Portfolio Selection in Agricultural Product Processing Industry

***Pisit Bungbua*[1]*, Pairoj Raothanachonkun*[2]*, and Nakorn Indra-payoong*[3]**
[1,2,3]*Faculty of Logistics, Burapha University, Chonburi, Thailand*
{pisit.bu[1], pairoj.iang[2], nakorn.ii[3]} @gmail.com

Introduction

Agricultural product processing is the process to add value to products. Sakaeo is the eastern border province of Thailand, located in the southern economic corridor. It links urban, economic areas, transportation and logistics with the upper eastern provinces and Cambodia as well as Vietnam. Because of the national policy to promote a special economic zone in Thailand, Sakaeo has an opportunity to develop its areas to support trade, agricultural and industrial investment. (Thailand's Department of Public Works and Town & Country Planning, 2015). From GPP of Sakaeo during 1995-2013, the agricultural production has the most value, compared with other productions (National Statistical Office of Thailand, 2015). Major industrial crops of Sakaeo are: rice, cassava, sugarcane, and maize, and agricultural processing activity is the key to generate income for local people, leading to sustainability of the city.

In order to obtain expected total return, the city needs to find the investment proportion in various assets that has the lowest investment risk, alternatively with a given level of risk with the maximum return. For the city administration in Sakaeo as a developing province, the policy is to target a satisfied level of return. The objective of this research is to analyze the portfolio selection in agricultural product processing industry of Thailand’s major industrial crops in Sakaeo, consisted of rice, cassava, sugarcane, and maize. This study tests the policy of selecting portfolio in two scenarios: 1) the minimum proportion for processing each type of agricultural products is not required, and 2) there is a minimum proportion.

Portfolio Selection

Sungkaew (2000) states that in efficient investment all investors are risk-aversed. Consequently, investors try to make diversification by investing in different assets in order to get efficient portfolio which has higher total return than other portfolio in the same risk level or has the lowest investment risk with the same return.

Investment return in portfolio is equal to the sum of investment return expected in each asset, multiplied by the proportion of investment in that asset, as shown in the following equation.

$$E\left(R_p\right)=\sum_{i=1}^{N} w_i E\left(R_i\right)$$

where $E\left(R_p\right)$ is the investment return rate expected in portfolio p, $E\left(R_i\right)$ is the investment return rate expected in asset i, w_i is the investment proportion in asset i, and N is the number of assets in portfolio.

Investment risk is the return an investor actually got (Actual return), dislocating or deviating from the return an investor expected to get (Expected return). The relations between investment return rate and investment risk are related in the same direction, which if investment return rate is higher, the investment risk will be higher too. The Investment risk of portfolio can be shown as the following equation.

$$Var\left(R_p\right)=\sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j Cov\left(R_i, R_j\right) \quad , i \neq j$$

where $Var(R_p)$ is the variance of investment return rate of portfolio p, $Cov(R_i, R_j)$ is the covariance of investment return rate in asset i and j, and w_i, w_j is the investment proportion in asset i and j respectively.

Optimal portfolio selection

Investors consider the return and the risk of the investment. They are more satisfied when they get more returns or have less risk. However, since investment getting high returns usually has high investment risk as well, so investors looking for higher returns have to accept more risk too.

Efficient portfolio means a portfolio giving the highest return at a risk level or a portfolio with the lowest risk level at the same return level, when considering from all feasible/opportunity sets. The efficient portfolio will be in a line called Efficient frontier (Budsaratrakul, 2005) as shown in Figure 1.

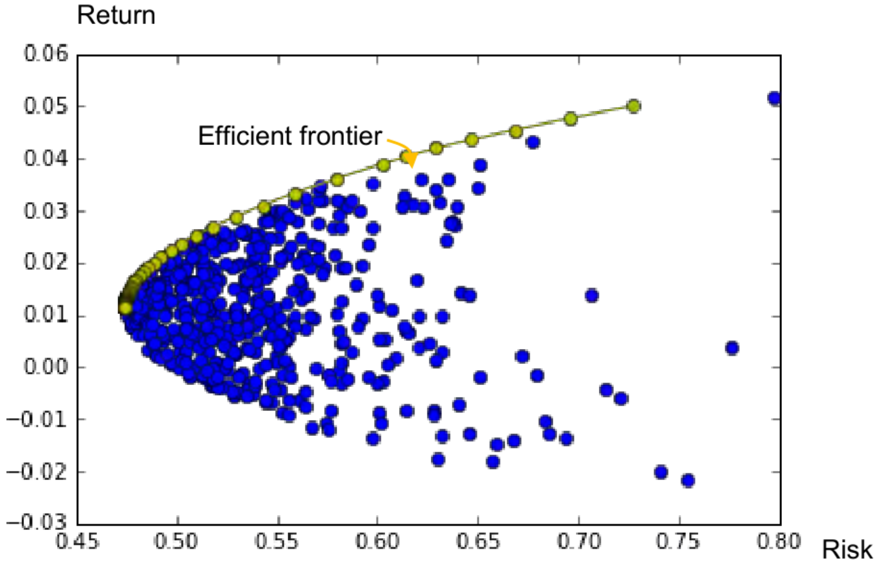

Figure 1: Efficient frontier (Starke *et al.*, 2015)

Quadratic Programming

Given: an *n*-dimensional real vector $\mathbf{c}$, an *n* × *n*-dimensional real symmetric matrix $\mathbf{Q}$, an *m* × *n*-dimensional real matrix $\mathbf{A}$, and an *m*-dimensional real vector $\mathbf{b}$, the objective function of quadratic programming is to find an *n*-dimensional real vector $\mathbf{x}$. The quadratic programming with *n* variables and *m* constraints can be written as follows.

Minimize	$\frac{1}{2}\mathbf{x}^{\mathrm{T}}\mathbf{Q}\mathbf{x}+\mathbf{c}^{\mathrm{T}}\mathbf{x}$
Subject to	$\mathbf{A}\mathbf{x} \leq \mathbf{b}$
	$\mathbf{x} \geq 0$

where $\mathbf{x}^{\mathrm{T}}$ and $\mathbf{c}^{\mathrm{T}}$ denotes the vector transpose of $\mathbf{x}$ and $\mathbf{c}$ respectively. The constraints $\mathbf{A}\mathbf{x} \leq \mathbf{b}$ means that every entry of the vector $\mathbf{A}\mathbf{x}$ is less than or equal to the corresponding entry of the vector $\mathbf{b}$. Besides, vector $\mathbf{x}$ has to be more than or equal to 0. (Wikipedia, 2015)

There have been study related researches which used quadratic programming to solve problems about setting portfolio such as Ekmaturapoj (2010) there was study a portfolio construction from investment in the Stock Exchange of Thailand by analyzing portfolio optimization from the Markowitz efficient portfolio theory. The study found that an efficient portfolio gave investment return rate 0.12% per day, and there was 0.75% of investment risk. Major portfolio were in the industries which were essential to survive such as energy and utilities industry, food and drink industry, medical industry, insurance industry etc. Meanwhile, Limwattana (2014) there was study the Markowitz efficiency of equity funds: a case study of the Thai equity market was studied to test the efficiency of modern portfolio theory of Markowitz to investment in Thailand's capital market by creating portfolio that were adjusted their management in three ways. These were 1) the variance of the portfolio was minimal, 2) the return was not less than the starting portfolio, and the variance was minimal, and 3) the risk was not more than the starting portfolio, and there was maximum return. The study found that the first way gave risk and average return less than the starting portfolio, the second way made average return and risk higher than the starting portfolio, and the last way made average returns higher than the starting portfolio but still less than the second. At the same time, Hernandez (2014) there was research to fine investment risk in the energy sector, including oil, natural gas, coal and uranium in Australia during the global financial crisis in 2008-2009 by measuring investment risk to decide to invest in the right stocks. The findings indicated that during the financial crisis, investment in oil stocks had higher risk than coal, uranium, and natural gas. Furthermore, there was research related to plan crop production. For example, Sayaphan (2001) it was the analysis of planning crop production in Phitsanulok province under the circumstance that was regardless of risk and the circumstance considering the risk of price fluctuations, by using linear programming model and minimization of total absolute deviation model respectively. Regardless of risk, the analysis showed that an appropriate production plan was in- season rice, off-season rice, peanut, and sugarcane should be planted and would give local agriculturists profits 35,849,290 baht. For the case with the risk of price fluctuations considered, an appropriate production plan at the high level of risk was planting sugarcane. In contrast, at low level of risk, a plan was suitable with maize and peanut. In addition, Hunkittikul (2007) there was study the planning of crop production in Pongyang sub district, Mae Rim district, Chiang Mai province by dividing cultivated areas into 11 zones distinguished by characteristics of crop varieties and irrigation systems acquired. Data was analyzed by using linear programming model. The results showed that zone 1 should plant peas, zone 2 should plant swan plant, strawberry, sayote, and onion, zone 3 was fit with banana, zone 4 should plant sweet pepper, zone 5 was appropriate with chrysanthemum, zone 6 was potato and carrot, zone 7 was potato, zone 8 was persimmon, zone 9 was suitable for roses, lychee, and banana, zone 10 should cultivate sweet pepper, and zone 11 was fit with planting gerbera. That would give local farmers maximum profit average 151,744.93 baht per year per household.

In most literature, it showed that quadratic programming is mostly used to solve the problems of selecting portfolio in the stock market. Nonetheless, the researchers have not found that there is quadratic programming applied to the solution of selecting portfolio for agricultural products processing. Meanwhile, there is research related to crop production planning which are raw materials of agricultural product processing. It is analysis to plan crop production appropriately with characteristics of the areas such as dividing cultivated areas and irrigation systems acquired. That plan might consider or did not consider risk of price fluctuations. Nevertheless, the researchers found no researches that related to planning of portfolio selection in agricultural product processing. This research, thus, desired to study portfolio selection in agricultural products processing industry in order to find the right portfolio based on the portfolio policy that was set. This can be used as a guide to plan and encourage agriculturists to grow crops that meet the demand for products processing, bringing benefits to the economic development of the city.

Methodology

This research applied quadratic programming model to analyze portfolio selection in agricultural product processing industry of Thailand's major crops in Sakaeo province, consisted of rice, cassava, sugarcane, and maize. In this study, we test the policy of portfolio selection in two scenarios: 1) the minimum proportion for processing each type of agricultural products is not required, and 2) there is a minimum proportion. The objective function of the problem is to find the lowest risk of portfolio, subject to a specific value of expected return and a minimum proportion for processing each type of agricultural products. The generalized reduced gradient algorithm in MS Excel solver is used to find the optimal selection of portfolio.

Agricultural product processing industry

Agricultural products processing industry is crucial to the economic development for farming province. Since the processing of agricultural products is taking the output from crops to process, it helps to add value to products, keep them for a long time, make new products, and increase the variety of distribution of agricultural products to the market. The major crops of Sakaeo province are rice, cassava, sugarcane, and maize. In order to analyze portfolio selection in this research, the outputs from processing was defined to make clear: paddy rice was defined to be processed into polished rice, and cassava, sugarcane, and maize are tapioca starch, sugar, and maize kernels respectively as shown in figure 2.

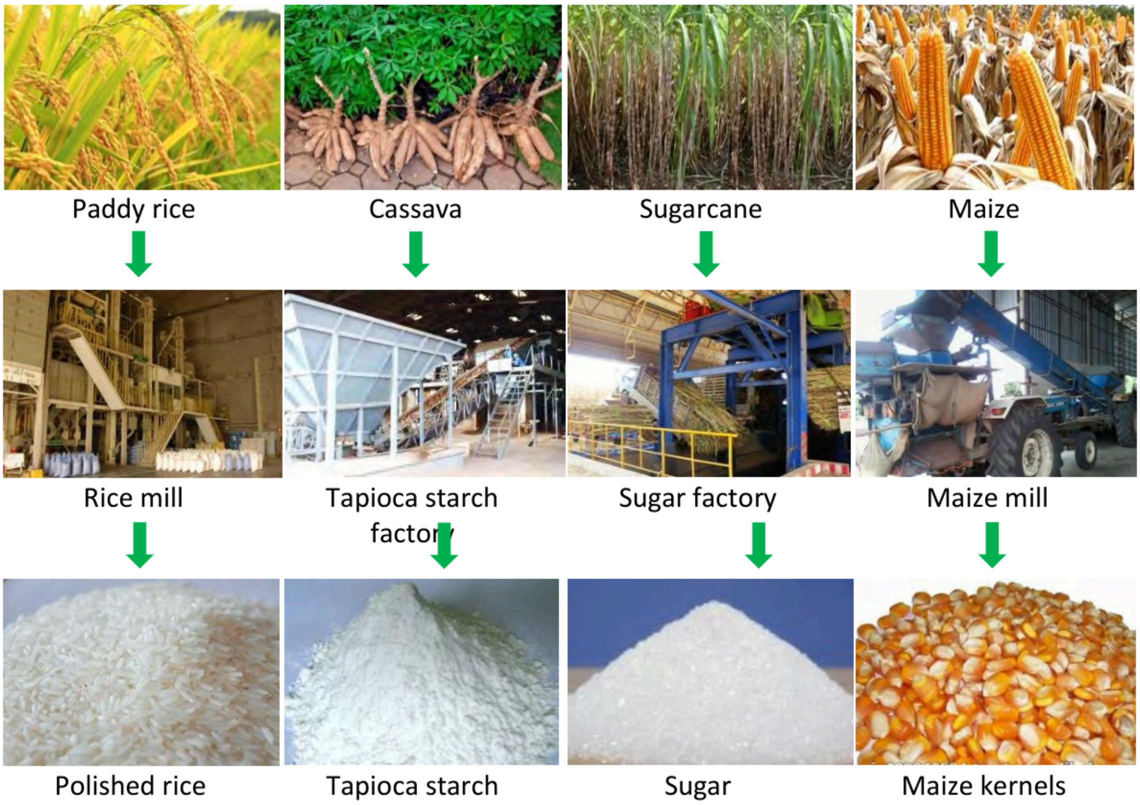

Figure 2: Processing of agricultural products from 4 major crops

Due to the researchers have not found that the agency collecting information about the return on agricultural products processing, the researchers used data from Centre for Agricultural Information Thailand (2010), Thailand's Office of Agricultural Economics (2014), Bureau of Trade and Economic indices Ministry of Commerce Thailand (2015), Thai Feed Mill Association (2015), Thai Tapioca Starch Association (2015), Office of the Cane and Sugar Board (Thailand) (2015), Office of the Cane and Sugar Fund (Thailand) (2015), CPF Feed Marketing Bureau in Thailand (2015), The Stock Exchange of Thailand (2015) to calculate the costs and returns in processing four agricultural products by comparing the percentage of return from products from the average price of each crop during 2007-2014 (Thailand's Office of Agricultural Economics, 2015). The percentage of return from each type of agricultural products is shown in Table 1.

Year	Percentage of return on agricultural products processing			
	Rice	Cassava	Sugarcane	Maize
2014	6.61	8.25	13.35	5.79
2013	7.47	7.95	13.68	5.83
2012	8.66	7.83	14.54	7.59

2011	8.24	9.57	14.48	6.18
2010	7.09	8.51	13.43	6.52
2009	8.07	4.99	11.62	4.39
2008	8.97	6.55	9.49	5.76
2007	5.62	5.22	9.88	5.55
Expected Return	7.59	7.36	12.56	5.95
Standard Deviation	1.05	1.52	1.86	0.85

Table 1: Return on agricultural products processing from 4 major crops

According to Table 1, it has shown that Sugarcane provides the expected return and standard deviation (risk) more than the return from other agricultural products. On contrary, maize processing has a minimum expected return and risk.

Mathematical model

The objective of the research is to minimize the risk of portfolio subject to a predetermined value of expected return, the criteria to find the optimal portfolio for agricultural products processing from the major crops of Sakaeo can be written in mathematical form as:

Minimize $$\sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j Cov(R_i, R_j) \quad , i \neq j \qquad (1)$$

Subject to $$\sum_{i=1}^{N} w_i E(R_i) = R^* \qquad (2)$$

$$\sum_{i=1}^{N} w_i = 1 \qquad (3)$$

$$0 \leq w_i \leq 1 \,, \quad i = 1,\dots,N \qquad (4)$$

where N is the number of types of processed agricultural products, w_i, w_j is the proportion of agricultural products processing type i and type j respectively, $Cov(R_i, R_j)$ is the covariance of investment return of agricultural products processing type i and type j, $E(R_i)$ is the expected return of agricultural products processing type i ,and R^* is the predetermined value of expected return of portfolio.

Eq. (1) the objective function is to find the lowest risk of portfolio subject to a predetermined value of expected return of portfolio. The model constraints are: Eq. (2) is that the sum of processing proportion multiplied by the expected return on each type of agricultural products must be equal to a predetermined value of expected return, Eq. (3) is the sum of proportion in processing all type of agricultural products must be equal to 1, and Eq. (4) is the proportion in processing each type of agricultural product is more than or equal to 0, but less than 1.

Results

We test the policy of selecting portfolio in two scenarios: 1) the minimum proportion for processing each type of agricultural products is not required, and 2) there is a minimum proportion. The result of optimal portfolio selection is shown in Figure 3.

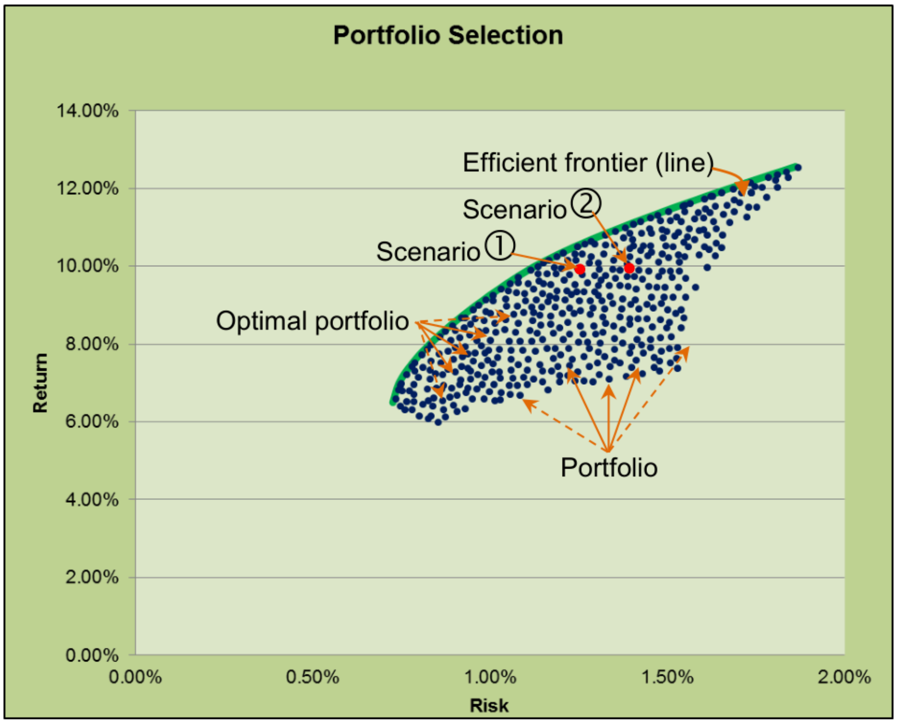

Figure 3: The result of optimal portfolio selection

From Figure 3, the optimal portfolios are on the efficient frontier line. Determining 10.00% of expected return without minimum proportion, the portfolio has a lowest risk (see ① in Figure 3). The portfolio has the total return is 10.00% (as determined), and the risk is 1.13%. Crop to process is consisted of 51.51% of rice, 48.49% of sugarcane, and there are no need from cassava and maize. By setting the minimum proportion at 15.00% for processing each type of products, the portfolio has a lowest risk (see ② in Figure 3), the portfolio has the total return is 10.00% (as determined), and the risk is 1.32%, which is slightly higher than the previous scenario. Crop to process is the proportion of 54.07% of sugarcane, 15.93% of rice, and 15.00% from cassava and maize respectively.

Conclusion

The portfolio selection model for agricultural products processing is developed in this paper, under two testing scenarios: 1) the minimum proportion for processing each type of agricultural products is not required, and 2) there is a minimum proportion at 15.00% for processing each type of products. It is found that both scenarios get the total return 10.00%, which is on the defined target. In scenario 1) 51.51% and 48.49% of outputs from rice and sugarcane are selected, while there are no need to process product from cassava and maize, resulting the risk of portfolio is 1.13%. In scenario 2) 54.07%, 15.93%, 15.00%, and 15.00% of sugarcane, rice, cassava, and maize are selected, and the risk of portfolio is 1.32%, which is more than the previous scenario 0.19%. The risk of portfolio in scenario 2 is slightly higher than scenario 1 because the return rate of processing some types of agricultural products has a relation in the same direction. Consequently, when finding optimal portfolio, it increase the risk of portfolio. The testing results of both scenarios, the risk of portfolio that is a little different. Thus, city administrators may decide to use the policy in scenario 2 which holds determination of minimum proportion at 15.00% for processing each type of products. That the risks of portfolio increase slightly, while processing 4 crops made more various agricultural products distributed to the market and farmers in Sakaeo have alternatives to plant more crops than scenario 1. In summary, the city administrators can practically use this developed model to select portfolio and to support policy making in planting and processing agricultural products.

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