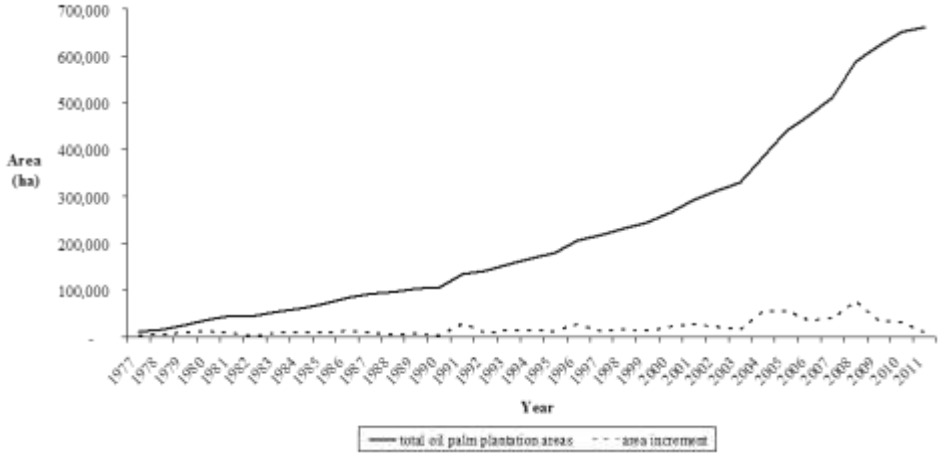

Fig. 1. Oil palm plantation areas in Thailand during 1977 to 2010
Source: Office of Agricultural Economics (2010, 2011 and 2012a)

When fresh fruits are harvested, oil palm farmers have alternatives to sell them directly to crushing mills. Crushing mills strongly depend on purchasing

fresh from independent oil palm farmers (Dallinger, 2011) or to local assemblers or cooperatives. On small farms, fresh fruits are normally harvested approximately every 15-20 days. Harvesting is often done by external harvesting teams who are paid according to weight of fruit harvested and deliver the fresh fruits to ramps to be picked up by trucks. Their wages vary depending on the harvested outputs, but they are usually higher than the minimum wages for industrial labor in Thailand (Dallinger, 2011). AgriSource , 2005 (as quoted by Dallinger, 2011) stated that only 10 percent of Thai oil palm farmers were fully managing their farms by themselves.

In a field survey of Thongrak *et al*. (2011 quoted by Dallinger, 2011), it was revealed that 80.50 percent of all farmers interviewed hired additional labor. Harvesting teams were generally organized by middlemen and their services included additional farm management activities such as pruning and weeding. Contracts for these laborers on smallholders' farms were quasi non-existent. In many cases, laborers were migrants from the North Eastern provinces and/or neighboring countries including Myanmar and Cambodia.

Marketing channel depends on amount of output. Normally, private smallholders and commercial companies who have a large amount of harvested oil palm each time sell directly to extraction plants by their pick-up trucks. For smallholders in land settlement whose quantities of output are small, their outputs are mainly sold to local assemblers or cooperatives. Local assemblers buy fresh fruit from many smallholder farmers and sell them in large amounts to extraction plants. They may buy fresh fruit at the plantation area where production is large. They may set up collection site called ***lan tay*** to buy fresh fruit bunches.

Market of oil palm consists of many sellers and buyers. Oil palm fruits are similar in physical appearance. Oil palm farmers can hardly differentiate their product. Therefore, there is no product differentiation and barrier of entry. The formation of oil palm price occurs on the spot and can even change within the same day (Dallinger, 2011).

Paid oil palm price does not relate to fresh fruit bunch's quality since crushing mills can not afford to reject or to penalize delivery of bad quality oil palm fresh fruit bunch, as they rely on a regular supply (Dallinger, 2011). Oil palm farmers can search for a suitable price, and they can switch from one crushing mill to another with little cost. Oil palm market is rather competitive. Oil palm price is determined by demand and supply forces. However, large oil palm farmers have market powers to bargain price, and they normally get a higher price than smallholder farmers (Wiwattanakantang, 1994).

Price variation behaviors of Thai palm oil and oil palm through time

Trend analyses of prices of palm oil and prices of fresh fruit show that increasing trends of 0.44 and 0.08 baht per kilogram per year, respectively. They can be specified as follows:

$$PPO = 17.78^{***} + 0.44TIM^{***}$$
$$(11.33) \quad (3.37)$$
$$R^2 = 0.67 \text{ Adj } R^2 = 0.64 \text{ D-W statistics} = 1.69 \text{ F-statistic} = 20.55^{***}$$

$$PPF = 2.47^{***} + 0.08TIM^{***}$$
$$(9.02) \quad (3.30)$$
$$R^2 = 0.70 \text{ Adj } R^2 = 0.67 \text{ D-W statistics} = 1.84 \text{ F-statistic} = 23.42^{***}$$

Note: numbers in parentheses are t-statistics, *** $p \leq 0.01$

Prices of palm oil and prices of fresh fruit gradually increase because of demands for palm oil increases as a result of increase in Thai population, income growth and marked increasing oil prices. These factors are major pressures on the food and energy supplies to meet increased demands for oil palm as raw materials for food and oleo-chemical industries (Department of Internal Trade, 2012b) leading to significant changes in government biodiesel policy.

Thailand has largely identified needs to increase its oil palm production 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. In addition, expansion of domestic areas for oil palm plantation will eliminate need to import oil palm products from foreign countries which will result to positive foreign exchange earnings. At the same time, it will increase oil palm farmers' income and enhance labor employment. There are other dues in the production and marketing levels including transport, communication and input costs.

Seasonal price index of palm oil is highest in January (113.19), and lowest in September (93.82) (Figure 2). Price variation of palm oil decreases in February (109.36). Prices gradually fall in the months that follow until it reaches its minimum in September. Seasonal price index increases continuously until it reaches its maximum in January.

Seasonal price index of fresh fruit is highest in January (118.94), and lowest in April (86.92) (Figure 3). Price variation of oil palm fresh fruit bunch decreases in February (110.30). Prices gradually fall in the months that follow

until it reaches its minimum in April. Seasonal price index increases continuously until it reaches its maximum in January.

Multiple regression analysis results revealed that seasonal factors have impact on prices of palm oil and prices of fresh fruit. Autocorrelation test using Breusch-Godfrey serial correlation LM test revealed that disturbance terms in different periods are correlated. Therefore, it was solved using Cochrane-Orcutt Iterative Method. Heteroskedasticity test using White heteroskedasticity test shows that variance of disturbance terms were inconstant. Thus, it was solved using White heteroskedasticity-corrected standard errors.

Oil palm is characterized by seasonality in production which is generally due to climatic conditions such as temperature, rainfall and sunlight which contribute to production instability of oil palm (Eksomtramage, 2011). Oil palm can be harvested throughout the year, but outputs vary from month to month. Consequently, prices of fresh fruit vary in the same fashion. In general, prices of fresh fruit are high in the end of rainy season from November to February, when little oil palm is harvested. Seasonal price indices of fresh fruit during this period are above average price.

Prices of fresh fruit are seasonally low in summer until the middle of the rainy season (March to October), when it is the peak of output period or there is a large amount of oil palm being harvested. Seasonal price indices of prices of fresh fruit during this period were below average price.

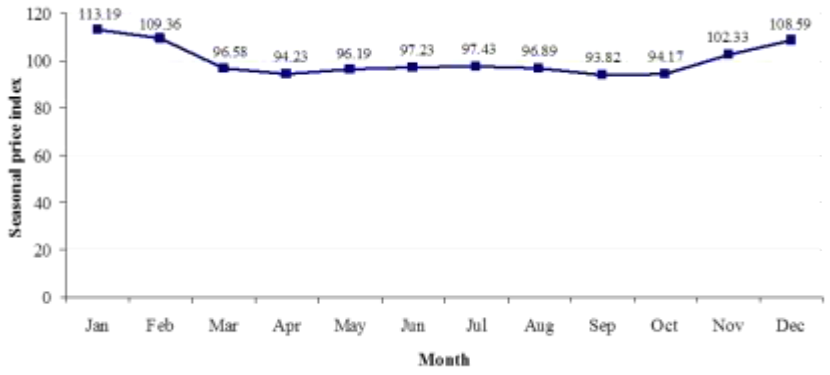

Fig. 2. Seasonal price index of palm oil

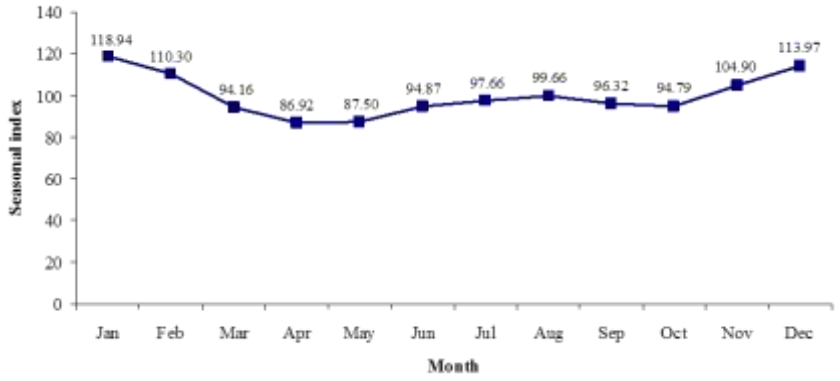

Fig. 3. Seasonal price index of oil palm fresh fruit bunch

Cyclical price indices of palm oil and fresh fruit were unclear (Figure 4 and 5). Cyclical price index of palm oil steadily decreased from 116.99 in 1989 to 93.86 in 1994. Cyclical price index of palm oil was then up again from 1995 (97.03) to 1998 (125.45). It afterwards continuously decreased from 105.76 in 1999 to 67.27 in 2001. In addition, cyclical price index of fresh fruit steadily decreased from 135.85 in 1989 to 87.64 in 1994. Cyclical price index of fresh fruit was then up again from 1995 (90.24) to 1998 (112.61). It afterwards continuously decreased from 92.65 in 1999 to 57.06 in 2001.

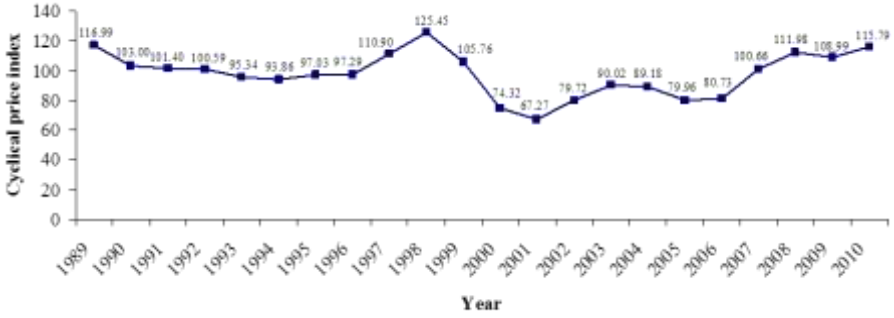

Fig. 4. Cyclical price index of palm oil

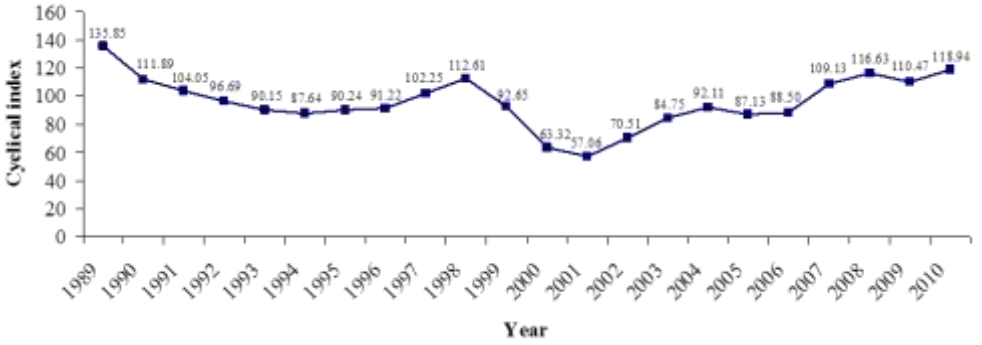

Fig. 5. Cyclical price index of oil palm fresh fruit bunch

The length of cycle of prices of palm oil and fresh fruit is 7 years (during 1995 to 2001). Netayarak (2007) mentioned that the length of cycle of agricultural product prices was two times of production period. Oil palm starts to produce fruit after 3-4 years after its planting (Eksomtramage, 2011), its cycle is about 6-7 years.

Most of the irregular price indices of palm oil and fresh fruit are close to average price. Irregular price index of palm oil was highest in 1998 (119.82) which has been 19.82 percent above the average price, and lowest in 2001 (83.57) which has been 16.43 percent below the average price (Figure 6). Irregular price index of fresh fruit was highest in 1998 (121.16) which has been 21.16 percent above the average price, and lowest in 2001 (75.29) which has been 24.71 percent below average price (Figure 7).

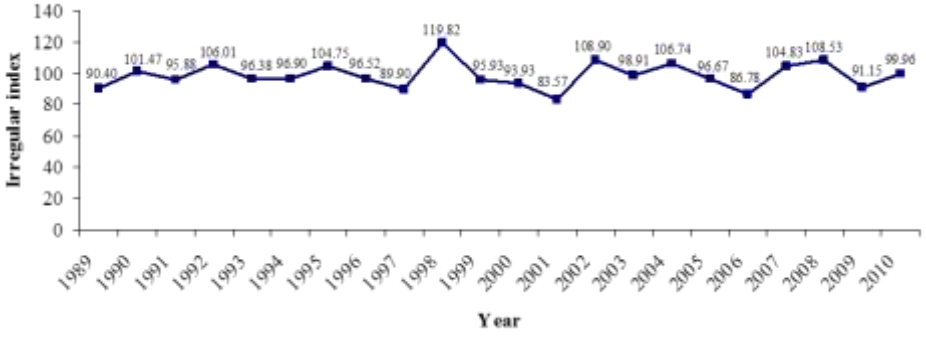

Fig. 6. Irregular price index of palm oil

This irregular price variation was brought about by the Tom Yam Kung crisis which started in Thailand in 1997. The Thai baht collapsed because the royal Thai government decided to float the baht and cut its peg to the US dollar. At that time, Thailand had acquired a burden of foreign debt that made the country effectively bankrupt even before the collapse of its currency.

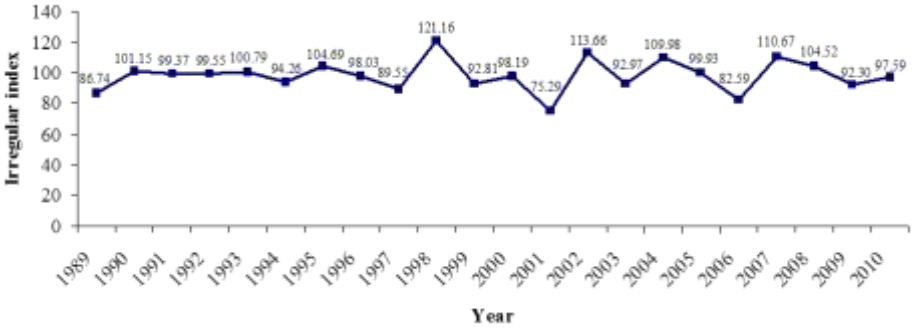

Fig. 7. Irregular price index of oil palm fresh fruit bunch

Price transmissions of Thai palm oil and oil palm among different market level

The results showed that, to some extent, price variation of one market reflects in price prevalence in the other market. The elasticity of price transmission from prices of refined palm oil to prices of palm oil is 1.17. That is, price transmission is elastic. The finding implies that the market is efficient in sending price signal because price of palm oil is more responsive to price of refined palm oil. As the price of refined palm oil increases (decreases) by 1 percent, the price of palm oil tends to increase (decrease) by 1.17 percent.

$$\ln(PPO) = -0.80^{***} + 1.17\ln(PRPO)^{***}$$
$$(-6.48) \qquad (30.35)$$
$$R^2 = 0.98 \text{ Adj } R^2 = 0.98 \text{ D-W statistics} = 1.89 \text{ F-statistic} = 4652.65^{***}$$

Note: numbers in parentheses are t-statistics, *** $p \leq 0.01$

The elasticity of price transmission from prices of Malaysian palm oil to prices of palm oil is 0.82. That is, price transmission is inelastic. The finding implies that the market is less efficient in sending price signal because price of palm oil is less responsive to Malaysian price of palm oil. As the Malaysian price of palm oil increases (decreases) by 1 percent, the price of palm oil tends to increase (decrease) by 0.82 percent.

$$\ln(PPO) = 0.63^{***} + 0.82\ln(PPOM)^{***}$$
$$(5.00) \quad (18.37)$$
$$R^2 = 0.95 \text{ Adj } R^2 = 0.95 \text{ D-W statistics} = 1.92 \text{ F-statistic} = 1615.86^{***}$$

Note: number in parenthesis was t-statistic, *** $p \leq 0.01$

Although Thailand is the third largest palm oil producing country in the world, it has a relatively small amount of palm oil production, compared with Indonesia and Malaysia. Thus, Thai palm oil farmers are essentially price takers. The results are consistent with the research of Kumda (2000) who found that prices of refined palm oil had positive impact on prices of palm oil (0.87). Moreover, Kasem (2003) found that prices of refined palm oil and Malaysian prices of palm oil had positive impact on prices of palm oil (1.006 and 0.83, respectively).

The elasticity of price transmission from prices of palm oil to prices of fresh fruit is 1.14. That is, price transmission is elastic. The finding implies that the market is efficient in sending price signal because price of oil palm fresh fruit bunch is more responsive to price of palm oil. As the price of palm oil increases (decreases) by 1 percent, the price of oil palm fresh fruit bunch tends to increase (decrease) by 1.14 percent.

$$\ln(PPF) = -2.38^{***} + 1.14\ln(PPO)^{***}$$
$$(-19.88) \quad (28.22)$$
$$R^2 = 0.97 \text{ Adj } R^2 = 0.97 \text{ D-W statistics} = 1.90 \text{ F-statistic} = 3753.50^{***}$$

Note: numbers in parentheses are t-statistics, *** $p \leq 0.01$

The result is consistent with the researches of Kumda (2000), Petchsuwan (2006) and Phuthep (2006) who found that prices of palm oil had positive impact on prices of fresh fruit (1.03, 0.19 and 1.80, respectively).

A system of equations of price determination for Thai palm oil and oil palm

The results indicate that the statistically significant variables in determining prices of palm oil are: prices of refined palm oil, farm prices of oil palm fresh fruit bunch and Malaysian prices of palm oil. The coefficient of multiple determinations is 0.99. That is, including independent variables to explain correctly the 99 percent of the total variation in prices of palm oil. In addition, the statistically significant variables in determining farm prices of

fresh fruit are price of palm oil. The coefficient of multiple determinations is 0.95. That is, including independent variables to explain correctly the 95 percent of the total variation in farm prices of fresh fruit (Table 1).

The results also indicate that the prices of refined palm oil has the highest and positive impact on prices of palm oil, similarly with the Malaysian prices of palm oil and farm prices of fresh fruit. Moreover, the price of palm oil has positive impact on farm price of fresh fruit.

The findings imply that as the price of refined palm oil, Malaysian price of palm oil and farm price of fresh fruit increase (decrease) by 1 percent, price of palm oil tends to increase (decrease) by 0.56, 0.22 and 0.18 percent, respectively. Furthermore, as the price of palm oil increases (decreases) by 1 percent, farm price of fresh fruit tends to increase (decrease) by 1.19 percent.

Price signals have contributed to relatively large shifts in domestic crop areas. That is, as the farm prices of fresh fruit increase, the incentives for oil palm farmers to grow oil palm also increase. Accordingly, area allocations are switched from one cash crop to another. Shifts in crop areas not only affect farmers but also has negatively impact on the entire local agribusiness industries, particularly those industries with crop-specific investments. For example, with the increase in farm prices of fresh fruit, farmers tend to allocate more areas to oil palm, and result in associated impacts on rubber production and rubber-related industries as amount of available land becomes a constraint.

In comparison to rubber plantation, oil palm cultivation has advantages over rubber cultivation in at least two aspects. Firstly, oil palm has lower gestation period. That is, three years after its planting oil palm starts its yield, while rubber farmers have to wait for another three years for first the latex. Secondly, in relation to labor, oil palm production requires fewer laborers to do field works in comparison with rubber production.

Another important factor which accelerates oil palm cultivation is the government's forest concession. The concession provides a large area for large scale plantation. In addition, a decrease in prices of coffee after 1977 induced coffee farmers to convert coffee cultivation to palm cultivation (Wiwattanakantang, 1994).

Table 1. Results of a system of equations of price determination for palm oil and oil palm

Variable	Estimated coefficient	Standard error	P-value
C^1	0.14	0.23	0.54
$PRPO^1$	0.56***	0.09	0.01
$PPOM^1$	0.22***	0.05	0.01
PPF^1	0.18***	0.06	0.01
PSO^1	0.05	0.06	0.41
C^2	-2.66***	0.22	0.01
PPO^2	1.19***	0.21	0.01
$PPOM^2$	-0.07	0.18	0.69
PSB^2	0.14	0.14	0.31
$R^2 = 0.9918^1$	Adj $R^2 = 0.9896^1$	D-W statistics = 1.5474^1	
$R^2 = 0.9541^2$	Adj $R^2 = 0.9454^2$	D-W statistics = 1.1124^2	

Note: [1] result of price determination for palm oil, [2] result of price determination for oil palm, [3] *** $p \leq 0.01$

Conclusions and recommendations

Palm oil and oil palm have been considered as economically important agricultural products in Thailand from the past to the present owing to their diverse advantages. Based on the results, it can be safely concluded that Thai oil palm plantation areas have increased for more than three decades. Oil palm planters are categorized into three groups namely: smallholders in land settlement, private smallholders and commercial companies. Prices of palm oil and prices of fresh fruit tend to increase over time. Seasonal price index of palm oil is highest in January and lowest in September, while seasonal price index of fresh fruit is highest in January and lowest in April. Cyclical price indices of palm oil and fresh fruit were unclear. Irregular price variation was a result of Tom Yam Kung Crisis. Price transmission from prices of refined palm oil to prices of palm oil is elastic. Price transmission from prices of Malaysian palm oil to prices of palm oil is inelastic. Price transmission from prices of palm oil to prices of fresh fruit is elastic. Prices of palm oil are mainly explained by prices of refined palm oil, Malaysian prices of palm oil and farm prices of fresh fruit. Farm prices of fresh fruit are only explained by prices of palm oil.

The research results led to proposing some important recommendations as follows:

1. Price of refined palm oil is a significant variable in determining the price of palm oil. At the same time, price of palm oil is a significant variable in determining farm price of fresh fruit. Therefore, palm oil producers as well as refined palm oil producers should focus on research and development and

investment in improving newly appropriate technologies and existing technologies in order to increase productivity and efficiency, and lessen risks and production costs. In addition, they should expand their capacity in order to lead to economies of scale. This capacity will enable them to compete with other producers;

2. Farm price of fresh fruit is a significant variable in determining the price of palm oil. Hence, the Ministry of Agriculture and Agricultural Cooperatives (MOAC) should devote incentives or subsidies such as provisions of disease-resistant and high-yielding palm seedlings, fertilizers, and other inputs to increase productivity and reduce production costs;

3. In case of a decline in price of oil palm, MOAC should temporarily apply price policy as an appropriate instrument to induce oil palm farmers to improve productivity instead of expanding area;

4. Oil palm planters, especially smallholders in land settlement should utilize seasonal price index as appropriate guidelines for their oil palm production, oil palm harvest and oil palm distribution to markets;

5. Oil palm planters, especially smallholders in land settlement should organize a training course in harvesting techniques for the improvement of fresh fruit quality, marketing strategies and price;

6. Oil palm planters, especially smallholders in land settlement should improve local information system through establishing information committee to provide key knowledge in production and marketing of Thai oil palm such as dissemination of newly developed technologies, price fluctuations, rules and regulations from government offices. It also makes them have a better understanding this information which can facilitate changes in their behaviours; and

7. Oil palm planters, especially smallholders in land settlement should promote establishment of farmer organizations to strengthen their bargaining powers.

Acknowledgements

The authors would like to express gratitude for grants provided by the Prince of Songkla University (PSU) for carrying out studies. They also would like to thank Graduate School, PSU for financial support exercised under the Songklanakarin Graduate Studies Grant. Furthermore, this research was supported by Oil Palm Agronomical Research Center, Faculty of Natural Resources, PSU.

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(Received 22 November 2012; accepted 30 June 2013)