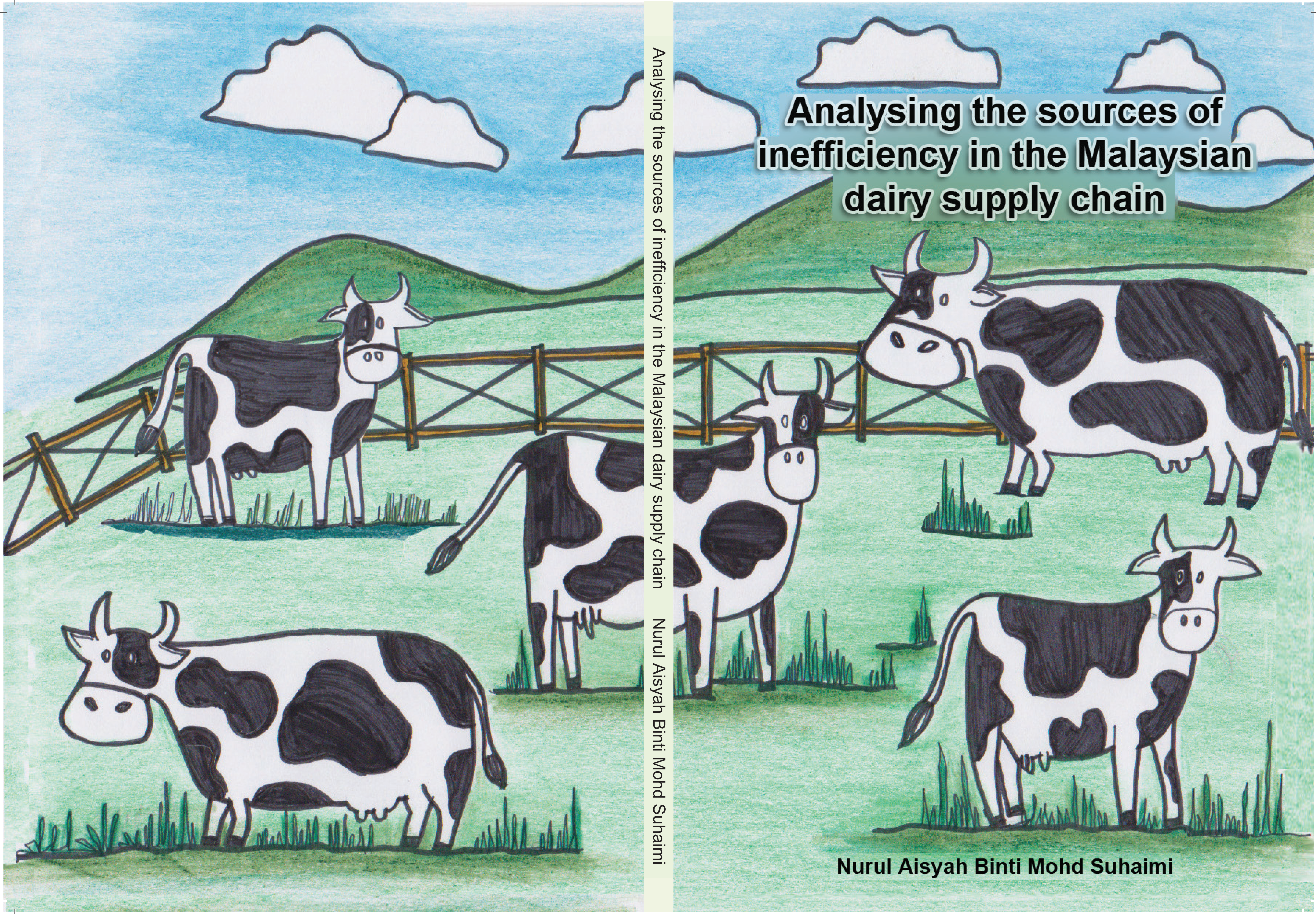

Analysing the sources of inefficiency in the Malaysian dairy supply chain

Nurul Aisyah Binti Mohd Suhaimi

Analysing the sources of inefficiency in the Malaysian dairy supply chain
Nurul Aisyah Binti Mohd Suhaimi

Propositions

1. Input over-usage, transaction costs and asymmetric price transmission are sources of inefficiency in the Malaysian dairy supply chain.
   (this thesis)

2. In the Malaysian dairy supply chain, price signals at the retail stage transmit upstream to the state-owned enterprise PPIT but not vice versa, suggesting the presence of imperfect competition.
   (this thesis)

3. Fermentation technology can contribute to human health by increasing the variety of biopharmaceutical products.

4. Overuse of technology leads to economic depression.

5. Communication is the key to personal and career success.

6. The Wageningen University and Research PhD programme forces PhD candidates out of their comfort zones.

Propositions belonging to the thesis, entitled

"Analysing the sources of inefficiency in the Malaysian dairy supply chain"

Nurul Aisyah Binti Mohd Suhaimi

Wageningen, 5 November 2018

Analysing the sources of inefficiency in the Malaysian dairy supply chain

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Analysing the sources of inefficiency in the Malaysian dairy supply chain

Nurul Aisyah Binti Mohd Suhaimi

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Contents

CHAPTER 1

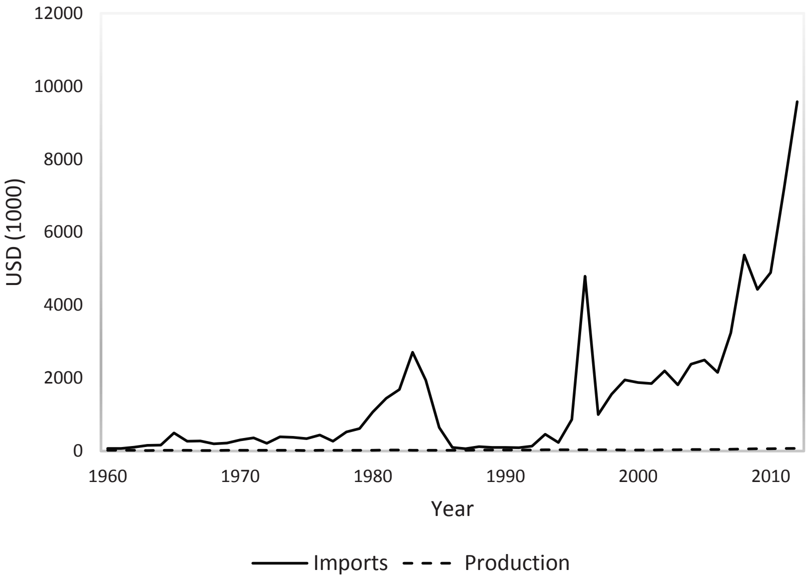
General introduction

1.1 Background

Milk is produced and consumed in basically all countries of the world. According to the Food and Agriculture Organization, milk contributes 27 percent to the global value added of livestock. By 2025, per capita consumption is projected to increase between 0.8 percent and 1.7 percent annually in developing countries, and between 0.5 percent and 1.1 percent in developed countries. Dairy consumption in Southeast Asia (including Malaysia) is expected to grow 3 percent every year until 2020, making the region one of the largest consumers of dairy products globally. In 2016, the Malaysian per capita consumption of milk was 37.99 litre, an increase of 19.7 percent from 2007. Figure 1.1 shows the trend of milk import and production from 2007 to 2012. Local milk production was only 36.74 million litres in 2016, while the dairy consumption was 1207.31 million litres, meaning that 97 percent of milk and dairy products were imported. Although milk production increased over the past decade, the growth was insufficient to satisfy the increasing demand. Because Malaysia heavily relies on imported milk and dairy products, tariffs rates on dairy products were much lower as compared to other foods (Sim and Suntharalingam, 2015) and for some dairy products such as skim milk and whole milk powder, the tariffs were zero (Warr et al., 2008).

Since the early 1970s, the Malaysian government has made efforts to increase the production of milk. Nineteen milk collection centers (MCC) were established during the Third Malaysia Plan (1976-1980) in order to stimulate production of fresh milk. The total number of MCC increased to 43 in the early of 1980s. In the 1980s, the government gave more focus on new industries such as heavy industry, plantation and shipping industry and as a result, the agriculture, including the dairy sector received less policy support. Until the Asian financial crisis hit Malaysia in 1997, there was an urgent need to enhance food security. The government quickly responded by formulating the Third National Agricultural Policy (NAP3) for the 1998-2010 period. Under NAP3, efforts were made on how to increase milk production. In 2010, the

Malaysian government implemented the National Key Economics Area (NKEA) program. Twelve NKEAs were announced such as Healthcare NKEA, Tourism NKEA, Business services NKEA and Agriculture NKEA. Under the Agriculture NKEA, there are 16 Entry Point Projects (EPP) focussed on sub-sectors with high growth potential. One of them is the dairy sector. This EPP of the dairy sector aims to reduce Malaysia's dependence on imported dairy products. Two EPPs were led by the Department of Veterinary Service (DVS) which are EPP13 and EPP16. EPP13 entails a partnership of local farms with a large dairy company (i.e. an anchor company) for instance Dutch Lady Milk Industries, Evergreen Livestock and Fonterra. Anchor companies will oversee all aspects of the dairy cluster operations, from production to marketing. Anchor companies also provided the assistance via technological and knowledge know-how. Individual farms will be guided by anchor companies, and guarantee purchases at a pre-determined price. EPP16 aims to secure a consistent and affordable source of live animals required for breeding, placement in feedlots and dairy operation over the next decade. The government invested in foreign cattle farms to ensure a steady supply of cows. According to the Economic Transformation Programme 2014 Annual Report, there are 281 farmers under EPP13, with 198 farmers considered as smallholder farmers (PEMANDU, 2015).



Reference: Food and Agriculture Organization

Figure 1.1 Milk imports and production in Malaysia (1961-2012)

1.2 Description of the Malaysian dairy sector

The Malaysian dairy sector can be categorized as a small sector in Malaysia as compared to the poultry and pork sectors. 89% of dairy farmers are small-scale farmers who owned around 10 to 29 of heifers. In 2017, there were approximately 823 farms and 21,000 dairy cows in Malaysia, while, the milk production was approximately 36.5 million litre per year (Hussin, 2017). On average, the production of milk increased by 4% annually from 2001 to 2012.

Dairy farming in Malaysia is practised in two main types of production systems, i.e. an intensive and a semi-intensive system. In the intensive system, grazing animals are confined to a small area. The number of cattle per shed ranges from less than 20 head to several hundred. The animals are fed few times a day. This system uses 40% of concentrated feed for the energy and the rest are from fodder. The concentrated feeds are mostly by-products of palm oil milling such as palm kernel cake and palm oil mill effluent. The semi-intensive system is a system in which animal freely graze on land that is also used for crop production. The cattle are allowed to graze the plant undergrowth found in the inter-rows of oil palm or rubber estates. Also, there is cattle that grazes on native grasses and other plant species found on the road sides, river banks and irrigation bunds. The semi-intensive system is a traditional system of dairy farming which uses less concentrated feed and labour, but needs more land (for grazing) than the intensive system.

Most of the farmers use Sahiwal –Friesian crossbred as this breed is adaptable to the hot and humid local environment. Milking can be done in two ways, i.e. manually or using a milking machine. Some of the farmers who cannot afford to buy an electrical milking machine, prefer to use a portable milking machine. Since most of them do not have proper cold storage, they will sell their milk immediately after milking in the morning and in the afternoon. Dairy farmers have multiple marketing channels to sell their milk. Figure 1.2 shows the marketing channels used by dairy farmers in Malaysia. They can sell their milk to the Dairy Industry Service Centre (PPIT), to agents or traders, to processors, to hotels or restaurants, to temples or small shops, and to end consumers. Agents or traders and end consumers will collect the milk from the farms. If the farmers plan to sell their milk to PPIT or processors, they have to transport the milk by themselves. Most farmers sell their milk to the government-run organization, PPIT. PPIT is supervised by Department of Veterinary Service and there are 34 PPIT around Peninsula Malaysia. Besides providing a marketing channel to the farmers, they also give various services and assistances such as veterinary services, rural credit, subsidies for buying cows and extension services. On average, PPIT receives 6.54 (30%) million litre milk annually. Then PPIT either sells the milk to a processor or sells it directly to the end consumer through a vendor.

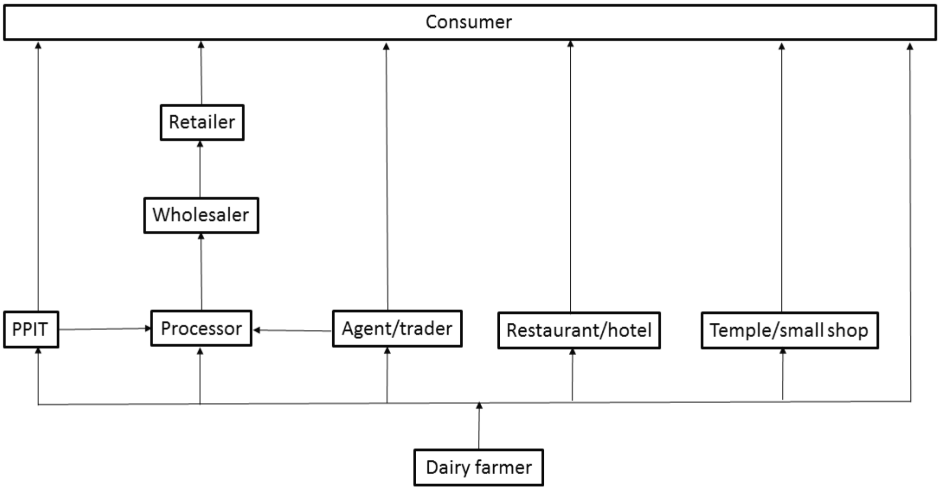


Figure 1.2 Milk distribution in Malaysia

1.3 Problem statement

Since the 1970s, the Malaysian government used the various strategies described above to increase domestic milk production. These efforts increased the self-sufficiency level for milk from 0.4% in 1974 to 5% in 2016. One way to further increase the self-sufficiency is through eliminating the technical and allocative inefficiency in the entire dairy supply chain. At the farm level, input-specific technical inefficiency can be measured in order to help farmers to identify which inputs can be saved while producing the same amount of output. Since there are two main systems of dairy farming in Malaysia, it might be relevant for the government to know which system is more efficient so that they can enhance the efficiency of milk production. It is important for farmers to have certainty about the sale of milk in order to avoid any losses. Dairy milk is a highly perishable product and the quality of milk will deteriorate after a few hours, thus it requires the farmer to sell their milk immediately. Farmers are free to choose any of the marketing channels available to them, such as PPIT, direct selling and intermediaries. However, there is a cost for farmers to switch between marketing channels such as information cost, negotiation cost and monitoring cost. Farmers have to bear these additional cost if they switch to other marketing channels. Therefore, identifying transaction costs invloved in the choice of marketing channel provides insight into market inefficiency. In addition, the choice of the marketing channel also determines the profitability of milk sales as different channels are characterized by different levels of profitability (Soe et al., 2015). Identifying the factors influencing marketing channel choice, gives a better understanding on the forces shaping channel structure (Klein et al., 1990) and can help farmers to optimize their profit (Soe et al., 2015).

As marketing of milk in Malaysia is dominated by the Dairy Industry Service Centre (PPIT), the processing part of the supply chain might be less competitive. This can be a source of x-inefficiency which is a result of a deficiency of external or market pressure, leading to an inferior performance (Leibenstein, 1976). X-inefficiency is defined as the difference between maximal effectiveness of the utilization of inputs and the actual effectiveness (Gillis, 1982). In 2008, 6.51 million litre (49%) was sold to PPITs (DVS, 2008). PPITs not only operate as a milk marketer but it also provide services related to dairy farming. As a government-run organization, the PPIT likely does not aim at maximizing profit, but might focus more on minimizing costs and providing value to the farmers. Therefore, the PPIT is expected to be allocatively inefficient. Measuring technical, allocative and scale efficiency can help the PPIT to identify how much inputs can be saved and by how much the costs could be further reduced.

As most of the Malaysian dairy farmers are small-scale farmers, they do not have any bargaining power vis-a-vis other supply chain actors. Basically, the price at farm gate is determined by the government through DVS. However, it remains an open issue how prices are transmitted in the market for fresh milk in Malaysia. There are a number of potential reasons for asymmetric price transmission such as a market power in the chain (Azzam, 1999; Meyer and Cramon-Taubadel, 2004), product perishability (Ward, 1982), adjustment and menu cost

(Bailey and Brorsen, 1989), search costs in local market (Benson and Faminow, 1985) and public intervention in producer prices (Kinnucan and Forker, 1987). Asymmetric price transmission may lead to inefficiencies in the market, preventing optimal resource allocation (Ben-Kaabia and Gil, 2007). Analysing the price transmission from farm gate to the PPIT then to the retailer can show whether the consumers are benefiting from a price reduction at the farmer' level, or whether farmers are benefiting from a price increase at the retail level. A better understanding of price transmission helps in designing a policy which could reduce not only the causes of market failure but also reduce poverty and food insecurity (Schroeder and Hayenga, 1987).

In recent years, research on Malaysia's dairy sector has been emphasizing the constraints for farm production and husbandry such as high input costs (Shanmugavelu and Azizan, 2006; Wells, 1981), lactation failure (Murugaiyah et al., 2001), milk quality (Chye et al., 2004), poor farm management (Shanmugavelu and Azizan, 2006) and unsuitability of dairy cows for the tropical weather condition in Malaysia (Boniface et al., 2007). Furthermore, Boniface et al. (2010) and Boniface et al. (2012) explored buyer and seller relationships between dairy producers and milk buyers, whereas Sim and Suntharalingam (2015) offered an overview of the initiatives taken by the government in order to reduce dairy import bills. Other Southeast Asian countries also aim at increasing milk production and enhancing dairy development. For instance, Wanapat et al. (2000) analysed dairy productivity through improving feeding systems for smallholder dairy farmers in the Northeast Thailand and Sulastri and Maharjan (2002) assessed the role of dairy cooperative services on dairy development in Yogyakarta, Indonesia.Furthermore, Alejandrino et al. (1999) identified constraints to productivity of dairy cows at the smallholder level in Philippines and Nguyen Hung et al. (2013) analysed the production and marketing constraints faced by the Vietnamese dairy farmer in the milk value chain.

Analysing inefficiencies in the Malaysian dairy sector can provide useful insights to different stakeholders. However, only few studies have analysed this issue in Malaysia. Therefore, there are still significant knowledge gaps with respect to the presence of inefficiency in the Malaysian dairy sector. A further study of the causes of inefficiency in the Malaysian dairy supply chain is a key to reducing the dependency of imported milk to enhancing the milk production. This research is scientifically important because such analysis has not been done yet in the Malaysian dairy supply chain.

1.4 Objectives

The overall objective of this thesis was to analyse the sources of inefficiency in the Malaysian dairy supply chain. Sub-objectives of this thesis were:

1. To measure the technical inefficiency of dairy farms and subsequently investigate the factors affecting technical inefficiency in the Malaysian dairy industry.
2. To explain the factors influencing marketing channel selection by dairy farmers.
3. To measure, and determine the factors affecting, the technical, allocative and scale efficiency of the state-owned enterprise, the Dairy Industry Service Centre (PPIT).
4. To analyse the price transmission throughout the supply chain of fresh milk in Malaysia.

1.5 Description of study area and data

For the second and third chapter, a survey was conducted in four regions in Peninsula Malaysia which represent 70.2% of milk production, i.e. Johor, Selangor, Melaka and Negeri Sembilan (DVS, 2012). Figure 1.3 shows the location of study area (names of regions written in capitals).

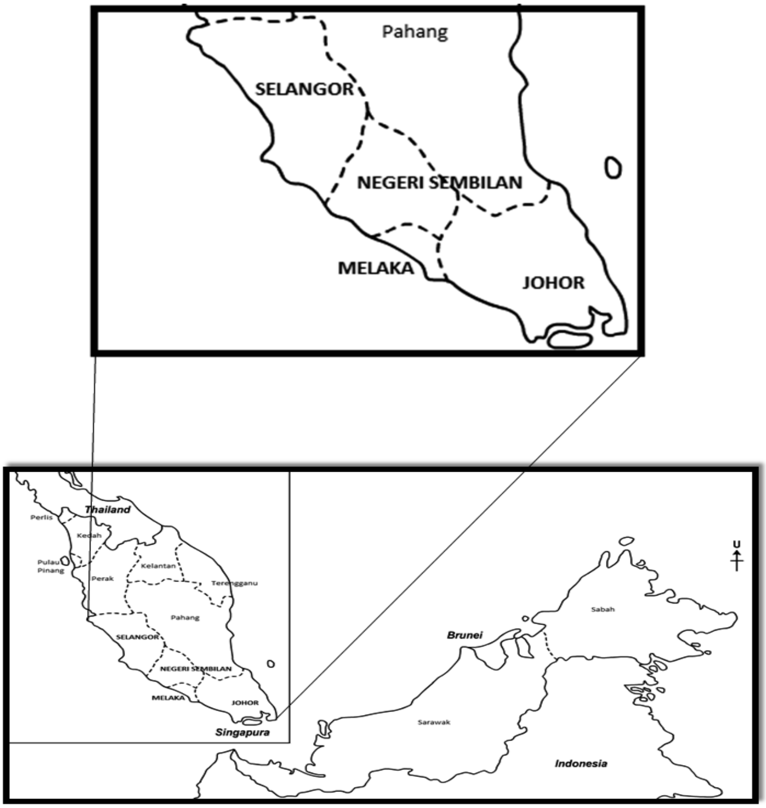


Figure 1.3 Location of study area

This research uses primary and secondary data. Data were collected by personal interviews using a combination of closed questions and Likert scale questions with a 5-point format. 200 dairy farmers were selected from four regions. Within each region, respondents were chosen using two types of sampling: convenience sampling and random sampling. Random sampling means that each unit in the accessible population has an equal chance of being included in the sample, and the probability of a unit being selected is not affected by the selection of other units from the accessible population (Teddlie and Yu, 2007). Convenience sampling is a nonprobabilistic method which entails sampling units because they are easily accessed (Yu and Cooper, 1983). The convenience sampling was used because some of the farms are located far from the main road and are not easily reached due to bad road conditions. For the convenience sampling, we waited at the premises of the local PPIT for the farmers who were going to sell their milk to the PPIT. In order to reach our target number of farmers in the sample, we then turned to random sampling by randomly choosing dairy farmers from the complete list of dairy farms which was provided by DVS. Personal interviews were conducted with these owners or managers of dairy farms between February and June 2015. For the fourth chapter, a second round of primary data collection was undertaken. Questionnaires were sent out to all PPITs in Peninsula Malaysia through emails and then each of them was called to make sure that they notified the email. The managers could decide to have the interview either by phone or to fill out the document file by themselves. This approach resulted in a response of 25 PPIT (74%). This survey was conducted between May and July 2017 and contained questions on the production of output, the use of material, equipment and other input by the PPIT, and socio-economics factors. For the fourth chapter, secondary time series data was used. Farm prices were obtained from DVS, PPIT prices were obtained from PPIT and retail prices were from the Ministry of Domestic Trade, Cooperatives and Consumerism Malaysia. All prices were in Malaysian Ringgit.

1.6 Outline of the thesis

This thesis is composed of six chapters, including a general introduction (Chapter 1), four research chapters (Chapter 2-5) and a general discussion (Chapter 6). Figure 1.4 provides an overview of how the thesis is structured along with its information flow in regards to the Malaysian dairy supply chain.

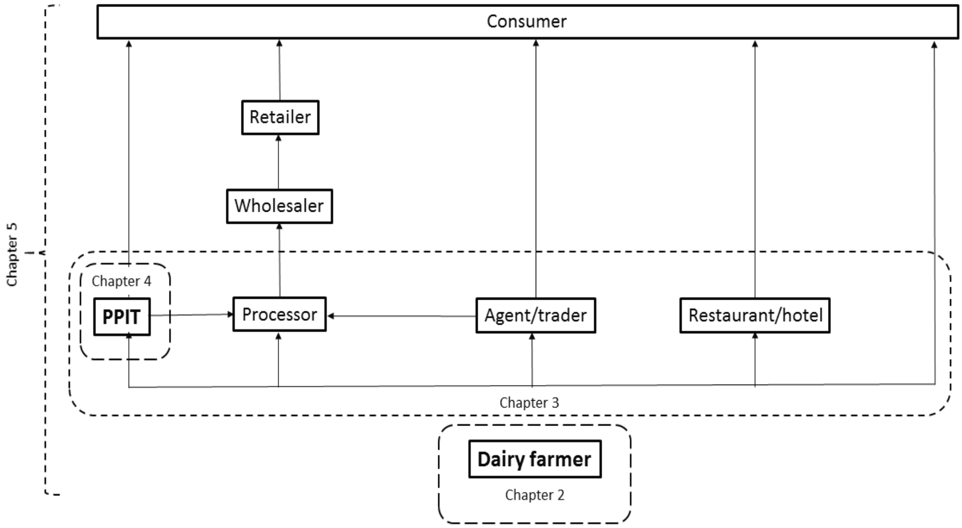


Figure 1.4 Structure of the thesis

Chapter 2 estimates the input-specific technical inefficiency of dairy farms in Malaysia by using multi-directional data envelopment analysis. This was followed by a single bootstrap truncated regression in order to determine the relation between input-specific technical inefficiency and socio-economics factors.

Chapter 3 investigates the factors influencing dairy farmers' selection of milk marketing channel in Malaysia based on transaction cost approach. The importance of the factors was determined using a multivariate probit model.

Chapter 4 measures the technical, allocative and scale efficiency of the state-owned enterprise, Dairy Industry Service Centre (PPIT) using Data Envelopment Analysis. Furthermore, a single bootstrap truncated regression analysis was used to estimate the relation between technical, allocative and scale efficiency and characteristics of the firm and manager.

Chapter 5 analyses the price transmission from dairy farms to the retail stage. To do so, this chapter estimates time series models that describe the short- and long-run relationship between different pairs of milk prices.

Finally, Chapter 6 discusses the main findings, methodological and data issues as well as the contribution of this thesis to the literature. The policy and business implications are also outlined in this chapter.

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CHAPTER 2

Measuring and explaining multi-directional inefficiency in the Malaysian dairy industry

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Abstract

The aim of this study is to measure the technical inefficiency of dairy farms and subsequently investigate the factors affecting technical inefficiency in the Malaysian dairy industry. This study uses multi-directional efficiency analysis to measure the technical inefficiency scores on a sample of 200 farm observations and single-bootstrap truncated regression model to define factors affecting technical inefficiency. Managerial and program inefficiency scores are presented for intensive and semi-intensive production systems. The results reveal marked differences in the inefficiency scores across inputs and between production systems. Intensive systems generally have lowest managerial and program inefficiency scores in the Malaysian dairy farming sector. Policy makers could use this information to advise dairy farmers to convert their farming system to the intensive system. Our results suggest that the Malaysian government should redefine its policy for providing farm finance and should target young farmers when designing training and extension programs in order to improve the performance of the dairy sector. The existing literature on Southeast Asian dairy farming has neither focussed on investigating input-specific efficiency nor on comparing managerial and program efficiency. This chapter aims to fill this gap.

Keywords

Technical inefficiency, multi-directional efficiency analysis, dairy industry, Malaysia.

2.1 Introduction

The demand for dairy products in the Asian region (including Malaysia), has doubled over the past decade. Currently, Malaysia still relies heavily on imports to satisfy its domestic demand for dairy products. Although milk production increased over the past decade, the growth was insufficient to meet the growing domestic demand for fresh milk. In 2012, domestic production accounted for only 4.06% of total consumption (DVS, 2012). Even though Malaysia does not have a comparative advantage in dairy production, the government uses tariffs to protect domestic markets and there is no export of dairy products to international markets (Peng and Cox, 2006). Recently, the dairy sector was selected by the Malaysian government as an Entry Point Project (EPP) under the National Key Economics Area program. The EPP aims among other things to reduce Malaysia's dependence on imported fresh milk in order to increase food security by forming dairy clusters under anchor companies to produce milk on a large-scale basis. The dairy industry can increase its production among others by improving the technical efficiency of the use of inputs such as land, feed and labour. It remains a question though how dairy farms can improve their technical efficiency. Moreover, what factors determine the technical efficiency and for what inputs specifically can savings be obtained?

Dairy farming in Malaysia is practiced in two main types of production systems: the intensive and semi-intensive system (note that in practice, some farms might hinge on the borderline between them of course). In the intensive system, grazing animals are confined to a small area on which no feed is produced and the animals are fed on stored feed. Farmers feed their cattle following a schedule. In the semi-intensive system, animal graze on land that is also used for crop production. Ruminants, such as buffalo, cattle and goats, are free to move under crop production, such as palm oil and rubber estate. This type of system uses less concentrated feed and labour, but requires more land than the intensive system. Intensive farms are more likely to have higher operational costs compared to semi-intensive farms. Hence, an analysis of technical efficiency of the Malaysian dairy industry should distinguish technical efficiency given the system under which the farm operates (intensive versus semi-intensive) from efficiency differences between the two systems. In what follows, this chapter refers to the efficiency within a system as managerial efficiency whereas differences in efficiency between systems is referred to as program efficiency. This approach of program (and managerial) efficiency was conceived by Charnes et al. (1981). Agricultural program efficiency has been considered by for example Gómez-Limón et al. (2012), who estimated the program efficiency of traditional rain-fed mountain groves, traditional rain-fed plain groves and irrigated intensive groves. Using the same approach, Beltrán-Esteve and Reig-Martínez (2014) assessed conventional and organic citrus grower efficiency in Spain.

According to Koopmans (1951), a producer is technically efficient if output can only be increased when at least one other output is reduced or at least one input is increased, or if a reduction in any input requires an increase in at least one other input or a reduction in at least one output. Producers directly benefit from improvements in input usage because more efficient farms tend to generate a higher income and have a better chance of staying in business (Bravo-Ureta and Rieger, 1991; Dartt et al., 1999; Lawson et al., 2004). Non-parametric methods, such as Data Envelopment Analysis (DEA), calculate the individual efficiency scores of decision-making units—such as dairy farms—by relating each farm's performance to a benchmark of the best practice farms (Tauer, 1993; Weersink et al., 1990). This chapter uses a multi-directional efficiency analysis (MEA) instead, as this enables us to investigate in greater detail potential differences in input utilization. By calculating both managerial and program input-specific efficiency scores, this approach allows us to present a detailed overall idea about the differences among inputs and between farming systems. There are studies focussing on the technical efficiency of farms in Malaysia; for example, Serin et al. (2008) identified the efficiency of the resources used in the beef cattle production in Johor and Iinuma et al. (1999)

estimated the technical inefficiency of carp pond culture in Peninsula Malaysia. The existing literature on Malaysian dairy farming, however, has not investigated the efficiency of the use of inputs. Also, no study compared the managerial and program efficiency of Malaysian dairy farms. Performing such an analysis would provide valuable information to policy makers and business actors that aim at decreasing the dependence of Malaysia on dairy imports.

Therefore, the objectives of this study are (i) to estimate the input-specific technical inefficiency of Malaysian dairy farms in terms of both managerial and program inefficiency and (ii) to identify the factors affecting the technical inefficiency scores. For the first step, the chapter uses a multi-directional efficiency analysis (MEA). For the second step, the managerial MEA inefficiency scores are regressed on potential determinants using a single-bootstrap truncated regression model. This is the first study to analyse the inefficiency of dairy farming in Malaysia, using a MEA framework and a single-bootstrap truncated regression approach to explain observed differences in managerial inefficiency. Scrutinizing the role of technical inefficiency in Malaysia dairy production can serve as an example to other Asian countries, especially in Southeast Asia. First, they have a similar climate which is tropical-hot and humid all year round with plentiful rainfall. Second, most of the dairy herds in Asia are owned by smallholders. Finally, in most of the Asian tropics, cattle production systems are also primarily grass-based with cows either allowed to graze freely or confined and provided with cut-and-carry harvested forages (Herath and Mohammad, 2009).

2.2 Materials and methods

This research adopts a two-stage approach. First, we employ MEA to measure technical inefficiency for specific inputs used in the production of milk on dairy farms in Malaysia. Second, a single-bootstrap truncated regression model is used to explain the determinants of technical inefficiency in Malaysian dairy farming. As there are two distinct production systems in our sample, we run the regression analysis separately for each system.

2.2.1 Multi-directional efficiency analysis

Following Bogetoft and Hougaard (1999) and Asmild et al. (2003), we identify a set of $k = 1, \dots, K$ farm observations. Each farm uses N inputs, $x = (x_1, \dots, x_N)$ and produces one output, y (total revenue). We assume a constant technology of production and that all farmers produce a homogenous product. In input-oriented MEA, an ideal point (x^*, y^0) for the farm under analysis (x^0, y^0) is first identified by considering sub-vector efficiencies for each dimension of the inputs separately, i.e. by solving five linear programming problems for $i = 1, \dots, N$ as follows:

$$x_i^* = min_{x_i,\lambda^k}\, x_i$$

s.t.

$$\begin{aligned}
&\textstyle\sum_{k=1}^{K} \lambda^k x_i^k \leq x_i \\
&\textstyle\sum_{k=1}^{K} \lambda^k\, x_{-i}^k \leq x_{-i}^0 \\
&\textstyle\sum_{k=1}^{K} \lambda^k\, y^k \geq y^0 \\
&\textstyle\sum_{k=1}^{K} \lambda^k = 1 \\
&\lambda^k \geq 0,\ k = 1, 2, \dots, K,
\end{aligned} \tag{1}$$

where $\sum_{k=1}^{K} \lambda^k = 1$ imposes variable returns to scale. Solving Equation (1) for each input provides the input coordinates of the ideal point, $x^* = (x_1^0, x_2^*, x_3^*, x_4^*, x_5^*)$. Note that $x^0 = x^*$ implies that x^0 is an efficient farm. Unlike DEA, where input adjustments are made in proportion to the input mix, MEA considers adjustments in proportion to the improvement potentials $(x^0 - x^*)$ (Asmild et al., 2016). Thus a vector of input-specific efficiencies is found by solving the following linear programming problem:

$$\beta^* = max_{\beta,\lambda^k}\, \beta$$

s.t.

$$\sum_{k=1}^{K} \lambda^k x_i^k \leq x_i^0 - \beta(x_i^0 - x_i^*), \;\; i = 1, 2, 3, 4, 5$$

$$\sum_{k=1}^{K} \lambda^k y^k \geq y^0$$

$$\sum_{k=1}^{K} \lambda^k = 1 \tag{2}$$

$$\lambda^k \geq 0, \;\; k = 1, 2, \dots, K$$

and input-specific MEA inefficiency scores for farm (x^0, y^0) are calculated as:

$$ie_i = \frac{\beta^*(x_i^0 - x_i^*)}{x_i^0}, \;\; i = 1, 2, 3, 4, 5 \tag{3}$$

The inefficiency scores (ie_i) take values between 0 and 1, where a value of 0 indicates no improvement potential on the variable in question when a firm is efficient, and 1 otherwise.

We follow Asmild et al. (2016), by using the MEA approach to estimate managerial and program inefficiency. The MEA managerial inefficiency scores are found by applying Equations (1) and (2) to each sub-sample of intensive and semi-intensive farms. Then, we replace the observations by their sub sample-specific MEA benchmarks, $\tilde{x}_i^0 = (1 - ie_i x_i^0)$ for all i to obtain a new set of observations. Running Equations (1) and (2) for this new set of observations provides the program inefficiency scores. Figure 2.1 illustrates the concept of MEA managerial and program inefficiency for 2 sub-groups (K^1 and K^2). In Figure 2.1, x^0 in K^1 is first projected onto frontier K^1, in the direction of the MEA ideal point, resulting in projection $\tilde{x}^0$. The difference between x^0 and $\tilde{x}^0$ is the absolute managerial inefficiency in each of the input dimensions. $\tilde{x}^0$ is subsequently projected onto the frontier of the full sample, $K = K^1 \cup K^2$, resulting in the projection $\tilde{\tilde{x}}^0$, and the difference between $\tilde{x}^0$ and $\tilde{\tilde{x}}^0$ is the absolute program inefficiency in the input dimension.

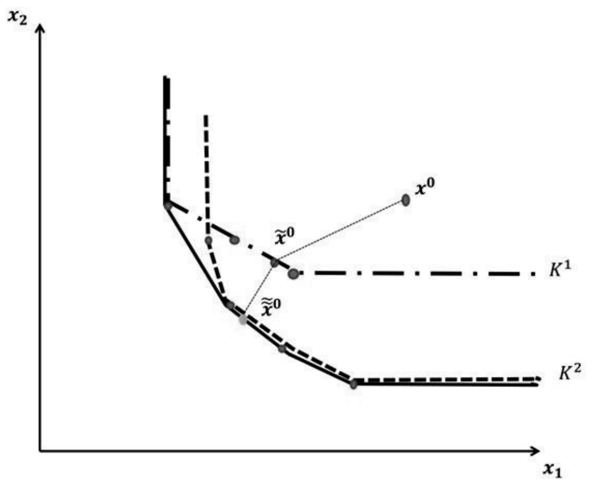

Figure 2.1 Multi-directional efficiency analysis assessment of managerial and program inefficiency

2.2.2 Single-bootstrap truncated regression model

The single-bootstrap truncated regression method, developed by Simar and Wilson (2007), is used for the second stage of the analysis. Estimated DEA efficiency scores are serially correlated (Simar and Wilson, 2007; Xue and Harker, 1999) and hence using these scores in a standard ordinary least square (OLS) regression analysis results in a violation of the basic assumption of independence within the sample values (Simar and Wilson, 2011). Assuming that MEA scores are also serially correlated, we use a single-bootstrap regression model with left truncation to determine the factors affecting managerial inefficiency. The model for the single-bootstrap truncated regression is:

$$\hat{\delta}_i = Z_i\beta + \varepsilon_i$$

where the dependent variable $\hat{\delta}_i$ is the estimated technical inefficiency score, Z is a vector of independent variables, β its associated vector of coefficients, and ε_i the idiosyncratic error term. The intensive and semi-intensive systems have different management practices, thus we assume that the independent variables may affect inefficiency differently in each system. Hence, we run the single-bootstrap truncated regression separately for each system.

According to Simar and Wilson (2007), the confidence intervals for the coefficients of the second-stage regression, which are appropriate for inference, can be constructed as follows (algorithm I):

1) Perform the MEA approach to get inefficiency score, $\hat{\delta}_i$, for each firm $i = 1, \dots, n$.
2) Regress $\hat{\delta}_i$ on the independent variables, Z_i, using left-truncation at 0 (i.e. only the inefficient observations are included) to obtain estimates $\hat{\beta}$ and $\hat{\sigma}_\varepsilon$ of the parameters β and σ_ε.
3) Repeat the following three steps below B (1,000 bootstrap iterations) times to obtain a set of bootstrap estimates $B^* = \left\{\left(\hat{\beta}^*, \hat{\sigma}_\varepsilon^*\right)\right\}_{b=1}^{B}$
   a) For each $i = 1, \dots, n$ draw ε_i^* from the $N(0, \hat{\sigma}_\varepsilon^2)$ distribution with left truncation at $\left(0 - Z\hat{\beta}\right)$.
   b) For each $i = 1, \dots, n$, compute $\delta_i^* = Z_i\hat{\beta} + \varepsilon_i^*$.
   c) Regress δ_i^* on the independent variables, Z_i, using left-truncation at 0 to obtain $\hat{\beta}_b^*$ and $\hat{\sigma}_{\varepsilon,b}^*$.
4) Obtain the mean and 95% confidence interval of the betas and sigma.

2.3 Data description

We collected original data from Malaysian dairy farms using a two-stage stratified sampling design. First, we purposely selected four distinct production regions in Malaysia based on the most representative milk production: Johor (43), Negeri Sembilan (54), Selangor (42) and Melaka (61). Within each region, respondents were then chosen using two types of sampling: convenience sampling and random sampling. [1] For the convenience sampling, we waited for the farmers who were going to sell their milk to the PPIT. In order to reach our target sample of 200 respondents, we then turned to random sampling by randomly choosing dairy farmers from the complete list of dairy farms which was provided to us by the Department of Veterinary Services. Personal interviews were conducted among these owners or managers of dairy farms between February and June 2015. The questionnaire includes the use of dairy inputs and outputs, farm revenue, the material and equipment used for farming, socio-economic factors, farm characteristics and transaction cost variables. Our final sample consists of 200 Malaysian dairy farms, classified into the intensive (n=100) and semi-intensive (n=100) systems. Our data is one-time cross-sectional data which reflects the activities of farmers in the production year 2014.

2.3.1 Data for the multi-directional efficiency analysis

For the MEA, we consider one output and five inputs. Summary statistics for these variables are shown in Table 2.1.

Output is total revenue calculated as the sum of annual sales of milk[1] and cattle, other sales, and own consumption. The first two components are estimates provided by the farmers in the local currency Ringgit Malaysia (MYR). Own consumption, however, is measured as the product of average consumption per capita (36.89 litre in 2007, Food and Agriculture Organization), the number of family members, and the average selling price in the sample for milk sold to the state-owned enterprise, Dairy Industry Service Centre, and milk sold directly to consumers. The inputs are land, labour, herd size, feed, and other expenditure. Land size is measured as the number of hectares used by the farmer for farming activities. Land also includes land rented for dairy activities. The land size ranged from 0.1 ha to 323.7 ha. The large variation in land size is due to the differences between intensive and semi-intensive systems. Labour is defined as the total labour used for dairy activities, including family and hired labour but

[1] When reported milk sales were missing or implausible (i.e. too low), they were replaced by the amount of milk sales provided by the farmers to the Department of Veterinary Service.

excluding the farm operator, measured in number of persons. Labour ranged from 0.1 to 12 persons. Herd size is defined as the number of cows that a farmer owned and it is measured in tropical livestock units. Using tropical livestock units, we assumed that 1 calf is equivalent to 0.2 cow. Feed is defined as the total cost of purchased feed for cattle and measured in MYR. The total value was obtained by asking farmers how much they spent annually on a few types of feed typically used for dairy farming in Malaysia (including an option "other") and then adding all components. Other expenditures (in MYR) are defined as expenditures on other goods and services, which includes farmers' estimates of breeding expenses, veterinary services and medicines, farm maintenance, and other expenses.

Table 2.1 Mean and standard deviation of output and inputs used in the MEA model

Variable	Unit	Mean	Standard deviation
Total revenue	10,000 MYR	13.95	11.81
Land	10 ha	7.07	13.71
Labour	Persons	3.09	1.51
Herd size	10 cows	3.15	1.92
Feed	10,000 MYR	3.95	4.29
Other expenditure	10,000 MYR	1.39	1.26

2.3.2 Data for the single-bootstrap truncated regression model

The existing literature suggests that farming efficiency might be affected by variables such as age of the farmer (Binam et al., 2003; Heriqbaldi et al., 2014), years of experience (Amaza and Olayemi, 2002; Tzouvelekas et al., 2002), family size ((Binam et al., 2003), off-farm employment (Wang et al., 2013), access to credit (Mlote et al., 2013), and availability of extension services (Mutai et al., 2013). The following paragraphs discuss each determinant considered in this study and its measurement in more detail. Table 2.2 presents summary statistics of the independent variables for our sample.

Farmer's *age* may have a positive relation with technical inefficiency. Older farmers may not be up-to-date with new technology, machinery, and equipment, and may have less energy to conduct farm activities. For example, Coelli et al. (2002) found that younger rice farmers in Bangladesh were more efficient than older rice farmers. In this study, farmer's age is measured as the age of the farmer in the year 2015.

Experience in dairy farming is expected to negatively affect inefficiency as it can be considered as informal training for farmers. Thus, an increase in experience is assumed to decrease the technical inefficiency of dairy farming. Singbo and Oude Lansink (2010) showed that technical inefficiency was negatively affected by the number of years of experience in lowland farming in Benin. Gelan and Muriithi (2012) found that experience had a positive effect on the efficiency of dairy farms in East Africa. Experience is measured as the number of years the farm operator has been operating the dairy farm.

Hallam and Machado (1996) argue that there is little evidence that higher levels of facilities, machinery, or equipment (such as milking parlours and free-stall housing) are associated with increased efficiency. However, Filipovic and Kokaj (2009) found that using a milking machine instead of hand milking can increase work efficiency on small family farms in Croatia. Thus, having a larger *number of portable milking machines* is expected to decrease the technical inefficiency of dairy farms. We measured this variable as the number of portable milking machines available to farmers.

At the start of the development of the Malaysian dairy industry, the sector was heavily subsidized by government (Wells, 1981). However, in recent years, the government has gradually reduced subsidies to limit government dependency. Erjavec et al. (2003) showed that subsidies that are provided as a supplement to farm income can—as an unintended consequence—increase the level of technical inefficiency, as farmers might reduce their efforts. Similarly, Bojnec and Fertő (2013) showed that subsidies negatively impact farm technical efficiency, as acquiring subsidies makes the farmer less motivated. In this study, *finance from government* is thus expected to have a positive influence on technical inefficiency. This variable is measured as the proportion of finance received from the government in total revenue (including the finance received from the government). Introducing subsidies in this way prevents any potential multicollinearity with the number of portable milking machines and allows for easy interpretation of its coefficient.

Table 2.2 Mean and standard deviation of variables used in the truncated bootstrap regressions

Variable	Unit	Mean	Standard deviation
Age	Years	44.25	11.2
Experience	Years	17.72	10.6
Portable milking machines	Number of machines	1.26	1.17
Finance from government	Share of government finance in total farm revenue	0.06	0.09

2.4 Results and discussion

2.4.1 Managerial efficiency analysis results

Using the General Algebraic Modelling System (GAMS, 2013) software package, MEA was applied to each sub-sample to determine the managerial inefficiency score for the intensive and semi-intensive systems. The mean and median scores of MEA input-specific managerial inefficiency are provided in Table 2.3. As the distributions for all inputs are negatively skewed, we also provide the median values, which may give a better representation of central tendency than the mean. Intensive farms, on average, have input-specific managerial inefficiency scores of 0.590, 0.555, 0.499, 0.513, and 0.545 for land, labour, herd size, feed and other expenditure, respectively. These results suggest that the intensive farms in our sample can reduce the use of land by 59%, labour by 56%, herd size by 50%, feed costs by 51% and other expenditure by 55% and still produce the same level of revenue. The semi-intensive farms in our sample, on average, can reduce land by 62%, labour by 44%, herd size by 51%, feed by 57%, and other expenditure by 54% and still produce the same level of revenue.

This finding indicates the intensive farms are more managerially-efficient than the semi-intensive farms for all inputs, except labour and other expenditure. For the intensive farms, land is the most inefficient input, followed by labour and other expenditures. Herd size has the lowest score for managerial inefficiency as expected because this system keeps animals in the shed, which makes it more convenient for a farmer to manage more animals. For the semi-intensive system, land has the highest score for managerial inefficiency, followed by feed, other expenditure, and herd size. Labour has the lowest score for managerial inefficiency for the semi-intensive system.

Overall, the MEA results show that the Malaysian dairy farms in both systems are technically inefficient in their use of inputs. This indicates that substantial amounts of input can be saved while maintaining the current level of output. Technical inefficiency of land is high for both systems. This can be explained by the routines of the farmers, as the farmers who have land are hesitant to use it for other activities such as planting a grass or other crop. Most farmers do not grow their own pasture. They tend to purchase feed or obtain it from abandoned land. Some of the farmers operate a large land area, especially in the semi-intensive system, and should consider having their own pasture area to maximize their land usage. For the intensive system, on average, labour has the second-highest inefficiency level, whereas labour has the lowest inefficiency level for the semi-intensive system. This was expected because the intensive system is more labour-intensive than the semi-intensive system. This implies that intensive farms can reduce labour by 56% and still produce the same output. Therefore, farmers could allocate this labour to other productive activities. Feed has the second-highest inefficiency in the semi-intensive system. This result implies that farmers can reduce feed by 63% and still produce the same output. This was expected, as farmers purchase large amounts of feed even though cattle are allowed to graze by themselves. This result suggests the farmers can limit their purchases of feed by better monitoring the amount of daily feed needed in order to better predict the total amount of feed required. The results also show that only nine farms in the intensive system and six farms in the semi-intensive are efficient.

Figure 2.2 shows the distribution of managerial inefficiency scores for the intensive and semi-intensive systems. The upper panel of Figure 2.2 shows that the patterns of inefficiency scores is quite similar across the different inputs in the intensive system. Farmers are mostly clustered at the 0.7 inefficiency level, especially for feed. The distribution of farmers is flatter in the middle classes (0.1 to 0.3). At the same time, there is a cluster of the most-efficient farmers at the 0 technical inefficiency level. The differences between average and median values in both systems suggest that distributions of inefficiency for all inputs are negatively skewed. The lower panel of Figure 2.2 shows that the patterns of inefficiency scores is less similar across inputs in the semi-intensive system. There is clustering of the most-efficient farmers at the 0 technical inefficiency level, especially for labour. The distribution of technical inefficiency scores is flatter (platykurtic) for labour compared to the other inputs. The difference in the distributions of technical inefficiency indicates that farmers perform differently in managing their inputs in the intensive and semi-intensive systems.

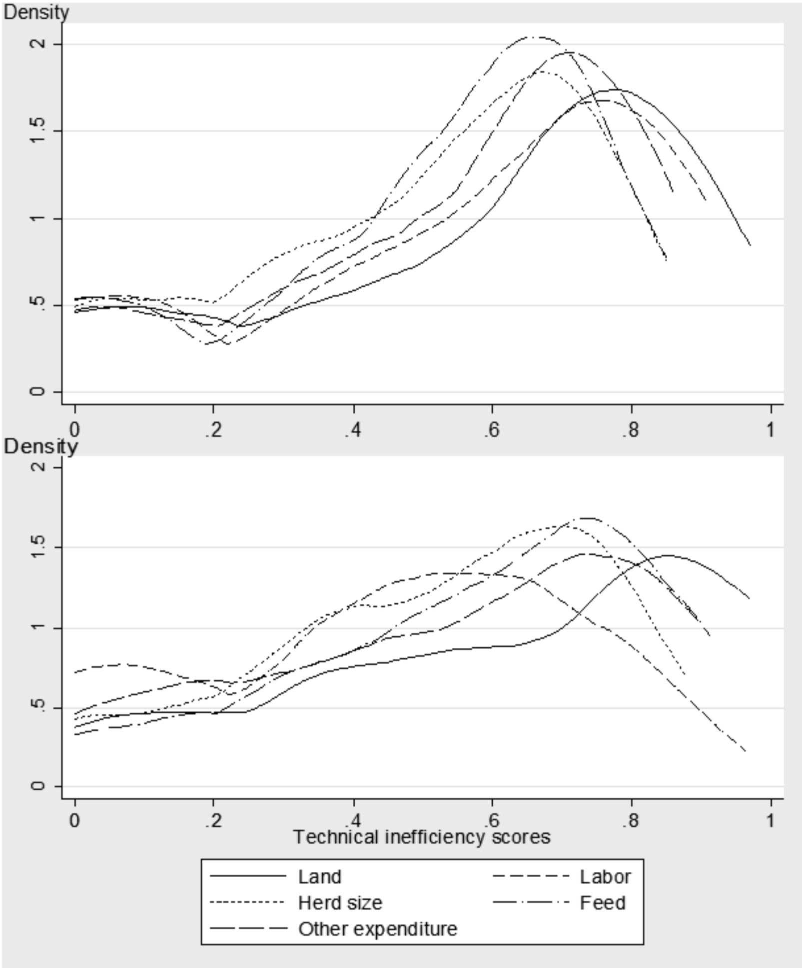

Figure 2.2 Kernel density plots of managerial inefficiency scores in the intensive (upper panel) and semi-intensive (lower panel) systems.

2.4.2 Program efficiency analysis results

The average program inefficiencies for the intensive and semi-intensive systems are shown in Table 2.3. The program efficiency can be assessed by comparing managerial efficient units to the frontier spanned by both farm types. The program inefficiency scores for the intensive systems are very close to 0. Accordingly, the frontier for the intensive system is almost identical to the pooled frontier. This implies that the intensive system can be considered best practice in general. By considering program inefficiency, MEA shows that there are significant differences not only between farm types, but also between inputs. Across these two farm types, the highest—both managerial and program—inefficiency is on land, which suggests that farmers generally have enough land available to them but do not optimize the use of land. Intensive farms, on average, have lower program inefficiency scores than semi-intensive farms. This means that intensive farms perform better than semi-intensive farms. As the intensive system also has the lowest managerial inefficiency compared to the semi-intensive system, we conclude that the intensive system is the best-performing farm system. This may be due to differences in the mode of production, quality of feed, and breed of cattle. For the intensive system, the program inefficiency score of labour is the lowest, whereas the managerial inefficiency scores of labour is the second highest. For the semi-intensive system, land has the highest score for program inefficiency and other expenditure has the lowest program inefficiency score.

As the intensive system is already the preferred farming type in Malaysian dairy farming—70% of dairy farmers run their farm using this system—there is some, albeit limited, scope for specific policies aimed at encouraging farmers to move from the semi-intensive to the intensive system. In addition, our results suggest that the program efficiency of the semi-intensive system could be improved as well, for example through research on novel production technologies tailored to the semi-intensive setting and targeted training on farming activities.

Table 2.3 Mean and median of managerial inefficiency and program inefficiency scores for intensive and semi-intensive systems

Farming type	Managerial inefficiency					Program inefficiency				
	Land	Labour	Herd size	Feed	Other expenditure	Land	Labour	Herd size	Feed	Other expenditure
Intensive										
Mean	0.590	0.555	0.499	0.513	0.545	0.013	0.001	0.011	0.004	0.013
Median	0.713	0.647	0.581	0.597	0.657	0.000	0.000	0.000	0.000	0.000
Semi-intensive										
Mean	0.618	0.441	0.511	0.569	0.540	0.169	0.054	0.083	0.040	0.037
Median	0.696	0.485	0.577	0.635	0.584	0.078	0.000	0.038	0.000	0.000

2.4.3 Single-bootstrap truncated regression results

A single-bootstrap truncated regression model was estimated using the Stata software package (StataCorp., 2011). The results in Table 2.4 and 2.5 show the factors affecting the input-specific managerial technical inefficiency of dairy farming in Malaysia, for the intensive and semi-intensive systems. For the intensive system (Table 2.4), the number of portable milking machines has a negative relation with the inefficiency of land and herd size. This results implies that the number of portable milking machine units in dairy farming makes farmers more efficient in the use land and herd. This result is in line with a previous study by Castro et al. (2012), who found that use of an automatic milking machine (in this chapter we refer to a portable milking machine) can increase milk production in Galicia, Spain. However, Steeneveld et al. (2012) found that an automatic milking machine did not affect the efficiency of Dutch dairy farms. The age of farmers has a positive relation with the technical inefficiency of labour. This results indicates that older farmers are *ceteris paribus* more inefficient. This result is in line with the study by Lachaal et al. (2002) in Tunisian dairy production, indicating that older farmer who lack motivation are less efficient. However, the result is inconsistent with the study by Zhengfei and Oude Lansink (2006) for Dutch agriculture. Experience has a negative relation with the technical inefficiency of other expenditure. This result indicates that more experience decreases the technical inefficiency of a farmer in managing other expenditures. This is expected, because experience helps the farmers to better estimate the cost of other expenditures.

For the semi-intensive system (Table 2.5), the number of portable milking machines has a negative relation with land and other expenditures. The coefficient of portable milking machines suggests that having more portable milking machines can reduce the technical inefficiency of land and other expenditure. Finance from government has a positive association with technical inefficiency for feed. This result means that the greater the proportion of finance coming from government support, the greater the technical inefficiency of managing feed. As finance from the government is not only specific for feed, farmers can use it for other farming activities and this could result in a lower efficiency in managing feed. This result is in line with Karagiannis and Sarris (2002) for wheat and mixed arable crop in Greece, Zhu and Oude Lansink (2010) for German, Dutch and Swedish crops farms, and Iraizoz et al. (2005) for Spanish livestock farms.

Table 2.4 Results of the truncated bootstrap regression models explaining differences in input-specific managerial inefficiency scores of intensive farms

Variable	Land			Labour			Herd			Feed			Other expenditure		
	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Age	0.003	-0.002	0.011	0.008**	0.001	0.014	0.004	-0.002	0.009	0.001	-0.004	0.007	0.004	-0.001	0.010
Experience	-0.006	-0.013	0.002	-0.005	-0.013	0.002	-0.005	-0.012	0.001	-0.002	-0.008	0.005	-0.006**	-0.013	-0.000
Portable milking machines	-0.050**	-0.104	-0.000	-0.013	-0.068	0.039	-0.049**	-0.099	-0.007	-0.031	-0.075	0.013	-0.045	-0.093	0.001
Finance from government	0.101	-0.519	0.695	-0.061	-0.737	0.558	0.151	-0.378	0.659	0.241	-0.302	0.791	0.139	-0.424	0.691
Constant	0.617	0.348	0.880	0.356	0.047	0.644	0.518	0.273	0.743	0.552	0.319	0.777	0.564	0.328	0.789
Sigma	0.276	0.233	0.323	0.276	0.234	0.324	0.233	0.199	0.268	0.233	0.197	0.274	0.242	0.203	0.280

Notes: Lower and Upper represent the bounds of a 95% confidence interval.

**Significant at 5% level.

Number of observations = 100.

Number of truncated observations: 9.

Table 2.5 Results of the truncated bootstrap regression model explaining differences in input-specific managerial inefficiency scores of semi-intensive farms

Variables	Land			Labour			Herd size			Feed			Other expenditure		
	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Age	0.005	-0.002	0.012	-0.003	-0.011	0.003	0.003	-0.002	0.009	0.004	-0.002	0.010	0.002	-0.004	0.009
Experience	-0.005	-0.012	0.003	-0.001	-0.008	0.006	-0.002	-0.008	0.004	-0.002	-0.008	0.004	-0.001	-0.007	0.006
Portable milking machines	-0.070**	-0.143	-0.011	-0.054	-0.133	0.003	-0.035	-0.090	0.010	-0.046	-0.104	0.001	-0.060**	-0.125	-0.004
Finance from government	0.662	-0.037	1.375	-0.047	-0.814	0.687	0.562	-0.018	1.113	0.587**	0.009	1.170	0.629	-0.042	1.327
Constant	0.558	0.287	0.805	0.664	0.422	0.911	0.453	0.244	0.657	0.482	0.263	0.697	0.511	0.267	0.760
Sigma	0.285	0.242	0.333	0.265	0.221	0.321	0.230	0.193	0.268	0.237	0.203	0.277	0.262	0.221	0.306

Notes: Lower and Upper represent the bounds of a 95% confidence interval.
**Significant at 5% level.
Number of observations = 100.
Number of truncated observations: 6.

2.5 Conclusion

The objectives of this study were to investigate the technical inefficiency, decomposed into managerial and program inefficiencies, of dairy farming in Malaysia, and to identify the sources of managerial inefficiency. Multi-directional efficiency analysis (MEA) was used to estimate technical inefficiency for individual inputs under variable returns to scale. The results for managerial inefficiency suggest that intensive farms can maintain their current production level and save 59% of land, 56% of labour, 50% of herd size, 51% of feed, and 55% of other expenditures. Semi-intensive farms, on average, can save 62% of land, 44% of labour, 51% of herd size, 57% of feed and 54% of other expenditures and still produce the same level of output. The application of the MEA approach shows that there are substantial input-specific production inefficiencies among farms for both systems and these dairy farms could increase their production through the improvement of technical efficiency. These results show that valuable insight can be gained from the input-specific inefficiency scores, which are obtained using MEA, which could help farmers to identify which inputs were overused and hence should be reduced.

Our program efficiency MEA results furthermore show that there are significant differences not only in the levels of inefficiencies of the different inputs, but also between the two main farming types in Malaysia. Of the 100 dairy farms sampled for each system, only 9% of intensive farms and 6% of semi-intensive farms were fully efficient. Based on the percentage of fully efficient farms, farms are similar in efficiency between the two systems. Semi-intensive farms have higher inefficiency scores for all inputs except labour and other expenditure. Semi-intensive farms also have higher program inefficiency scores for all inputs. We therefore conclude that semi-intensive farms are managerially inefficient (except for labour and other expenditure; labour has the lowest inefficiency score among inputs for both systems) and also program inefficient. This may be because of different practices between the intensive and semi-intensive systems. The lower program inefficiency of semi-intensive farms suggests that additional efforts are needed to improve its performance, e.g. by additional research and development into improving technologies tailored to this system. Alternatively, policy makers could use this information to improve the efficiency of Malaysian dairy farmers by advising them to convert to the intensive system.

In the second stage of this study, single-bootstrap truncated regression models were used to investigate the factors affecting the input-specific managerial inefficiency scores. The results of the single-bootstrap truncated regression models for intensive system show the following: the number of portable milking machines has a negative relation with technical inefficiency scores of land and other expenditure, age has a positive relation with labour inefficiency, and experience has a negative relation with other expenditure. For the semi-intensive system, the number of portable milking machines has a negative relation with technical inefficiency scores of land and other expenditure and finance from government has a positive relation with the technical inefficiency score of feed. Finance from government does not appear to improve farm efficiency, especially regarding feed input. This outcome suggests that the government should redefine its policy for providing farm finance. The government could consider providing portable milking machines at subsidized price instead of credit or other subsidies. In this case, extension officers can provide guidance to the farmers on how to use portable milking machines, as these farmers may not be familiar with this technology. Our results further suggest that Malaysian policy makers should target young farmers when designing training and extension programs. Dairy farmers can improve their input management skills by following the best practise of farm.

The limitations of this study are that we have a limited number of observations and variables available to explain the differences in technical inefficiency. Future research could use samples stratified to not only get good estimates of input-specific inefficiency scores, but also to maximise observed differences in terms of explanatory variables. Future work could also focus on measuring (input-specific) technical inefficiency of production over time and explore additional explanatory variables that can explain the technical inefficiency scores in the single-bootstrap truncated regression analysis.

Notes

[1] The combination of convenience sampling and random sampling was chosen in favour of full random sampling in order to optimally make use of the time and budget available. The target sample size of 200 respondents was determined in the same vein and is in line with similar program/managerial inefficiency analysis studies (e.g. Gómez-Limón et al. (2012); Beltrán-Esteve and Reig-Martínez (2014).

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CHAPTER 3

Marketing channel selection by dairy farmers in Malaysia: A transaction cost approach

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Abstract

The purpose of this study is to explain which factors influence the choice of marketing channel by Malaysian dairy farmers. Data from a sample of 200 farmers from four regions with the most representative milk production are used. A multivariate probit model was employed to determine the factors affecting marketing channel choice: i) the government through Dairy Industry Service Centres (PPIT), ii) direct selling and iii) intermediaries marketing channel. The results reveal that expectation of price has a positive relation with the likelihood of using the PPIT. Payment delay and buyer trust have a negative relation with the likelihood of using direct selling. Furthermore, price fluctuation has a negative relation with the likelihood of using intermediaries, while expectation of price and farm service has a positive relation with the likelihood of using intermediaries. The results also reveal that age and education (secondary school) are negatively associated with the likelihood of using the PPIT, while experience and off-farm employment have a positive relation with the likelihood of using the PPIT. Number of people in household is negatively associated with the likelihood of using direct selling. Education (college) is positively associated with the likelihood of using intermediaries. In addition, government financing has a negative relation with the likelihood of using intermediaries marketing channel. This study concludes that transaction cost variables are associated with the marketing channel choice by Malaysian dairy farmers.

Keywords

Multivariate probit, transaction cost, Malaysia, dairy industry

3.1 Introduction

After the Asian financial crisis hit Malaysia in 1997, there was an urgent need to increase food security and the Malaysian government responded swiftly by formulating the Third National Agricultural Policy. However, there were no clear directions and approaches outlined to increase the self-sufficiency level of milk or dairy products (Sim and Suntharalingam, 2015). The National Agro-food policy (DAN) was introduced in 2011, after the Third Agricultural Policy, and focuses on ensuring sustainable production for food security and safety. Under DAN, the government attempts to reduce Malaysian dependence on imported dairy products and strengthen the marketing of local dairy products. Even though the import of certain food products has reduced, Malaysia still relies heavily on imports for dairy product to satisfy its domestic demand. The Malaysian market is currently flooded by imported milk, causing a disadvantage to local dairy farmers, who are unable to market fresh milk at a competitive price.

Marketing plays an important role for smallholder farmers in developing countries to achieve the goals of food security, poverty alleviation and sustainable agriculture (Altshul, 1998). Agricultural marketing differs from general marketing with respect to its products' attributes and natural characteristics, but also in terms of price determination, promotion, advertising and distribution (transport–storage) procedures (Siskos et al., 2001). The choice of marketing channel is one of the important determinants for farmers, because channels are characterized by different levels of profitability and cost (Soe et al., 2015). According to Arinloye et al. (2015), the concept of marketing channel selection refers to the process by which several actors decide to sell their products in different marketing outlets. Many studies have scrutinized marketing channel choice by producers of agricultural products or commodities. Identifying the factors that influence the decision process, can be a strategy to protect the return on past investments and maximize profits (Soe et al., 2015). Transaction cost theory can be used to understand the forces shaping channel structure (Klein et al., 1990). Hobbs (1996) showed that transaction costs significantly affect marketing channel choice, while Gong et al. (2006) found that the cattle farmer's marketing channel choice can be affected by transaction costs and socio-economic characteristics of the both farmer and farm.

Dairy milk is a highly perishable product requiring either cold storage or immediate market access. Hence, it is associated with potentially high transaction costs. The quality of milk will deteriorate after a few hours, thus requiring farmers to sell their milk immediately. It is also a bulky commodity, which may limit marketing options for small and remote dairy farmers, implying greater losses due to spoilage (Staal et al, 1997). Such conditions normally subject producers to limited marketing flexibility as they often find themselves in an unfavourable bargaining position (Jaffee, 1995). In recent years, research on Malaysia's dairy sector has emphasized the constraints for farm production and husbandry such as poor milk quality (Chye et al., 2004), high input costs (Wells, 1981) and unsuitable dairy cows for tropical weather (Boniface et al., 2007). However, other factors that could significantly contribute to higher incomes for farmers such as marketing channel selection have thus far been neglected. Research on farmers' behaviour when selecting a marketing channel may provide insight into the transaction costs associated with this choice and could eventually help to design policies that increase efficiency.

The main objective of this chapter is to investigate which factors influence dairy farmers' selection of milk marketing channels in Malaysia. This study empirically investigates the determinants affecting the choice of milk marketing channel based on a transaction cost approach. A few studies have analysed the links between Malaysian dairy farmers and their buyers for instance, a study by Boniface et al. (2010) explores the nature of supplier loyalty in the Malaysian dairy supply chain and found that the supplier trust in their buyers will eventually lead to loyalty. Boniface et al. (2012) also found that price satisfaction affects the relationship between Malaysian dairy farmers and milk buyers. However, there is still a lack of studies that address the marketing of fresh milk, leading to an inability to fully understand the current state of the Malaysian dairy sector (Sim and Suntharalingam, 2015). It is essential to examine the transaction costs that may affect the choice of marketing channel because identifying and understanding these costs for each channel may help enhance the marketing performance of Malaysian dairy farmers. This is especially relevant for smallholder farmers in developing countries, who operate in a difficult environment with poor infrastructure leading to higher transaction cost. The results of this chapter provide insights in marketing channel choice and in particular the transaction costs that affect it. This can inform extension officers about the potential barriers due to transaction costs associated with marketing channel selection. Policy makers would also be able use the results of this study to amend existing policies and improve marketing channels to motivate farmers to access high-value markets.

3.2 Malaysian dairy farming marketing channels

Malaysian dairy farmers have three marketing channels to sell their milk: selling (i) to the government through milk collection centres, (ii) directly to the consumers/traders and (iii) through intermediaries. Table 3.1 presents these three marketing channels and their characteristics.

The Dairy Industry Service Centres (PPITs) are the main buyer of milk in Malaysia. Typically, farmers can sell through PPITs at the contract price. The contract, however, does not restrict the producers from selling their milk to other buyers so consequently, there are multiple markets available to producers (Boniface et al., 2012). The main aim of the establishment of the PPIT is to provide a marketing channel to the dairy farmers. PPITs also operate as consultants and give various incentives, such as centralised milk collection and distribution facilities, rural credit and milk subsidies. From our data survey, 171 out of 200 farmers sell their milk to PPITs. Farmers who want to sell their milk to PPITs have to arrange their own milk transportation, which is often a motorcycle. Usually farmers send their milk in the morning or in the evening to the nearest PPIT branch. A sample of the milk will be sent out for quality assessment, and the price will be determined based on the milk's grade. The price ranges from MYR 2.45 (€ 0.54) to MYR 2.65 (€ 0.58) per litre depending on the region. The prices offered by PPITs rarely change and may be constant for a year. The PPIT channel can typically move large quantities of product quickly but at lower prices than other channels. Because PPITs offer facilities and guidance, farmers choose to sell their milk to PPITs even though they will get a lower price. The PPIT marketing channel can also be considered as a formal market for selling dairy milk.

Farmers can also sell their milk directly to consumers and private traders. This marketing channel is labelled 'direct selling'. The farmers who sell their milk to private traders may receive a higher price compared to the PPIT and will receive immediate payment. The price ranges from MYR 2.7 (€ 0.59) to MYR 4 (€ 0.88) per litre. The buyer will collect the milk at the farm; therefore, the farmer will not incur any transportation cost. The price will be determined based on both the appearance and the taste of the milk. It is important to note, that under the direct selling marketing channel, buyer and seller generally have an informal (oral) agreement without any written contract. The drawback of this informal agreement is that the agreed transaction can change unexpectedly. Once the agreement is terminated, the farmer needs to invest more time to find a new buyer. In our survey, 52.5% of the farmers sell their milk to this marketing channel. The average size of the sales through the direct selling marketing channel is MYR 23,781.17 per year.

Approximately 22% of the farmers in our survey sell their milk directly to restaurants, hotels or processing firms. We label this marketing channel as 'intermediaries'. This channel may offer the highest milk price, but the farmers have to comply with strict requirements that are not easily fulfilled. The price ranges from MYR 3 (€ 0.66) to MYR 5 (€ 1.10) per litre. The average herd size of farmers who sell to the intermediaries channel is 31.6 heads of cattle versus 26.6 and 25 for farmers using the PPIT and direct selling, respectively. Restaurants and hotels might request a certain amount of milk for everyday use. The farmers will incur transportation costs when selling their milk to intermediary buyers.

Table 3.1 The three marketing channels and their characteristics

Characteristics/Type of marketing channel	PPIT	Direct selling	Intermediaries
Number of farmers	171	105	44
Price range (MYR)	2.45–2.65	2.7–4	3–5
Transportation arrangement	Farmer	Buyer	Farmer
Milk inspection	Yes	No	Yes
Formal contract	Yes/Semi	No	Yes

3.3 Conceptual approach

Several approaches to study the selection of marketing channels (including financial, microeconomic, managerial and behavioural approaches) have been proposed in the literature, but the transaction costs approach has been the most influential stream (McNaughton, 1999). In this study, we assume that the choice of different marketing channels, as well as their simultaneous use is led by transaction costs in addition to farm and farmer characteristics. Williamson (1979) defined transaction costs as a trade-off between the costs of coordination within an organisation and the costs of transacting and forming contracts in the market. Coase (1937) linked transaction costs to the decision whether to have a transaction within a firm or in the market. Building on Coase's work, Hobbs (1997) classified transaction costs into information, negotiation and monitoring or enforcement costs.

Transaction costs arise from the role of *ex ante* assessment, which includes costs of information gathering, negotiation and decision-making. *Ex post* assessment, on the other hand, includes the costs of monitoring and enforcement, costs of misalignments and maladaptation of transactions that drift out of agreed specifications or alignment, and costs of dispute resolution

(Rao, 2002). Many researchers have adopted transaction cost theory. For instance, Frank and Henderson (1992) examined the causal relationship between coordination and transaction cost in the US food manufacturing industries. Hobbs (1997) measured the importance of transaction costs in cattle marketing for UK farmers. Arinloye et al. (2012) applied transaction cost theory in determining the multi-governance choices made by smallholder farmers in the pineapple supply chain in Benin. Staal et al. (1997) applied transaction cost theory to the smallholder dairy industry in East Africa and found that transaction costs are high, as evidenced by the much lower percentage of milk production that is commercialised in Kenya and Ethiopia than in developed countries.

According to Hobbs (1997), transaction costs are difficult to measure directly and hence must be identified and defined before obtaining the appropriate measurements. Following previous studies such as Gong et al. (2006), Hobbs (1997) and Shiimi et al. (2012), we divided the transaction costs into three categories which are information costs, negotiation costs and monitoring costs; in addition we identified a set of control variables. We explain the theoretical expectation for each category below.

Information costs

Information costs arise *ex ante* to an exchange and include the costs of obtaining price and product information and the costs of identifying suitable trading partners (Hobbs, 1997). In this study, information costs are composed of price information and price fluctuation. Before deciding which marketing channel to use, dairy farmers must determine the expected price of milk. Obtaining *price information* incurs an information cost and takes time to. It also depend on the availability of information on market price. In the Malaysia milk market, sources of price information are not well developed especially for direct selling and intermediaries marketing channels. Due to limited available price information and variation in prices among different buyers, farmers are likely to incur high price information cost. Price variation can increase the search costs. Gong et al. (2006), Hobbs (1997) and Shiimi et al. (2012) argued that the cost of accessing price information depends on the extent to which market information is readily available to farmers. Information about the milk price offered by the PPIT is directly available to the farmers, and hence less costs are involved in obtaining this knowledge.

A large *price fluctuation* indicates that producers may capture only a proportion of the expected price (Gong et al., 2006). Farmers incur more information costs if the price of milk fluctuates. Farmers that want to avoid price variation are more likely to choose the PPIT marketing channel since the price offered by the PPIT is more stable than the price obtained through the direct selling and intermediaries marketing channels. In the latter two, farmers can predict the milk price based on the previous transaction, but there is more uncertainty about the final price they will receive for their products.

Negotiation costs

Negotiation costs are the costs of physically carrying out the transaction and may include commission costs, the costs of physically negotiating the terms of an exchange, and the costs of formally drawing up contracts (Hobbs, 1997). These are costs that arise while transactions take place. Negotiation cost is measured by the delay of payment and price expectation. The *delay of payment* occurs when the delivery of the milk and the payment do not occur simultaneously. Gong et al. (2006) found that payment delay significantly affects the choice of marketing channel for cattle farmers in China. In practice, dairy farmers sell their milk to the direct selling channel and receive payment immediately. The PPIT delay their payment to farmers until one or two weeks after receiving the milk, as it has to undergo a quality inspection before the price can be determined. Hence, farmers that prefer direct payment to delayed payment are *a priori* expected to choose direct selling and intermediaries marketing channels over the PPIT.

The *price expectation* can also be considered a negotiation cost when farmers try to negotiate with buyers to get a price approximating their expectation. The average price received or paid is expected to be inversely proportional to the transaction costs involved. For sellers, high transaction costs will result in receiving a lower nett price (Key et al., 2000). For buyers, it means paying higher prices for the products. Price expectations are likely higher in the direct selling marketing channel, since this channel offers higher milk prices than the PPIT marketing channel. Buyers in the direct selling marketing channel also offer different prices for an otherwise homogenous product; hence, farmers with good negotiation skills may receive higher prices. Negotiation costs are less likely to occur in the PPIT marketing channel where the price is based on milk quality. Neither party has the power to manipulate the price.

Monitoring costs

Monitoring or enforcement costs occur *ex post* to a transaction and are the costs incurred for ensuring that the terms of the transaction, for example, quality standards or payment arrangements, are adhered to by other parties to the transaction (Hobbs, 1997). The monitoring costs considered in the study are the trust in buyer and farm services. *Trust in buyer* captures the opportunity costs of mobilising the producer's time and efforts against the grading and pricing information asymmetry problem between buyers and sellers (Ndoro et al., 2015). Farmers trust in their buyer's business skills and expertise can lower the monitoring costs. Farmers are likely putting more trust in PPITs due to it experience in handling raw milk compared to buyers in the direct selling or intermediaries marketing channels.

Farm services refer to the technical support and assistance provided by buyers to the farmers. The services reduce the monitoring cost by limiting the farmers' efforts. The PPIT provides a variety of such services to farmers, including purchasing cattle at a subsidised price, providing milking machinery, and giving information to farmers. These encourage farmers to choose the PPIT as their marketing channel. Farmers are likely to incur more monitoring costs if they sell their milk to the direct selling or intermediaries marketing channels, because neither offer any assistance to the farmers.

Farmers' socioeconomics and farm characteristics

We hypothesise that farmer socioeconomic factors (age, experience, education, household size) and farm characteristics (type of farm, herd size, labour, farm size, finance from government and off-farm employment) will influence the marketing channel choice in Malaysian dairy farming.

Age—Generally, the PPIT will help farmers who recently started their business. Young farmers with less experience in marketing might need assistance, such as veterinary advice or strategical marketing guidance. Therefore, we hypothesise that they opt to sell through the PPIT, in contrast to older, more experienced farmers who may prefer the direct selling marketing channel.

Experience increases confidence in business and in marketing. Likewise, with increasing experience in dairy farming activities, farmers are more likely to choose the direct selling or intermediaries marketing channels. In other words, we expect experience to be positively associated with the likelihood of opting for direct selling and intermediaries. More experienced farmers might prefer a higher price offered by the direct selling marketing channel. Less experienced farmers are more likely to choose the PPIT marketing channel.

Education may affect a farmer's choice of marketing channel. We hypothesise that farmers with a higher level of education prefer the intermediaries marketing channel, which offers a good price. Educated farmers have better skills to gather up-to-date market and price information. They are also more knowledgeable about the requirements and procedures set by the intermediaries marketing channel. Conversely, farmers with elementary education only are expected to prefer the PPIT or the direct selling marketing channel as such transactions involve fewer requirements and less documentation.

Household size—The farm's household provides the majority of labour for most farming families in Malaysia. We expect that household size is positively associated with the likelihood of choosing the PPIT channel. This channel has better guarantees for a secure income, required to feed all members of a larger household., We hypothesise that larger households prefer this security, rather than seeking higher prices in other marketing channels and run the risk of ending up with unsold leftovers.

Type of farm—Two types of dairy farming systems are commonly practiced in Malaysia: an intensive system and a semi-intensive system. In the intensive system, animals are confined and provided with cut-and-carry harvested forages, whereas in the semi-intensive system the animals are allowed to graze freely. There is no clear hypothesis about the relationship between the type of farm and the farmer's marketing channel selection.

Herd size—A higher number of cattle enables farmers to produce more milk. Therefore, we expect that herd size is positively associated with the likelihood of choosing the PPIT channel, *ceteris paribus*. An increase in milk production is expected to encourage farmers to choose PPIT as it will accept any amount of milk. However, a larger herd size also increases the bargaining power of farmers, and thus implicitly decreases negotiation costs. This may increase the likelihood of choosing the direct selling marketing channel (Gong et al., 2006).

Labour is expected to be positively associated with the likelihood of farmers selling their milk to the direct selling marketing channel. Having more labour on the farm provides farmers more time to look for the potential buyers under the direct selling marketing channel or the intermediaries marketing channel.

Land size—Feder et al. (1985) consider land size as a surrogate to wealth and hence it would be positively associated with the likelihood of selling to the PPIT channel.

Finance from government—This study assumes that farmers who receive an incentive from the buyer, such as financial support or technical training, are more likely to be loyal to their buyer, which may affect their long-term relationship. This said, farmers are more likely to choose PPITs if they receive an incentive from the government. In contrast, farmers are likely to choose direct selling and intermediaries if they have no relationship with the government.

Off-farm employment—We hypothesise that farmers with off-farm employment are *a priori* more likely to choose the PPIT channel, since PPITs can accommodate a large amounts of milk and in turn give them a chance to undertake other activities. Conversely, farmers without off-farm activities have more time to look for different buyers to deal with under the direct selling marketing channel.

3.4 Analytical approach

As farmers select one or a combination of different marketing channels that provide them the lowest transaction costs, we used a multivariate probit (MVP) regression model to explain marketing channel choice. The model allows for simultaneous choices, accounting for situations in which farmers use more than one marketing channel simultaneously (Baskaran et al., 2013). Following Cappellari and Jenkins (2003), the model is represented by:

$$Y_{ij} = X_{ij}\beta_j + S_i\Upsilon + \varepsilon_{ij}, \quad (1)$$

Where Y_{ij} are binary choice (yes/no) variables reflecting the marketing channel choice ($j =$ PPITs, direct selling or intermediaries marketing channel) of farmer i. It is assumed that farmer i uses a particular marketing channel ($Y = 1$) if $Y_{ij}^* > 0$ and does not use that marketing channel ($Y = 0$) if $Y_{ij}^* \leq 0$. β_j is a set of coefficients that reflects the impact of changes in the vector of marketing-channel-specific explanatory variables $X_{i,}$ on farmers' choice toward marketing channel j. $X_{i,j}$ includes information costs (price information, price fluctuation), negotiation costs (payment delay and price expectation) and monitoring costs (farm service and trust). S_i represents specific control variables for farmer/farm i: age, experience, education, household size, type of farm, herd size, total labour, farm size, finance from government and off-farm income.

$\varepsilon_{ij}(j = 1, \ldots, M)$ are random errors with a multivariate normal distribution. The MVP model estimates the parameters β_j and the variance covariance matrix of the multivariate normal distribution of the error terms. ε is a random errors distributed as multivariate normal distribution with zero conditional mean and variance normalised to unity, where $\varepsilon \sim N(0, \Sigma)$, and the covariance matrix Σ is given by:

$$\Sigma = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} \\ \rho_{21} & 1 & \rho_{23} \\ \rho_{31} & \rho_{32} & 1 \end{bmatrix}$$

3.5 Data description

Data were collected by personal interviews using a combination of closed questions and 5-point Likert scales. Two hundred respondents were randomly selected from four Malaysian regions with the most representative milk production: Johor (n=43), Negeri Sembilan (n=54), Selangor (n=42) and Melaka (n=61). Dairy farmers were traced with the assistance of the Department of Veterinary Service (DVS), which provided a list with names of all farmers in each region. The interviews were carried out among dairy farmers between February and June 2015.

Descriptive statistics, as well as variable definitions, are reported in Table 3.2. Farmers in the survey may use one or more of the marketing channels to sell their milk. The dependent variables in this study are binary (yes = using the channel, 0 = not using the channel) for each marketing channel. From the survey, 86% (n=171) of farmers sell to the PPIT, 53% (n=105) sell directly and 22% (n=44) farmers sell to intermediaries. The independent variables in this study may be divided into two groups (see Table 3.2). The first group includes all transaction cost variables, which are information, negotiation and monitoring costs. All these variables were measured using 5-point ordinal variables (An example question is "I am well informed regarding the price of milk", the farmer can then choose only one answer: 1-strongly disagree, 2-disagree, 3-neither agree nor disagree, 4-agree and 5-strongly agree). For this study, we converted all ordinal variables into dummy variables (0 for strongly disagree, disagree and to neither agree nor disagree; 1 for agree and strongly agree). Since farmers did not answer the transaction cost questions for marketing channels they did not use, we were left with multiple missing values. As these missing values would have drastically reduced our sample size available for estimation, we imputed these missing values using bivariate probit models to overcome this problem.

In this approach, we used the individual marketing channel-specific transaction cost variables with missing variables (price information, price fluctuation, delay of payment, price expectation, trust in buyer and farm service) as a dependent variable, and farmer-specific socioeconomic variables (age, experience, level of education, household size, herd size, type of farm, finance from government, farm size and total labour) as independent variables. Using the resulting estimated models (18 models in total: six transaction cost variables specific to three different marketing channels), we predicted the missing values for our independent variables in our main analysis. We made a prediction of the value of six transaction cost variables for 29 farmers in the PPIT, 95 farmers in direct selling and 156 farmers in the intermediaries; all were converted into dummies based on the rule: 0 for values below 0.5 and 1 for values equal to or above 0.5.

The second group of dependent variables are farmer and farm characteristics. The definitions and descriptive statistics of the data on socioeconomic aspects (age, experience, level of education and household size) and farm characteristics (type of farm, herd size, total labour, land size, finance from the government and off-farm employment) are given in Table 3.2.

Table 3.2 Description and summary statistics of variables.

Variables name	Description	Mean	S.D.
y_1	1 if farmer uses the PPIT marketing channel	0.86	0.35
y_2	1 if farmer uses the direct selling marketing channel	0.53	0.50
y_3	1 if farmer uses the intermediaries marketing channel	0.22	0.42
Information costs			
Price information	The price of milk is well informed	0.94	0.25
Price fluctuation	The price of milk fluctuates a lot	0.57	0.50
Negotiation costs			
Payment delay	Farmer does not receive his/her payment on time	0.69	0.46
Price expectation	Farmer receives a price close to his/her expectation	0.23	0.42
Monitoring costs			
Trust in buyer	Farmer trusts buyer's business skills	0.82	0.39
Farm services	Farmer receives technical support from buyer	0.15	0.35
Farmer and farm's characteristic			
Age	Age of farmer in 2015	44.24	11.20
Experience	Number of years in farming activity	17.71	10.58
Secondary school	1 if farmer completed secondary school, 0 otherwise	0.65	0.48
College or university	1 if farmer completed college or university, 0 otherwise	0.08	0.27
Household size	Number of family members	5.86	2.23
Type of farm	Type of farm (0 = semi-intensive, 1 = intensive)	0.5	0.50
Herd size	Number of cattle in the farm in 2015	31.53	19.26
Total labour	Number of people working on the farm	3.09	1.51
Land size	Size of land for farming activities (in hectares)	70.74	137.21
Finance from government	Farmer received finance from the government (0 = No, 1= Yes)	0.44	0.50
Off-farm employment	Farmer has another job (0 = No, 1 = Yes)	0.27	0.44

3.6 Results and discussion

We ran the multivariate probit regression model using Stata 12. As presented in Table 3.3, the Wald Chi^2 is statistically significant at the critical 5% level, which indicates that the subset of coefficients of the model are jointly significant and that the explanatory power of the factors included in the model is satisfactory. We also ran the multivariate probit regression analysis excluding the socioeconomic variables. The results show that the coefficient and sign of the significant variables do not change. Therefore, we choose to include them, assuming that those variables provide information on factors determining marketing channels choice.

The variance influence factors (VIF) were estimated to check the degree of multicollinearity. The results show there are no serious multicollinearity problems among independent variables in the model. The correlation matrix in Appendix 3.A shows that the highest value of the coefficient is less than 0.40, indicating weak relations among explanatory variables.

The likelihood ratio test of the null hypothesis of independency among the marketing channel choice ($\rho_{21} = \rho_{31} = \rho_{32} = 0$) is significant at the critical 5% level. Therefore, we rejected the null hypothesis, which implies that there is dependency among the marketing channel choice. Separately considered, the ρ values indicate the degree of correlation between each pair of dependent variables. The ρ_{21} (correlation between the choice for direct selling and PPITs) and ρ_{31} (correlation between the choice for intermediaries and PPITs) are both negative and statistically significant at the 1% level. This finding indicates that farmers who sell to the PPIT are less likely to sell directly or through intermediaries. The ρ_{32} is positive and statistically significant, indicating that farmers who choose direct selling are also likely to choose the intermediaries marketing channel. These results suggest that farmers who sell through the PPIT, prefer to sell all of their milk to PPITs, while farmers who choose direct selling will also consider selling their milk to the intermediaries marketing channel.

Regarding information costs, the coefficient of price fluctuation is negative and significant (at 5%) for the intermediaries marketing channel. This result indicates that price fluctuation is negatively associated with the probability of choosing the intermediaries marketing channel. This implies that having price fluctuation in the intermediaries channel discourages farmers to select this channel. The farmers prefer the marketing channel that offers more stable prices, i.e. PPITs.

With regard to negotiation cost, the sign for delay of payment is negative and statistically significant for the direct selling marketing channel. This result implies that delay of payment is negatively associated with the probability of a farmer choosing the direct selling marketing channel. Usually, direct selling offers immediate payment to the farmers. However, if a delay of payment occurs in the transaction, farmers are less likely to choose direct selling. Price expectation is positively associated with the likelihood of choosing the PPIT and the intermediaries marketing channel. Unlike direct selling, farmers should have a formal contract if they deal with the PPIT or the intermediaries marketing channel.

Concerning monitoring costs, the coefficient of farm service is positive and significant for direct selling and selling through intermediaries. The coefficient of trust in buyer is negative and significant (at 5%) for the direct selling marketing channel. This finding indicates that trust in a buyer lowers the likelihood of choosing the direct selling marketing channel. Since there is no formal contract involved in the transaction between buyer and seller, the farmers will put less trust in the buyer when selling the milk to the direct selling marketing channel, i.e. they may account for the possibility that the informal contract is broken. James and Sykuta (2006) found that farmers marketing soybeans place higher trust in producer-owned-firms than investor-owned-firms and that trust is correlated with the decision to market soybeans to a producer-owned-firm.

Our results suggest that farmer socioeconomic factors and farm characteristics also play an important role in marketing channel choices. The coefficient of age is negative and significant (at 5%) for the PPIT. This result indicates that older farmers are, *ceteris paribus,* less likely to choose PPITs. A potential explanation is that older farmers may have a good network in the direct selling marketing channel. Consistent with the finding of Matungul et al.

(2001), older household heads tend to have more personal contacts, allowing them to discover trading opportunities at low cost. Younger farmers are more likely to choose PPITs, since it will help those farmers who just started their business.

The coefficient of the farmer's experience is positive and significant for the PPIT marketing channel. This finding indicates that experience is positively associated with the likelihood of choosing the PPIT. A plausible explanation is that the PPIT was established in order to help farmers in many ways, especially on how to market their milk. Therefore, experienced farmers—who have experience dealing with PPITs—are more comfortable to have transaction with them. Experienced farmers could become reluctant to adopt new marketing channels with different market requirements. This finding is in line Shiimi et al. (2012), who conclude that cattle producers in North-Central Namibia who engaged in the marketing of cattle for long periods of time, are more likely to sell through a formal market.

The coefficient of education (secondary school) is significant (α = 0.10) and negative for PPITs. This result implies that having education up to secondary school is negatively associated with the probability of farmers choosing the PPIT marketing channel. This finding suggests that better educated farmers are able to understand the requirements set by the direct selling and intermediaries marketing channels and they also are better in gathering the latest market information. Rather than selling to PPITs and receiving a lower price, they are more capable of dealing with more challenging and also more profitable marketing channels.

The coefficient of education for college or university is positive and significant for the intermediaries marketing channel. This finding suggests that having an education up to college or university is positively associated with the likelihood of choosing the intermediaries marketing channel. Farmers who have a higher education are able to identify good opportunities in the market place that offer higher prices. They are also able to fulfil the requirements set by intermediaries. This result is in line with the finding of Maina et al. (2015), demonstrating that mango farmers in Kenya who have enjoyed more education are more likely to choose marketing groups rather than local traders.

The negative coefficient of household size for the direct selling marketing channel is in line with our theoretical expectations. This result indicates that having a larger household size, *ceteris paribus,* lowers the probability of farmers choosing the direct selling marketing channel. Farmers are more likely to choose the marketing channel that can secure their income, while in the direct selling marketing channel, farmers have no guarantee that all of their product will be sold. Monson et al. (2008) found that farmers in Virginia with larger households tend to sell a smaller percentage of their output through direct channels.

The coefficient of the finance from government is negative and significant for the intermediaries marketing channel. This finding suggests that obtaining finance from the government is negatively associated with the likelihood of choosing the intermediaries marketing channel. Farmers who get financial support from the government tend to send their product to PPITs instead of marketing it through direct selling or to intermediaries. This may be because farmers who receive an incentive from the buyer are more likely to be loyal to their buyer. This result is in line with the study by Woldie and Nuppenau (2009), showing that access to credit has a negative and significant impact on the proportion sold through traders.

The results show a significant and positive coefficient of off-farm employment for the choice of the PPIT marketing channel. This result indicates that off-farm employment is positively associated with the probability of choosing PPITs. In line with our theoretical expectation, this result suggests that as farmers have off-farm employment, they will have less time to manage their farming activities and to look for other buyers for their milk. Therefore, they are more likely to send their product to PPITs, where any amount of milk is accepted.

Table 3.3 Multivariate probit results

Variables	Type of marketing channel		
	Sale to PPITs	Direct selling	Sale to intermediaries
Price information	−1.89	−0.58	0.46
	(2.53)	(0.50)	(0.63)
Price fluctuation	−0.18	0.01	−0.67**
	(0.36)	(0.22)	(0.29)
Delay of payment	−5.78	−0.74**	0.07
	(182.64)	(0.30)	(0.35)
Price expectation	1.39**	0.07	0.89**
	(0.66)	(0.25)	(0.38)
Farm service	5.15	1.27***	0.57*
	(275.74)	(0.31)	(0.34)
Trust in buyer	−0.66	−0.49*	0.05
	(2.27)	(0.28)	(0.41)
Age	−0.07***	−0.00	0.02
	(0.02)	(0.01)	(0.01)
Experience	0.05**	0.01	0.01
	(0.02)	(0.01)	(0.01)
Education: Secondary	−0.66*	−0.20	0.12
	(0.37)	(0.25)	(0.27)
College/ University	4.56	−0.27	1.17**
	(357.51)	(0.45)	(0.51)
Household size	0.02	−0.08*	0.09
	(0.08)	(0.05)	(0.07)
Intensive farm	0.32	0.11	0.01
	(0.37)	(0.24)	(0.33)
Herd size	0.00	0.00	0.00
	(0.01)	(0.00)	(0.01)
Labour	−0.04	0.06	0.10
	(0.13)	(0.07)	(0.09)
Farm size	0.00	−0.00	0.00
	(0.00)	(0.00)	(0.00)
Finance from government	−0.01	−0.20	−0.63**
	(0.36)	(0.22)	(0.31)
Off-farm employment	0.70*	−0.34	−0.08
	(0.41)	(0.21)	(0.25)
Constant	10.93	1.82*	−3.66***
	(182.68)	(0.94)	(1.29)
ρ21	−0.72***		
ρ31	−0.43***		
ρ32	0.35**		
Number of observations	200		
Wald chi2	70.32		
Probability	0.04		
Log Likelihood	−249.21		
Likelihood ratio test H_0 : ρ21 = ρ31 = ρ32 = 0; chi2(3) = 21.22***			

Notes: Standard errors in parentheses. *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level.

3.7 Conclusion

This study examines the association of transaction costs and of farmers' and farm characteristics on the marketing channel selection of Malaysian dairy farmers. Most farmers in our study area sell their milk through the government-run Dairy Industry Service Centres (PPIT): 171 out of 200 farmers use PPITs as their prime marketing channel. Directly selling to private traders is the second most common channel used; 105 farmers directly sell their milk, while 44 farmers use intermediaries as their preferred marketing channel, including restaurants, hotels or processing firms. The results of the multivariate probit regression support the hypothesis that transaction cost variables are associated with the selection of milk marketing channels. Price expectation is positively associated with the likelihood of using PPITs, delay in payment and trust in buyer is negatively associated with the likelihood of using direct selling. Price fluctuation is negatively associated with the likelihood of using intermediaries, while price expectation and farm service is positively associated with the likelihood of using intermediaries. The results also reveal that the socioeconomic backgrounds of farmers, as well as farm characteristics affect the milk marketing channel choice. Age and education (secondary school) are negatively associated, while experience and off-farm employment are positively associated with the choice of the PPIT marketing channel. Household size has a negative relation with the direct selling marketing channel. Education (college/university) is positively associated with intermediaries, while government financing is negatively associated with the intermediaries marketing channel. The results of the correlations indicate that farmers who choose PPITs are less likely to choose direct selling and intermediaries, while farmers who sell their milk to direct selling, sell their milk to intermediaries marketing channel as well. This result supports the hypothesis that farmers make their marketing channel choice decisions simultaneously.

The results of this study have important implications for dairy marketing policies in Malaysia. Knowing the sources of transaction costs can help in designing policy or changing business practices that improve the efficiency of milk marketing. Government agencies or extension services can enhance the awareness among farmers of having a formal contract, especially in the direct selling marketing channel. Such a contract may help reduce the delay in payments and may also create trust between buyer and seller. Efforts should be made by relevant agencies in order to encourage farmers to use technologies such as SMS service and internet so they can easily access price information as well as information about price fluctuations. Farmers are more likely to choose direct selling and the intermediaries marketing channel if they would offer farm services such as technical assistance and credit support or credit facilities. Therefore, these two marketing channels are encouraged to provide farm services to stimulate more engagement from farmers. Dairy farmers who did not have the chance to gain secondary education could be encouraged to attend training or take courses to develop their veterinary or management skills. Our results indicate that this could improve their ability to understand and fulfil the requirements set by the direct selling marketing channel. Furthermore, farmers are encouraged to pay more attention to hygiene; to ensure milking equipment is clean, for example, and to follow basic hygiene rules. These are required in order to improve milk quality, as high quality milk ensures that farmers receive their expected milk price. Policy makers could also consider establishing dairy cooperatives in Malaysia as several studies (Abdulai and Birachi, 2009; Staal et al., 1997) suggest that collective action through cooperatives can reduce the bureaucratic hurdles and thereby reduce transaction costs.

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Appendix 3.A

Correlation matrix for independent variables used in the empirical model

PPIT marketing channel

	Info1	Fluc1	Delay1	Expect1	Service1	Trust1	Age	Experience	Education	Family	Type	Herd size	Labour	Land	Finance	Off-farm
Info1	1.000															
Fluc1	−0.113	1.000														
Delay1	−0.062	0.145	1.000													
Expect1	−0.141	0.002	0.084	1.000												
Service1	−0.126	0.057	0.114	0.265	1.000											
Trust1	−0.080	−0.009	0.121	−0.104	0.076	1.000										
Age	−0.101	0.068	−0.028	−0.043	−0.107	0.058	1.000									
Experience	−0.144	0.248	0.060	−0.071	−0.012	0.019	0.580	1.000								
Education	0.117	−0.048	0.048	0.119	0.145	−0.199	−0.446	−0.269	1.000							
Family	0.101	0.209	0.047	−0.210	0.013	−0.007	−0.003	0.200	−0.041	1.000						
Type	−0.053	−0.260	0.025	−0.048	−0.076	0.101	0.068	−0.178	0.044	−0.125	1.000					
Herd size	0.046	−0.001	0.082	0.074	0.117	0.021	−0.082	0.019	0.169	0.225	−0.232	1.000				
Labour	−0.125	−0.032	0.127	0.106	0.065	−0.012	0.013	0.033	0.113	0.152	0.036	0.370	1.000			
Land	−0.018	0.228	−0.164	0.021	−0.021	−0.181	0.062	0.154	−0.081	0.084	−0.475	0.107	−0.087	1.000		
Finance	0.125	−0.035	−0.110	0.015	0.109	−0.174	0.093	0.169	0.163	0.178	−0.181	0.358	0.124	0.162	1.000	
Off farm	0.061	−0.035	0.017	−0.018	0.055	−0.025	−0.103	−0.056	0.147	−0.028	0.056	0.005	0.086	0.002	0.084	1.000

Direct selling marketing channel

	Info2	Fluc2	Delay2	Expect2	Service2	Trust2	Age	Experience	Education	Family	Type	Herd size	Labour	Land	Finance	Off-farm
Info2	1.000															
Fluc2	0.065	1.000														
Delay2	−0.031	0.000	1.000													
Expect2	0.001	0.213	0.289	1.000												
Service2	−0.040	0.137	−0.181	0.183	1.000											
Trust2	−0.103	−0.181	−0.003	−0.170	0.026	1.000										
Age	0.088	0.070	−0.183	−0.218	−0.095	−0.170	1.000									
Experience	−0.014	0.073	0.054	0.010	−0.132	−0.355	0.580	1.000								
Education	−0.032	0.282	0.228	0.285	0.099	0.018	−0.446	−0.269	1.000							
Family	0.083	0.061	−0.034	−0.005	−0.041	−0.302	−0.003	0.200	−0.041	1.000						
Type	0.120	0.370	−0.067	0.021	0.096	0.012	0.068	−0.178	0.044	−0.125	1.000					
Herd size	0.070	0.131	0.127	0.331	−0.092	−0.287	−0.082	0.019	0.169	0.225	−0.232	1.000				
Labour	−0.019	0.071	0.248	0.181	−0.060	0.010	0.013	0.033	0.113	0.152	0.036	0.370	1.000			
Land	−0.257	−0.128	−0.048	0.076	−0.038	−0.052	0.062	0.154	−0.081	0.084	−0.475	0.107	−0.087	1.000		
Finance	0.046	0.167	−0.040	0.343	0.121	−0.148	0.093	0.169	0.163	0.178	−0.181	0.358	0.124	0.162	1.000	
Off farm	0.021	0.006	0.053	0.108	0.024	0.023	−0.103	−0.056	0.147	−0.028	0.056	0.005	0.086	0.002	0.084	1.000

Intermediaries marketing channel

	Info3	Fluc3	Delay3	Expect3	Service3	Trust3	Age	Experience	Education	Family	Type	Herd size	Labour	Land	Finance	Off-farm
Info3	1.000															
Fluc3	−0.140	1.000														
Delay3	−0.087	−0.103	1.000													
Expect3	−0.034	0.028	0.124	1.000												
Service3	−0.006	0.252	−0.251	−0.354	1.000											
Trust3	0.246	0.035	−0.008	0.219	−0.058	1.000										
Age	0.041	−0.019	−0.154	−0.195	0.052	0.278	1.000									
Experience	−0.161	0.051	−0.393	−0.124	0.196	0.007	0.580	1.000								
Education	−0.075	−0.009	0.065	0.127	−0.213	−0.245	−0.446	−0.269	1.000							
Family	−0.132	−0.080	−0.025	−0.411	−0.000	−0.529	−0.003	0.200	−0.041	1.000						
Type	0.120	0.164	0.028	0.346	−0.368	0.168	0.068	−0.178	0.044	−0.125	1.000					
Herd size	−0.203	0.105	0.112	0.063	−0.108	−0.304	−0.082	0.019	0.169	0.225	−0.232	1.000				
Labour	−0.308	0.167	0.243	0.016	0.076	−0.292	0.013	0.033	0.113	0.152	0.036	0.370	1.000			
Land	−0.464	0.013	0.136	−0.088	0.067	0.040	0.062	0.154	−0.081	0.084	−0.475	0.107	−0.087	1.000		
Finance	−0.099	−0.420	0.154	0.213	−0.407	−0.135	0.093	0.169	0.163	0.178	−0.181	0.358	0.124	0.162	1.000	
Off farm	−0.088	0.115	−0.051	0.090	0.052	−0.128	−0.103	−0.056	0.147	−0.028	0.056	0.005	0.086	0.002	0.084	1.000

CHAPTER 4

Measuring and explaining technical, allocative and scale efficiency for the state-owned dairy enterprise in Malaysia

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Abstract

The aim of this chapter is to measure the technical, allocative and scale efficiency of the state-owned enterprise called the Dairy Industry Service Centre (PPIT), and to determine the factors affecting these efficiencies. The study uses data envelopment analysis to measure technical, allocative and scale efficiency scores on a sample of 25 PPITs over the period 2014–2016. We find that PPITs have higher technical efficiency scores than allocative efficiency scores. This indicates that PPITs perform relatively well in terms of using all resources, but perform less well when choosing the proper input mix given their respective prices. Scale efficiency scores further suggest that PPITs should focus on using and allocating inputs more efficiently, rather than adjusting their size of operation. Using a single truncated bootstrap regression model, the market share, milk grade, age and location of the firm, and the age and education of the manager are identified as determinants of technical, allocative and scale efficiency scores.

Keywords

Data envelopment analysis, technical efficiency, allocative efficiency, scale efficiency, Malaysian dairy industry

4.1 Introduction

The demand for dairy products has expanded rapidly in Asia (including Malaysia) due to economic growth, population growth and a shift in consumer preferences toward higher-valued foods, including livestock products. Despite its growth in recent years, milk production remains insufficient to meet domestic demands, as Malaysia's consumption of fresh milk is also increasing. This situation requires an improvement in the dairy supply chain which not only comprises improvements from the primary production side, but also from other actors in the chain such as milk processors. As the processing and marketing of milk in Malaysia is dominated by the state-owned Dairy Industry Service Centre (PPIT), there is a lack of competitive pressure to trigger PPITs to perform at optimal level. It remains unclear how well PPITs currently perform and what factors determine the technical, allocative and scale efficiency of the PPITs. The second chapter of this thesis has examined efficiency for the upstream side of milk production (Mohd Suhaimi et al., 2017), however, evidence for the downstream side is still lacking.

In Malaysia, most dairy producers sell their milk to the government through the PPIT. The main reason for existence of the PPIT was to provide a marketing channel to dairy farmers. PPITs also operate as consultants and give various development incentives to farmers, for instance by offering centralised milk collection and distribution facilities, rural credit programmes and milk subsidies. There are 34 PPITs on the Malaysian peninsula. In 2016, the total local production of milk was 127.43 million litres of which 6.83 million litres (25%) was sold to PPITs (DVS, 2016). Producers sell their milk to the PPIT at a predetermined price. However, producers are free to sell their milk to other buyers such as traders or agents, or directly to restaurants and hotels. As a government-run organisation, the PPIT is mainly focused on helping farmers by providing services, rather than on increasing profit levels. Improving the efficiency of the PPITs can thus be achieved by improving the quality of services.

Efficiency can be expressed in terms of technical efficiency (TE), allocative efficiency (AE) and scale efficiency (SE). Koopmans (1951) defined a producer as technically efficient if, and only if, increasing any output or decreasing any input is possible only by decreasing another output or increasing another input, respectively. Conversely, allocative efficiency measures a firm's success in choosing an optimal set of inputs with a given set of input prices (Daraio and Simar, 2007). Scale efficiency measures whether a firm is providing the most cost-efficient level of output, i.e., whether a firm is operating at the optimal scale. Different studies have different views on efficiency. Hicks (1935) stated that the absence of competitive pressure might allow producers the freedom to not fully optimize conventional objectives, and conversely, that the presence of competitive pressure might force producers to do so. Leibenstein (1987), on the other hand, argued that production is bound to be inefficient as a result of motivation, information, monitoring and agency problems within the firm, which may lead to so called "X-inefficiency". A basic point of the theory of X-inefficiency is that firms do not minimise costs. There are numerous studies on the efficiency of dairy processing firms or dairy cooperatives (Ariyaratne et al., 2000; Porter and Scully, 1987; Singh et al., 2001; Soboh et al., 2012; Soboh et al., 2014) and there are also a few studies on the efficiency of the public sector (Madden et al., 1997; Ruggiero, 1996), but to the best of our knowledge there is a very limited number of studies focusing on government-run organisations, especially in the agricultural sector. This is a clear gap in the literature as an assessment on how efficient inputs are used, not only for production but also as services providers, can be a major force in shaping the growth and economic strength of the dairy sector.

The aims of this study are two-fold. First, we want to measure the technical, allocative and scale efficiencies of PPITs in Malaysia. To estimate efficiency scores, the data envelopment analysis (DEA) method is applied to annual data over three years for twenty-five PPITs in Malaysia. Then, the second step is to determine the factors affecting each of those efficiencies.

The truncated bootstrap regression is used to identify the determinants of efficiencies. This study provides not only empirical measures of different components of efficiency, but also identifies several key variables that explain them. This study can help in designing new policies that aim at enhancing milk production as well as increasing food security in Malaysia. It can also provide the top management of PPITs the necessary information to become technically and allocatively efficient.

4.2 Materials and methods

This research consists of a two-stage analysis. First, we used DEA to measure technical, allocative and scale efficiency of a sample of twenty-five PPITs in Malaysia. Second, a truncated bootstrap regression model is employed to explain the determinants of these efficiency scores. Technical, allocative and scale efficiency are measured using a series of linear programs (Färe et al., 2013). Technical efficiency is maximizing output with the given input or minimizing input in order to get the same amount of output. Allocative efficiency means optimisation of the input and output mix, while scale efficiency means that increasing or decreasing the size of the firm will make the unit less efficient because its size is at the optimal level. As we pool our data from three years, we assume that there is no technical process change within these three years of observation.

4.2.1 Data envelopment analysis

Non-parametric methods, such as data envelopment analysis (DEA), can be used to calculate the individual efficiency scores of decision-making units, such as dairy processing firms, for performance measurement, analysis and benchmarking (Tauer, 1993; Weersink et al., 1990). The DEA model was introduced by Charnes et al. (1978) and has been widely used to measure the efficiency of individual decision-making units (DMUs) in a variety of industries (Heinrichs et al., 2013), from farming and air transportation to social insurance and banking. In this study, we used an input-oriented model as we assumed that PPITs have more flexibility in contracting their input use, rather than expanding their outputs.

Technical efficiency

The DEA model is used to simultaneously construct the production frontier and obtain the technical efficiency measures. The explanation below (for technical, allocative and scale efficiency) was adapted from Coelli et al. (2002). The model is presented for the case where there is data on K inputs and M outputs for each of N firms. For the i-th firm, input and output data are represented by the column vectors x_i and y_i, respectively. The $K \times N$ input matrix, X, and the $M \times N$ output matrix, Y, represent the data for all N firms in the sample.

The DEA model used for calculation of technical efficiency is:

$\min_{\theta,\lambda} \theta$

Subject to $\quad -y_i + Y\lambda \geq 0,$

$\theta x_i - X\lambda \geq 0,$

$N'\lambda = 1,$

$\lambda \geq 0,$ (1)

where θ is a scalar, N is an $N \times 1$ vector of ones, and λ is an $N \times 1$ vector of constants. The value of θ obtained is the technical efficiency score for the i-th firm. It will satisfy: $\theta = 1$, with a value of 1 indicating a point on the frontier and hence a technically efficient firm, according to the definition by Farrell (1957). Note that the linear programming problem must be solved N times to obtain a value of θ for each firm in the sample.

In Figure 4.1, the four firms (A, B, C and D) produce the same level of output, using various amounts of two inputs, denoted by x_1 and x_2. Firms A, C and D form the production frontier (or isoquant) because it is not possible for any of these firms to radially reduce their input use and still remain within the production possibility set. Firm B, however, is inefficient because it can reduce its input use to the projected point B', so its technical efficiency score is measured as 0B'/0B.

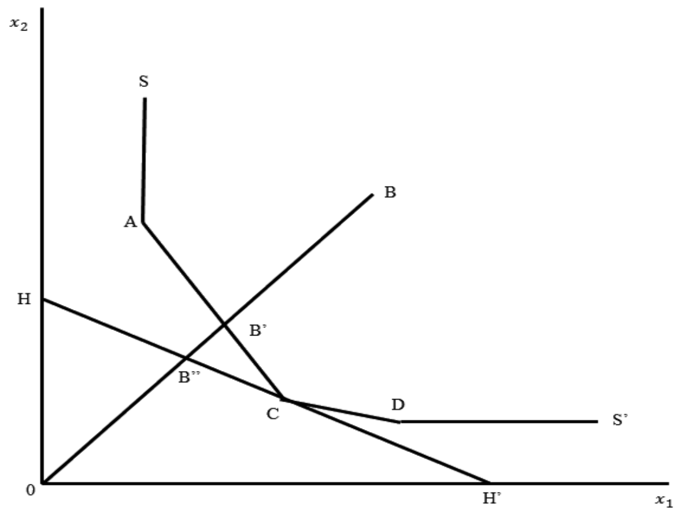

Figure 4.1 Technical and allocative efficiencies

Allocative efficiency

If we have input price information, allocative efficiency (AE) can be measured as well (using the isocost line, HH'). If all firms face the same relative prices reflected by this line, firm C is producing at minimum cost, while the other firms are not. Thus, even though firm A and D are both technically efficient, they are not cost efficient because they are allocatively inefficient. They do not use the inputs in optimal proportions, given the observed input prices and hence do not produce at minimum possible cost. Firm B is both technically inefficient and allocatively inefficient. Its allocative efficiency can be measured by the ratio 0B''/0B'.

In order to calculate AE, first we have to calculate cost efficiency (CE). The CE can be obtained by solving the following cost minimisation (under constant return to scale) DEA problem:

$$\min_{\lambda, x_i} w_i' \, x_i^*$$

Subject to $\quad -y_i + Y\lambda \geq 0,$

$x_i^* - X\lambda \geq 0,$

$N'\lambda = 1,$

$\lambda \geq 0,$ (2)

Where w_i is a vector of input prices for the i-th firm and x_i^* (which is calculated by the model) is the cost-minimising vector of input quantities for the i-th firm, given the input prices w_i and the output levels y_i. The total cost efficiency of the i-th firm is calculated as:

$$CE = w_i'x_i^*/w_i'x_i \tag{3}$$

That is, CE is the ratio of minimum cost to observed cost for the i-th firm. As the CE for a DMU can be also be represented as the product of TE and AE for the DMU, or $CE = TE \times AE$ (Farrell, 1957), AE can thus be calculated as:

$$AE = CE/TE \tag{4}$$

Figure 4.2 illustrates the calculation of scale efficiency using a one-input (x), one-output (y) example. The constant returns to scale (CRS) and variable returns to scale (VRS) frontiers are indicated in the figure. Under CRS, the input-oriented technical inefficiency of the point P is the distance PP_C. However, under VRS, the technical inefficiency would only be PP_V. The difference between these two TE measures, P_CP_V, is due to scale inefficiency. Hence, we can calculate scale efficiency (SE) as:

$$SE = TE_{CRS}/TE_{VRS} \tag{5}$$

To obtain a robust DEA measurement, we used the bootstrap methodology developed by Simar and Wilson (2007). Their bootstrap method gives more stable estimates and can accommodate bias correction of efficiency scores relative to the sampling variations of the estimated frontier.

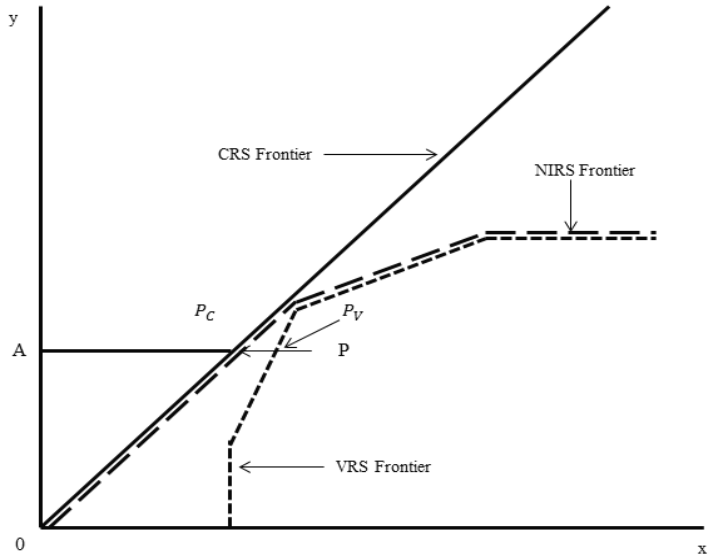

Figure 4.2 Constant, increasing and decreasing returns to scale

4.2.2 Truncated bootstrap regression model

In order to explain the differences in efficiency levels, the efficiency scores were regressed on firm characteristics using a truncated bootstrap regression model developed by Simar and Wilson (2007). As estimated DEA efficiency scores are serially correlated (Xue and Harker, 1999), using these scores in a standard ordinary least square regression analysis results in violation of the basic assumption of independence within the sample values (Simar and Wilson, 2011). The model for the truncated bootstrap regression is:

$$\hat{\delta}_i = Z_i\beta + \varepsilon_i$$

where the dependent variable $\hat{\delta}_i$ is the bootstrapped efficiency score, Z is a vector of independent variables, β its associated vector of coefficients and ε_i the idiosyncratic error term. According to Simar and Wilson (2007), the confidence intervals for the coefficients of the second-stage regression, which are appropriate for inference, can be constructed as follows (algorithm I):

1) Perform the DEA approach to get efficiency score, $\hat{\delta}_i$, for each firm $i = 1, \dots, n$.

2) Regress $\hat{\delta}_i$ on the independent variables, Z_i, using left-truncation at 0 to obtain estimates $\hat{\beta}$ and $\hat{\sigma}_\varepsilon$ of the parameters β and σ_ε.

3) Repeat the following three steps below, for B (1,000 bootstrap iterations) times to obtain a set of bootstrap estimates $B^* = \{(\hat{\beta}^*, \hat{\sigma}_\varepsilon^*)\}_{b=1}^{B}$

   a) For each $i = 1, \dots, n$, draw ε_i^* from the $N(0, \hat{\sigma}_\varepsilon^2)$ distribution with left-truncation at $(0 - Z\hat{\beta})$.

   b) For each $i = 1, \dots, n$, compute $\delta_i^* = Z_i\hat{\beta} + \varepsilon_i^*$.

   c) Regress δ_i^* on the independent variables, Z_i, using left-truncation at 0 to obtain $\hat{\beta}_b^*$ and $\hat{\sigma}_{\varepsilon,b}^*$.

4) Obtain the mean and 95% confidence interval of the betas and sigmas.

4.3 Data description

We collected original data from 25 out of 34 PPITs for a three-year time period (2014–2016) using a questionnaire. The complete list of PPITs was provided by the Department of Veterinary Services. We sent out the questionnaire via email to all PPITs on the Malaysian peninsula and then called the manager of each PPIT to make sure they received the email, understood the questions and answered the questionnaire properly. The manager could decide to have the interview either by phone or to fill in the document file independently. The questionnaire surveyed the use of inputs and the production of outputs, the material and equipment used in the PPIT, and socio-economic factors. The surveys were conducted between May and July 2017.

4.3.1 Data for the data envelopment analysis

For measuring technical, allocative and scale efficiencies, we consider two outputs and five inputs. Summary statistics for these variables are shown in Table 4.1. The inputs and outputs (except milk) were expressed in thousands of Malaysian Ringgit of the year 2014 by deflating the monetary values with corresponding price indexes (obtained from the Department of Statistics Malaysia).

There are two outputs used in this study: the volume of milk sales in litre and the total amount of resources that the PPIT spent for providing services to the farmers (deflated using a price index for services).

The inputs are raw milk, labour, machinery, materials and maintenance. Raw milk is the volume of milk bought by the PPIT in litre. Labour is defined as the number of workers in full time equivalents (fte). The price of labour is measured as total wage (in Malaysian Ringgit, MYR) divided by the number of workers in fte. Machinery includes all essential equipment used by the PPIT, such as pasteurisation machines, chiller tanks and transportation equipment. It is measured as replacement value (in MYR) and deflated using a price index for capital goods. Materials included all expenses for materials such as fuel, energy and water used for operation of the PPIT (measured in MYR) and deflated using a price index for consumer nondurables. Maintenance covers all expenses for repairing costs of the building, machinery and transportation in the PPIT (measured in MYR) and deflated using a price index for household maintenance.

Table 4.1 Mean and standard deviation of outputs and inputs used in the bootstrap data envelopment analysis model

Variable	Unit	Mean	Standard deviation
Milk sales	10,000 litre	21.14	28.80
Service	10,000	6.17	4.41
Raw milk	10,000 litre	22.27	29.05
Labour	Persons	6.00	3.75
Machinery	10,000	23.67	36.54
Material	10,000	4.39	4.43
Maintenance	10,000	1.52	1.75
Price of milk sales		1	0
Price of service		1.047	0.034
Price of raw milk		1	0
Price of labour		31984.43	6452.22
Price of machinery		1.007	0.017
Price of material		1.023	0.021
Price of maintenance		1.033	0.025

Notes: Sample size = 75

4.3.2 Data for the truncated bootstrap regression model

As Lovell (1993) indicated, identifying the factors that explain differences in efficiency is essential for improving the results of firms, although unfortunately, economic theory does not supply a theoretical model of the determinants of efficiency. However, according to Caves (1992) several studies have developed a strategy for identifying the sources of efficiency. The determinants can be (i) external factors such as the degree of competition existing in the markets, (ii) characteristics of the firm such as size, type of organisation and location of the firm, (iii) dynamic deviations from the firm's long-term equilibrium situation, and (iv) public versus private ownership of the firm. Based on literature, we compiled a selection of factors that could influence the efficiency of PPITs. We used the manager's socioeconomic background and the firm's characteristics to explain the level of efficiency. Each factor may have a different impact on technical, allocative and scale efficiency as they are very distinct measures of efficiency. Summary statistics for these variables are shown in Table 4.2.

Perfect competition can exist when a large number of firms, using the same technology, produce a homogeneous product and when producers and buyers are able to get perfect information on the conditions of the market (Sexton, 2013). In a highly competitive market, only efficient firms have a good chance of survival (Halpern and Körösi, 2001). Berger and Hannan (1998) summarise that a few reasons that may explain the influence of market structure, as a proxy for market power, on efficiency. First, managers do not have incentives to work hard. Second, managers devote resources to obtaining and maintaining market power, which raises costs and reduces cost efficiency. Third, if the firm has market power, incompetent managers can survive without doing their best effort. We expect that market share is negatively associated with both technical and scale efficiency and positively associated with allocative efficiency. A positive relation is expected for allocative efficiency might be because firms with a larger market share are able to produce at low operational costs, resulting in the ability to use inputs given input prices. This study captures this effect by incorporating the variable *market share* which is defined as the percentage of the total milk production that is sent to the PPIT in each region.

Firm size is measured as the number of farmers who send their milk to a given PPIT firm or office. Large firms are in a better position to use economies of scale (Majumdar, 1997), therefore, firm size is expected to have a positive relation with technical efficiency. Larger firms are more efficient because of a selection process where efficient firms grow and survive, while inefficient firms stagnate or exit the industry (Lundvall and Battese, 2000). Kapelko and Oude Lansink (2013) find that technical efficiency increases with the size of Spanish dairy processing firms. For our study, however, there is no clear hypothesis about the association between firm size and allocative and scale efficiency.

When firms operate near to a major city or town, there are good opportunities for information exchange and there is access to knowledge-intensive services and specialised capital. Consequently, the probability of making decisions that lead to higher input use efficiency may decline (Tveteras and Battese, 2006). The firm's location may also affect its innovation activities, with consequences for its production process and efficiency (Cooke et al., 2004). Gumbau Albert and Maudos (1996) found substantial differences in average levels of efficiency among regions in Spain. We include the *location* of the PPIT as an explanatory variable in order to capture regional effects, and we expect that location is positively associated with technical, allocative and scale efficiency. Location was measured as distance of the PPIT from the main city in the region in kilometres using *Google Maps*.

The *age of the firm* can be positively or negatively associated with technical efficiency. Older firms are expected to be more experienced in operation because of "learning by doing", which could make them technically more efficient, however, they may also be less inclined to invest in new technology, resorting instead to the use of dated machines and equipment, which could lower their technical efficiency levels. Conversely, we hypothesise that the age of the firm is positively associated with allocative and scale efficiency. Age of firm is measured as the number of years the firm has been in operation. Some studies suggest that young firms tend to start with more up-to-date technologies, resulting in a relatively higher efficiency (Kapelko and Oude Lansink, 2015). As technologies decay with time, efficiency may decrease. Little et al. (1987) found that technical efficiency decreased with a firm's age, which they explained by older firms tending to invest less in new capital. They used capital from earlier investments, which is less productive, leading to inefficiency. Berger and Mester (1997) suggested that a firm's age might be related to technical efficiency because a firm's production might involve "learning by doing", and young firms may suffer from liability of newness (Stinchcombe and March, 1965), leading to low efficiency.

The age of the manager can be positively or negatively associated with technical, allocative and scale efficiency. Older managers are expected to be more experienced, which could make them more technically, allocatively and scale efficient. However, they may also be less energetic or less connected to the newest developments and information, which could in turn lower their efficiency levels. Older managers may have improved their skills in using and allocating resources, resulting in higher efficiency. In addition, we expect that the education level of the manager is positively associated with technical, allocative and scale efficiency. Less experience and education regarding PPIT activities could result in an inability to manage the firm and maximise the output (Alvarez and Crespi, 2003). Most empirical evidence suggests that firms with better-schooled owners and managers are more efficient (e.g., Burki and Terrell, 1998; Tan and Batra, 1995). In this chapter, the manager's *age* is measured as his or her age in each respective year and the manager's *education* as a categorical variable with one of the following levels: (i) secondary school, (ii) vocational level and (iii) pre-bachelor level. We also included age-squared to test a potential quadratic relationship between age and efficiency.

The PPITs receive milk of a range of quality categories, namely AA, A and –A. The *milk grade* was based on a total plate count test and a total digestible solids test. AA is the best quality group, with a total plate count higher than 100,000 on and less than 13% total digestible solids. There is no clear hypothesis about the relationship of milk grade with technical, allocative and scale efficiency.

Table 4.2 Mean and standard deviation of variables used in the truncated bootstrap regressions

Variable	Unit	Mean	Standard deviation
Market share	Percentage of milk buy by PPIT to total milk production in one region	52.93	94.02
Firm size	Number of farmers sent milk to PPIT	12.36	15.22
Location	Kilometres	68.90	49.21
Age of firm	Years	33.96	5.55
Age of manager	Years	45.34	10.02
Age square	Years[2]	2155.4	849.08
Education[1]	Dummy: Secondary school*	36	
	Vocational	32	
	Pre-bachelor	32	
Milk grade	Percentage of grade AA milk	39.12	32.09
	Percentage of grade A milk	18.67	17.39
	Percentage of grade –A milk*	18.22	21.93

Notes: Sample size = 75
* Reference level
[1] Reported means are percentages of the sample
[2] Years squared

4.4 Results and discussion

4.4.1 Efficiency results

Using the R programming language and the package FEAR developed by Wilson (2008), bootstrap DEA was applied to determine technical (TE), allocative (AE) and scale (SE) efficiency for the PPITs. Summary statistics of the technical (original and bias-corrected), allocative and scale efficiency scores are presented in Table 4.3. Table 4.4 presents the percentiles for bias-corrected technical efficiency VRS score and the 95% confidence interval.

The bias-corrected TE score under VRS ranged from 0.30 to 0.94, with an average of 0.79. These estimates indicate that there was scope for efficiency improvement for the PPITs by reducing their inputs. On average, PPITs can reduce their inputs of production by 21% while still producing the same level of output. In other words, PPITs could save 21% of inputs if they were efficient in production. The SE score ranges from 0.5 to 1.0 and is 0.89 on average. This indicates that on average, PPITs can reduce their input use by 11% by producing at an optimal scale, i.e. a scale where they operate under CRS. Operating at an inefficient scale might happen because the firm size is too small, for example because of insufficient market share, or that it is too large because of a degree of monopoly power (Ferrier and Porter, 1991). The average AE score is 0.54 which implies that on average, PPITs are not using inputs at cost-minimizing levels given the input prices they face. In other words, there is further scope to decrease the inputs use by 46%, by suitably reallocating inputs as used by the best practice firms. The higher average score of TE relative to AE indicates that PPITs used all resources relatively well, but that they were inefficient in using inputs with respective prices. The absence of competitive pressure might be the source of this allocative inefficiency. This is reasonable since PPITs do not only produce milk, but also provide services and conducting different sets of activities at different intensities. They also may have a limited number of input suppliers to choose from and lack access to information about input prices.

Table 4.5 presents the return-to-scale summary statistics. Half of the firms exhibit decreasing returns to scale (DRS), implying that their output increases by a smaller proportion than increases in input, and thus that they need to reduce their size in order to achieve optimal scale. Conversely, only 16% of all firms exhibit increasing returns to scale (IRS), indicating that these PPITs increase their output by a greater proportion than the increase in input. Some 32% of firms operate at optimal size (i.e. exhibit constant returns to scale, CRS) meaning that 24 PPITs were operating at their most productive scale size.

Table 4.3 Mean, minimum (min), maximum (max) and standard deviation for cost, technical, allocative and scale efficiency scores

Efficiency	Mean	Min	Max	Standard deviation
Cost efficiency	0.425	0.031	1.000	0.222
Technical efficiency VRS[1]	0.870	0.312	1.000	0.185
Scale efficiency	0.895	0.500	1.000	0.142
Allocative efficiency	0.542	0.101	1.000	0.216

[1] VRS, variable return to scale

Table 4.4 Percentile of bias-corrected technical efficiency under variable return to scale and the 95% confidence interval

Efficiency	Percentile	Centile	Lower	Upper
Bias-corrected technical efficiency (variable return to scale)	25	0.724	0.645	0.785
	50	0.857	0.849	0.865
	75	0.890	0.871	0.905

Notes: Lower and Upper represent the bounds of a 95% confidence interval.

Table 4.5 Return-to-scale summary statistics

Scale Classification[1]	Number	Percent (%)
CRS	24	32
IRS	12	16
DRS	39	52
Total	75	100

[1] CRS, constant returns to scale; IRS, increasing returns to scale; DRS, decreasing returns to scale.

4.4.2 Truncated bootstrap analysis

For the second stage, the estimated bias-corrected technical efficiency (under VRS, from here on referred to as technical efficiency), allocative efficiency and scale efficiency scores were regressed on firm and socio-economic factors using a truncated bootstrap regression analysis performed using the Stata software package (StataCorp., 2011). The results are presented in Table 4.6.

Market share has a positive and significant relationship with technical efficiency, while it is negatively associated with allocative efficiency. This finding contradicts our prior expectations for technical and allocative efficiency. A positive association indicates that PPITs with a larger market share have a higher technical efficiency level. A plausible explanation for this positive relation could be that a firm with higher market share receives more milk and benefits from economies of scale. A negative association between market share and allocative efficiency indicates that PPITs with a large market share have a lower allocative efficiency. This could be explained by the fact that managers of PPITs with a larger market share put more focus on maintaining their market share rather than on the efficient allocation of their input.

Milk grade (grade A group) has a negative relation with technical efficiency, which indicates that PPITs that received more grade A milk compared to grade –A milk have lower technical efficiency levels. In other words, PPITs that receive grade A milk are less technically efficient. This result could be explained by the notion that PPITs might be the last resort for farmers to deliver their milk and that milk quality deteriorates easily after a few hours.

Our results show that the age of the firm has a positive and significant relation with technical efficiency. This result indicates that PPITs that were established a longer time ago are more efficient in terms of managing their inputs. This supports the finding by Admassie and Matambalya (2002), who explained that firms become more efficient over time as a result of increased experience. An alternative explanation is that older PPITs may also identify and reject inefficient production methods, becoming more efficient over time (Malerba, 1992).

The results for location of firm suggest that PPITs located further from a city have lower levels of technical, allocative and scale efficiency. These results are in line with our expectation that PPITs which are located near to the city centre are more up-to-date with information and have better access to inputs. Therefore, they are not only efficient in using inputs, but they are also efficient in allocating the inputs given input prices.

The relation between the age of the PPIT manager and PPIT efficiency is nonlinear. As we take into account the effect of age squared, the age of the PPIT manager negatively associates with allocative efficiency. The allocative efficiency of the PPIT increases as its manager ages, until peak efficiency is reached when the manager is 39.5 years old. Further age increases result in a decrease in efficiency for the PPIT under the manager's control. This result implies that older managers who have reached the top of the administrative ladder might become less motivated and consequently, allow to reduce the efficiency of their PPIT to reduce (Lachaal et al., 2002). Conversely, younger managers may be more willing to adopt new production methods and management techniques, leading to better resource allocation. On the other hand, the age of the PPIT manager has a positive relation with scale efficiency, which indicates that older (more experienced) managers are more skilled in optimising input use. This result implies that as a young manager ages, the scale efficiency of the PPIT will decrease until a minimum is reached when the manager is 39 years old. Beyond that age, the PPIT of the manager increases in scale efficiency with age.

In line with prior expectations, education at vocational level is positively associated with scale efficiency. Managers with increased knowledge (through education), are able to interpret and respond to a new information and technology, and therefore use their resources more efficiently in order to get an optimal scale of operation.

Table 4.6 Results of the truncated bootstrap regression model explaining technical, allocative and scale efficiency

Variable	TE_{VRS} Bias-corrected			AE			SE		
	Mean	Lower	Upper	Mean	Lower	Upper	Mean	Lower	Upper
Market share	0.001**	0.000	0.002	−0.004**	−0.005	−0.002	0.001	−0.000	0.001
Firm size	−0.001	−0.003	0.000	0.003	−0.000	0.005	0.002	−0.000	0.003
Milk grade									
AA	−0.000	−0.001	0.001	0.001	−0.000	0.002	−0.000	−0.001	0.001
A	−0.003**	−0.005	−0.001	0.000	−0.002	0.003	0.000	−0.002	0.002
Age of firm	0.013**	0.007	0.019	0.004	−0.004	0.012	−0.005	−0.010	0.000
Location	−0.001**	−0.002	−0.000	−0.002**	−0.003	−0.001	−0.001**	−0.001	-0.000
Age of manager	0.025	−0.004	0.054	0.058**	0.016	0.100	−0.040**	−0.067	-0.012
Age square	−0.000	−0.001	0.000	−0.001**	−0.001	−0.000	0.001**	0.000	0.001
Education									
Vocational	−0.023	0.091	0.044	−0.097	−0.149	0.055	0.110**	0.046	0.173
Pre-bachelor	0.010	−0.059	0.081	−0.078	−0.175	0.019	0.022	−0.044	0.085
Constant	−0.054	−0.720	0.565	−0.399	−1.325	0.552	1.743**	1.090	2.341
Sigma	0.117**	0.100	0.135	0.165**	0.139	0.191	0.108**	0.093	0.124

Notes: Lower and Upper represent the bounds of a 95% confidence interval.
** $P < 0.05$.
N = 75.

4.5 Conclusion

This chapter analysed cost efficiency and its decomposition in technical, allocative and scale efficiency for a sample of 25 state-owned enterprises, Dairy Industry Development Centres (PPITs) on the Malaysian peninsula. Technical, allocative and scale efficiency were estimated with the nonparametric DEA method. Determinants of efficiency were evaluated using a truncated bootstrap regression model.

The DEA reveals average levels of technical, allocative and scale efficiency of 79%, 54% and 89%, respectively. These findings suggest that the average PPIT can maintain its current production level and save 21% of the inputs used. The average PPIT could also reduce the cost of operation by 46% by taking more notice of input prices when choosing input quantities. The lower average scores for allocative efficiency than for technical efficiency indicate that PPITs optimise the inputs of production well, but allocate the input mix rather poorly given the prices. However, the scale efficiency of 89.5% implies that most of the PPITs operate at close to optimal scale. This finding suggests that managers should focus on using and allocating inputs efficiently rather than increasing their size.

In the second stage of the analysis, truncated bootstrap regression was used to estimate three separate equations, in which technical, allocative and scale efficiency were regressed on seven firm/manager characteristics: market share, milk grade, age of the firm, firm distance from the city, age of the manager, age squared and education of the manager. The results of the truncated bootstrap regression show the following: market share and firm age have a positive relation with technical efficiency, while milk grade (A) and firm distance negatively associate with technical efficiency. The age of the manager has a positive relation with allocative efficiency and market share, location and age squared negatively associate with allocative efficiency. Education at vocational level and age squared has a positive relation with scale efficiency, while firm location and manager age have a negative relation with scale efficiency.

These results have significant implications for the management of PPITs. The efficiency analysis indicates that there is room for improvement for PPITs to raise their level of cost efficiency, especially in terms of allocative efficiency. In order to improve efficiency in resource use and allocation, access to current technology and price information is needed, as information communication is an important accelerator in the process of technology transfer (Ali, 2007). Therefore, the government should facilitate this as a policy matter. Findings suggest that older PPIT managers who are more efficient could share their experience through courses to young managers. Furthermore, the results also suggest that PPITs located near the city centre are *ceteris paribus* more efficient. Therefore, policy makers could provide a better infrastructure, such as good roads, since relocation of PPITs is difficult. In addition, our findings suggest that PPIT market share is associated with a higher level of technical efficiency. One solution to increase market share is by merging. However, since there is only one PPIT per region, a merger within the region is not possible. Instead, PPITs could consider to collaborate more effectively, for example by organising marketing activities jointly and by sharing resources.

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CHAPTER 5

Asymmetric price transmission in the Malaysian dairy supply chain

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Abstract

This chapter investigates the causal relationship and price transmission in the markets between farmers, the state-owned intermediate Dairy Industry Service Centre (PPIT) and retailers in the fresh milk supply chain in Malaysia. Asymmetries in price transmission are examined using the vector autoregressive model as well as the error correction approach, while causal relationships are tested using a Granger causality test. The results show that retail prices affect farm and PPIT prices in the Malaysian dairy sector in the short run. Results also suggest there is no long-term cointegration relationship among these three prices.

Keywords

Vector autoregression analysis, causality test, price transmission, Malaysian dairy industry.

5.1 Introduction

As local milk production is too low to meet domestic demand, Malaysia has to import almost 95% of its fresh milk and dairy products. As a result, import tariffs on dairy products are much lower as compared to other foods (Sim and Suntharalingam, 2015). To date, the applied tariff for some dairy products in Malaysia, such as skim milk and whole milk powder, is zero (MITI, 2015). If the price transmission between specific levels of the supply chain is asymmetric, the price changes at the farm level are not quickly or fully transmitted to the processing and/or retail level and vice versa (Reziti, 2015). It is important to understand price transmission in the Malaysian milk supply chain since farm prices are set by the government and farmers may suffer from market power exerted by downstream supply chain actors such as retailers and processors. A better understanding of price transmission is important to design policy measures that seek not only to reduce the causes of market failures in order to increase competitiveness, but also to reduce poverty and food insecurity (Schroeder and Hayenga, 1987).

Asymmetric price transmission implies that production price increase and decrease influence consumption at different rates. Meyer and Cramon-Taubadel (2004) observed that possible implications of asymmetric price transmission are that consumers are not benefiting from price reductions at the producer level, while producers might not benefit from a price increase at the retail level. There are a number of reasons for asymmetric price transmission, such as market power at the processing and retail levels (Azzam, 1999; Meyer and Cramon-Taubadel, 2004; Peltzman, 2000), product perishability (Ward, 1982), adjustment and menu costs (Bailey and Brorsen, 1989), search costs in local markets (Benson and Faminow, 1985) or public intervention in producer prices (Kinnucan and Forker, 1987). Price transmission asymmetry may lead to inefficiencies in the market, which in turn prevents optimal resource allocation (Ben-Kaabia and Gil, 2007). In developing countries, it is important to evaluate how actors such as processors, distributors and retailers behave, as they generally have more market power than farmers at the start of the supply chain (Ishaq et al., 2016).

Various studies of diverse geographical scope have investigated price transmission for milk and dairy products. Kinnucan and Forker (1987) were the first to highlight that asymmetries in both magnitude and time of response are found in the retail prices of dairy products in the US. Serra and Goodwin (2003) applied asymmetric threshold error correction models for the analysis of transmission among farm and retail markets for a variety of dairy products in Spain and found that the transmission of shocks is largely unidirectional, running from the farm to the retail level. Fałkowski (2010) suggested that price transmission between farm and retail levels in the Polish fluid milk sector is affected by both short-term and long-term asymmetries. Stewart and Blayney (2011) analysed price transmission in the US for whole milk and cheddar cheese and indicate that price shocks at the farm level are transmitted asymmetrically and with a delay to retail prices. Reziti (2015) used a threshold error correction autoregressive model and found a nonlinear price adjustment between milk consumer and producers and abuse of market power by milk processor and retailers.

There are only a few studies of price transmission of other commodities in Malaysia. For example, Yeong-Sheng (2009) investigated the farm-retail price transmission of pork and found that a change in the farm price is accompanied by a similar change in retail price. Arshad and Hameed (2014) examined the cointegration and causality of the relationship between the farm and retail prices in the fruit market. Their findings suggest a long-run bidirectional causal relationship between farm and retail prices for banana and water melon. However, the analysis revealed a long- unidirectional relationship from farm prices to retail price with no evidence of reverse causality running from farm price to retail prices for jackfruit and durian. Muazu et al. (2014) analysed the transmission of prices between farm-wholesale-retail market levels of broiler meat. The results of their study show symmetric price transmission from farm to retail, but significant asymmetry in price behaviour from retail to farm. However, to the best of our knowledge, no study has thus far looked into price transmission in the dairy supply chain in Malaysia or in other Southeast Asian countries. Performing such an analysis would provide valuable information on the direction of price adjustments, which would be useful for different stakeholders in the Malaysian dairy sector, including the Department of Veterinary Services (DVS), the state-owned enterprise Dairy Industry Service Centre (PPIT) and any private agencies. Therefore, the objective of this chapter is to examine the price transmission in the Malaysian fresh milk markets between farmers, PPITs and retailers and detect potential asymmetries in price transmission.

5.2 The Malaysian milk sector

The Malaysian dairy sector is small compared to other sectors of livestock products such as poultry and pork. The dairy sector produces only 5% of all milk consumed in Malaysia. In 2017, there were approximately 852 farms and 21,000 dairy cows in Malaysia. Milk production was approximately 36.5 million litre per year (Hussin, 2017). According to the DVS, small-scale dairy farmers with 10 to 29 of heifers constituted nearly 90% of all dairy farmers in 2013.

In Malaysia, the fresh milk supply chain comprises five different actors, i.e. producers, agents/traders/PPITs, milk processors, wholesalers and retailers. The Malaysian supply chain of fresh milk is illustrated in Figure 5.1. The milk marketing channels are divided into formal and informal marketing channels. Informal or traditional marketing channels deal with agents or traders, or directly with end consumers, without any formal contract. In the formal milk marketing channels, PPITs and processors are the main actors and they work with formalised contracts which specify pre-determined prices. The farmers bear the cost of transporting milk if they decide to sell in the formal market. Farmers are free to sell their milk through the informal or formal channel or a combination of both. Milk marketing in Malaysia is basically dominated by the PPIT as it has a market share of almost 30%.

PPIT is a government-run organization supervised by DVS Malaysia. There are 34 PPITs in Malaysia. Their main purpose is to provide a marketing channel to the dairy farmers. They also operate as consultants and give various incentives to farmers. On average, the PPIT receives 6.54 million litre of milk to be marketed every year. At the PPIT, the raw milk is inspected in order to determine quality and price. Milk is classified in three groups: AA, A and –A, depending on the quality.

The PPIT sends out the milk to processing firms. The selling price is determined by PPIT with agreement from the processing firm. The selling price includes the cost of transportation and other costs during the handling process. Some PPITs provide machinery services to vendors, such as the use of a homogenizer and pasteurizer. Hence the service charge will also be included in the milk price.

The main milk processor in Malaysia is Dutch Lady Malaysia, holding 40% of the national market share in 2011 (Bernama, 2011). At the processing firm, the raw milk is transformed into fresh milk. After packaging and labelling, the fresh milk is distributed by wholesalers to retail stores in Malaysia.

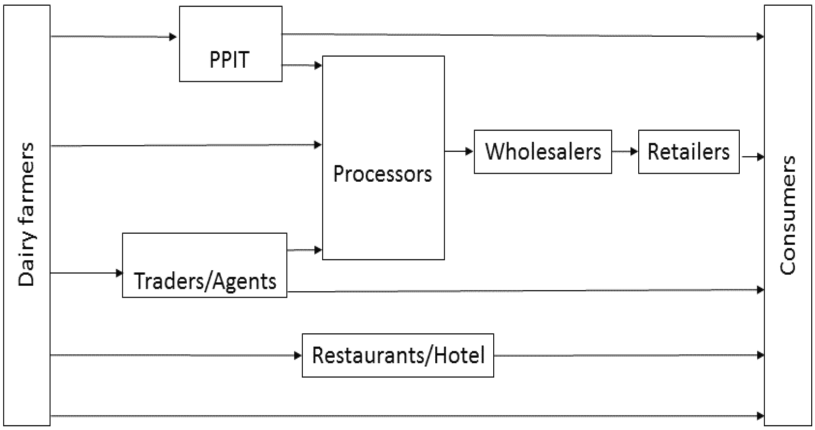

Figure 5.1 Supply chain of fresh milk in Malaysia

5.3 Materials and methods

The supply chain for milk in Malaysia consists of few actors, i.e. farmers, PPITs, processors, wholesalers and retailers. The linking markets can be described as follows: (i) farmers sell raw milk to the PPITs, (ii) PPITs sell it to processing firms, (iii) at the processing firm, milk is packed and labelled and then distributed to wholesalers, (iv) from the wholesaler the milk is then distributed to retailers and finally (v) retailers sell it to end consumers. However, in this study we only have price information of the markets between the farmers, PPIT and retailers stages.

5.3.1 Data collection and description

We used monthly nominal prices of milk at the farm, PPIT and retail stages for the period from January 2013 to December 2016. All prices were measured in Ringgit Malaysia (MYR) per litre. The farm price was obtained from the Department of Veterinary Service Malaysia. The price at PPIT level was obtained directly from PPIT and the price at retail level was obtained from the Ministry of Domestic Trade, Cooperatives and Consumerism Malaysia. Table 5.1 presents the descriptive statistics of these prices. It is apparent that the PPIT price was

10% higher than the farm price. This can be explained as some of the PPIT provide services to small processors/vendors and the difference between farm price and PPIT price represents a charge for these services. The retail prices are approximately twice as high as the PPIT price, which is plausible since there are processors and wholesalers between the PPIT and retail stages. Figure 5.2 shows the monthly average of farm, PPIT and retail prices. The prices of all markets for fresh milk in Malaysia show an increasing trend from January 2013 up to the last included date. In general, a change in the farm price of milk is accompanied by to a similar change in the PPIT price. Farm prices are set by the government through DVS, based on a gross margin analysis of farmers. This explains why the farm price stays at the same level for a few months and sometimes throughout the year. PPIT prices are more likely to follow the farm prices with some differences observed because of services provided.

Table 5.1 Descriptive statistics of farm and PPIT price for milk from January 2005 – December 2015

	Farm price	PPIT price	Retail price
Mean	2.50	3.01	6.47
Standard deviation	0.13	0.25	0.44
Min	2.30	2.70	5.76
Max	2.65	3.30	7.06

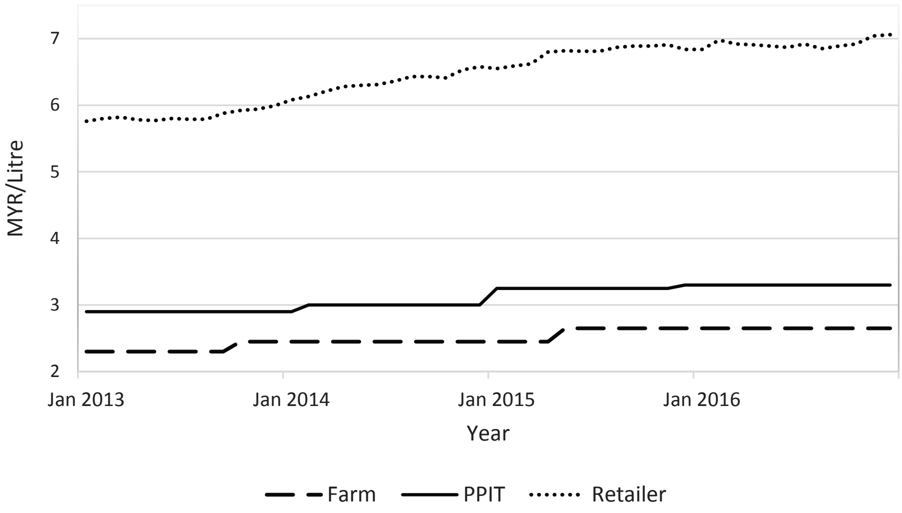

Figure 5.2 Nominal farm, PPIT and retail prices in Ringgit Malaysia from Jan 2013–Dec 2016

5.3.2 Asymmetric price transmission

This study adopts the following model to express the relationship between farm, PPIT and retail prices for fresh milk:

$$RP_t = \alpha'_0 + \alpha'_1 PP_t + \alpha'_2 FP_t + v'_t \qquad (1)$$

where, α'_0 is a constant term, RP, PP and FP are the retail, PPIT and farm prices, respectively, for fresh milk at time t and v'_t is the error term.

The following table (Table 5.2) shows the steps that should be implemented to identify the appropriate econometric model to analyse price transmission. Depending on the price series properties, various econometric models will be estimated.

Table 5.2 Algorithm for the price transmission analysis

Step	Test	Result	Action
1	Stationarity test of time series for unit root	Stationarity	Perform test for Granger Causality and estimate vector autoregression (VAR) model with stationary data
		Non-stationarity	Move to step 2
2	Cointegration test	Exists	Estimate the Vector Error Correction model (VECM) and measure asymmetry
		No	Perform test for Granger Causality and estimate VAR model using prices in first differences

Source: (Kharin, 2015)

Testing for stationarity

The first step of the price transmission analysis is to examine the stationarity of the time series data to avoid a spurious regression (Asteriou and Hall 2007) and to test whether each series is integrated with the same order. Stationarity represents a process in which the mean and standard deviation do not change over time. If there is stationarity in the data, then equation 1 can be estimated with ordinary least square. In the presence of non-stationary data, however, a transformation (such as differencing) is required to make them stationary. In this study, the Augmented Dickey-Fuller (Dickey and Fuller, 1981) test is used to evaluate the time-series properties of the data as it can deal with serial correlation. This can be written with differentiated terms as:

$$\Delta y_t = \alpha_0 + \delta y_{t-1} + \sum_{j=1}^{p} \alpha_j \, \Delta y_{t-1} + \alpha_p y_{t-p} + \epsilon_t \tag{2}$$

The null hypothesis for this test is that the price series is non-stationary. For the Augmented Dickey-Fuller test, the lag length was selected using the Akaike information criterion (AIC). If a time series is stationary at level, then it is said to be integrated of order zero. If it requires first order differencing to be stationary, then it is said to be integrated of order one.

Testing for cointegration

Next, we used the Johansen (1991) approach to test for cointegration of pairwise/ prices. Cointegration implies a causal long-term relationship between pairwise prices, i.e. farm-PPIT and PPIT-retailer. To test for cointegration, we have to test whether the price series have the same order of integration using unit-root tests. To do so, we used the Trace and the Maximum Eigenvalue test statistics. If both price series have the same order of integration, we proceed to test for cointegration among the variables. The criterion of selecting lag length for cointegration tests was based on the AIC, the Schwarz Bayesian Information Criterion (SBIC), the Hannan-Quin criterion, the likelihood ratio and final predictor error points at the same lag length.

Testing for price asymmetry

After testing for cointegration, we check for asymmetric price transmission and quantify the price adjustment. Asymmetry of price transmission exists if the response to an increase in the price at any level of the value chain differs from the response to a price decrease. We used a vector error correction model (VECM) for the cointegrated prices and a vector autoregression (VAR) model for non-cointegrated prices.

i. The vector error correction model (VECM)

Following (Cramon-Taubadel, 1998), our asymmetric VECM for cointegrated pairwise prices was specified as:

$$\Delta P_{1,t} = \gamma_0 + \sum_{i=1}^{n} \gamma_{1,,i} \Delta P_{1,t-i} + \sum_{i=0}^{n} \gamma_{2,i}^{+} \Delta P_{2,t-i}^{+} + \sum_{i=0}^{n} \gamma_{2,i}^{-} \Delta P_{2,t-i}^{-} + \gamma_3^{+} ECT_{t-1}^{+} + \gamma_3^{-} ECT_{t-1}^{-} + \varepsilon_t \quad (3)$$

where Δ is the first difference operator and n is the lag length. The cointegration relation is given as $P_{1,t} = \gamma_0 + \gamma_1 P_{2,t} + \varepsilon_t$. The error correction term ECT_{t-1} is the first lagged residual of the long-term relationship of pairwise prices: $ECT_{t-1} = \varepsilon_{t-1} = P_{1,t} - \gamma_0 - \gamma_1 P_{2,t}$. To capture the short- and long-term asymmetry in price transmission, ΔP_2 and ECT are split into their positive (+) and negative (−) components respectively. The parameters $\gamma_{1,i}$,$\gamma_{2,i}$ represent the speed of adjustment, showing how quickly $P_{1,t}$ is corrected in the short run in response to the change in lagged $P_{1,t}$,$P_{2,t}$. Similarly, the parameter γ_3 represents the speed of adjustment of the price $P_{1,t}$ towards the long-term equilibrium price.

The following rules were applied in calculating the negative and positive components of the split independent variables of $\Delta P_{2,t}$ and ECT_t:

$ECT_t^+ = \begin{cases} ECT_t \; if \; ECT_t > 0 \\ 0 \quad otherwise \end{cases}$ and $ECT_t^- = \begin{cases} ECT_t \; if \; ECT_t < 0 \\ 0 \quad otherwise \end{cases}$

$\Delta P_{2t}^+ = \begin{cases} \Delta P_{2t} \; if \; \Delta P_{2t} > 0 \\ 0 \quad otherwise \end{cases}$ and $\Delta P_{2t}^- = \begin{cases} \Delta P_{2t} \; if \; \Delta P_{2t} < 0 \\ 0 \quad otherwise \end{cases}$

When price transmission is asymmetric in the short-term (monthly) and long-term (yearly) equilibrium, the F-test should reject the following hypothesis:

$H_{0,SR}: \sum_{i=0}^{n} \gamma_{2,i}^+ = \sum_{i=0}^{n} \gamma_{2,i}^-$ and $H_{0,LR}: \gamma_4^+ = \gamma_4^-$

Next, we followed Boswijk and Urbain (1997) to test whether $P_{1,t}$ is driven by $P_{2,t}$ with respect to the short-term parameters in Equation 2. The margin model for P_2 takes the form (Cramon-Taubadel, 1998):

$$\Delta P_{2,t} = \mu_0 + \sum_{i=1}^{n} \mu_1 \Delta P_{1,t-i} + \sum_{i=1}^{n} \mu_2 \, \Delta P_{2,t-i} + \varepsilon_t \qquad (4)$$

ii. Vector autoregression (VAR) model

If our tests reveal non-cointegration, we can specify and estimate a VAR model. The reduced form (unrestricted) VAR model can be expressed as:

$$RP_t = \alpha_0 + \alpha_1 RP_{t-1} + \cdots + \alpha_k RP_{t-k} + \Upsilon_1 PP_{t-1} + \cdots + \Upsilon_k PP_{t-k} + cFP_{t-1} + \cdots + c_k FP_{t-k} + \varepsilon_t \qquad (5)$$

We then apply the Granger causality test to evaluate the possible direction of the price transmission.

5.4 Results and Discussion

5.4.1 Stationarity

Table 5.3 shows the results of the ADF unit root test for the price series in levels and first differences. The null hypothesis is that the price is not stationary, or in other words, there is a unit root in the price series. Our result shows that the test statistics for farm, PPIT and retail prices are smaller than the 5% critical value, thus we cannot reject the null hypothesis. This shows that the price series in all levels are non-stationary with the presence of a unit root. However, the null hypothesis is rejected at the 5% level of significance for all of them in their first differences. This implies that stationarity is achieved after first differencing. This also indicates that all variables are integrated to the order of one. The number of lags used in this test (i.e. two lags) was obtained from the minimum value of the AIC and SBIC.

Table 5.3 Stationarity test

	Non-differenced	Lag	First differenced	Lag
Farm price	−1.314	2	−4.028**	2
PPIT price	−0.863	2	−4.171**	2
Retail price	−0.985	2	−3.817**	2

Notes: The ADF test includes an intercept, ** denotes significance at the 5% level.

5.4.2 Cointegration

Using Johansen's maximum likelihood approach, we tested the relationship between farm, PPIT and retail prices. The trace and Max-eigenvalue statistics for testing the rank of cointegration are shown in Table 5.4. The results indicate there is no cointegrating relation between farm and PPIT prices, or between PPIT and retail prices, indicating that these prices do not move together in the long run. Hence, we cannot proceed with a VECM analysis, and proceed with the VAR model instead.

Table 5.4 Cointegration test

Maximum rank	Trace statistics	5% critical value	Max statistic	5% critical value
0	24.88	29.68	17.32	20.97
1	7.56	15.41	6.68	14.07
2	0.88	3.76	0.88	3.76

5.4.3 Asymmetry and causality

Since we confirmed there is no long-term relationship, we proceed our analysis using the VAR model to check the asymmetry of prices in the short run. Table 5.5 presents the empirical results of the VAR model. The results show that the retail price at lag 1 is significant in explaining the farm price and that at lag 2 it is significant in explaining the PPIT price. This indicates that a change in retail price would lead to a change in farm price after one month, whereas it would take two months for the PPIT price to change. However, changes in farm or PPIT prices do not influence the retail price. This suggests that the retailers have some degree of market power, as they can influence both farm and PPIT prices, while farms and PPITs use retail price information to set their own price, indicating asymmetric price transmission in the Malaysian dairy supply chain in the short run. Furthermore, the farm price at lag 1 is significant in explaining the PPIT price. This indicates that a change in farm price would take one month for the PPIT price to follow. This result can be attributed to the governmental policy of fixing the farm price at a predetermined level, while PPITs, as state-owned enterprises, will basically follow this price.

This result is consistent with a study by Muazu et al. (2014), who found symmetric price transmission from farm to retail, but asymmetric price transmission from retail to farm, in the broiler industry in Malaysia. However, it is inconsistent with the findings by Yeong-Sheng (2009), showing that a change in the farm price of pork in Malaysia causes a similar change in the retail price. In other words, the price transmission in the Malaysian pork industry is symmetric. The broiler and pork sectors are different from the dairy sector since both types of meat can be kept for a longer time, while milk is a highly perishable product. The broiler and pork sectors are also more integrated and have less government intervention.

For the global milk market, this result is in line with the findings of Serra and Goodwin (2003), who found limited asymmetries for sterilized milk in the Spanish dairy industry. The authors suggest menu costs, inventory management, search costs and public market intervention as key attributes to this asymmetric price transmission. It is also in line with the findings from Kinnucan and Forker (1987) and Acosta and Valdés (2014), who confirmed the presence of asymmetric price transmission in the US dairy sector. The result is also consistent with Rezitis and Reziti (2011) who found the existence of a nonlinear adjustment between consumer and producer prices in the Greek milk sector, which suggests that there is possibly unequal market power by the milk processing and retail sectors.

Table 5.5 Results of vector autoregression model

Variables	Coefficient	Standard error	*t*-statistic
Farm			
Farm lag 1	−0.049	0.149	−0.33
Farm lag 2	−0.007	0.131	−0.06
PPIT lag 1	−0.018	0.088	−0.21
PPIT lag 2	−0.100	0.089	−1.12
Retail lag 1	0.342**	0.093	3.68
Retail lag 2	−0.011	0.108	−0.10
PPIT			
Farm lag 1	−0.441*	0.230	−1.91
Farm lag 2	−0.116	0.202	−0.57
PPIT lag 1	−0.092	0.136	−0.68
PPIT lag 2	−0.056	0.137	−0.41
Retail lag 1	0.015	0.143	0.11
Retail lag 2	0.511**	0.166	3.07
Retail			
Farm lag 1	−0.047	0.239	−0.20
Farm lag 2	−0.027	0.209	−0.13
PPIT lag 1	0.174	0.141	1.24
PPIT lag 2	−0.074	0.142	−0.52
Retail lag 1	0.007	0.148	0.04
Retail lag 2	−0.134	0.172	−0.78
R-square			
Farm		0.241	
PPIT		0.186	
Retail		0.060	

Notes: ** denotes significance at the 5% level, * at the 10% level.

Table 5.6 presents the results of the Granger causality tests, which were performed after VAR model results were obtained. This test determines the possible direction of the price transmission. Directional causality implies that each market uses information from the other markets when forming its own price expectations, while unidirectional causality indicates leader-follower relationships in terms of price adjustment. The appropriate lag length was selected based on the likelihood ratio, the Hannan-Quin criterion and the SBIC test. The results show there is unidirectional causality in the short run in the dairy supply chain. A change in the retail price is transmitted to the farm and PPIT price in the short run. However, a change in farm or PPIT prices is not transmitted back to retail level. Therefore, we can conclude that the price transmission from farm to retail level is upwardly asymmetric in the short run. This suggests that farmers and PPITs do adjust to changes in retail prices, while the retail price does not adjust to changes in farm and PPIT prices. In other words, the farm and PPIT use information from retail to develop their own price setting. This might be because of the presence of imperfect competition where one of the actors in the supply chain has the possibility to exhibit strategic behaviour in setting their price, therefore preventing price changes to be fully transmitted. It also might be due to transaction costs from changes in costs in processing, distributing and retailing that may lead to a situation where suppliers are more reluctant to reduce prices than raise them (Ball and Mankiw, 1992).

Table 5.6 Results of the Granger causality tests

Dependent variables	Independent variable		
	Farm	PPIT	Retail
Farm	-	1.277	13.574**
PPIT	3.864	-	9.418**
Retail	0.053	1.868	-

Notes: **denotes significance at the 5% level.

5.5 Conclusion

This study investigates the market linkages between milk prices at farms, state-owned intermediate PPITs and retailers in Malaysia in the period January 2013 through December 2016. Specifically, we have investigated potential asymmetries in price transmission from the retail stage to dairy farms and vice versa.

From our findings, all three price series were stationary at first difference. The Johansen cointegration test provided evidence that a long-term cointegration relationship does not exist between farm and PPIT prices or between PPIT and retail prices. Since we find no evidence for a long-term cointegration relationship, a VAR model is used. The results do suggest a relationship between farm, PPIT and retail prices. The results show that in the short run, farm and PPIT prices adjust to a change in the retail price. Furthermore, the PPIT price also adjusts to a change in farm prices. However, changes in farm or PPIT price do not affect the retail price. The outcomes of the Granger causality test validate the evidence of price causality from retail to PPIT prices (and not vice versa) and from retail to farm prices (and not vice versa).

The findings of this chapter have implications for policy makers. Our results suggest retailers have some degree of market power, since changes in the retail price do affect farm and PPIT prices. Therefore, policy makers could design policies that reduce the market power of retailers, for example by encouraging more retailers to enter the Malaysian market or by designing anti-trust regulations that limit the market share of retailers. Since farms and PPITs are price followers, further research could investigate formally whether there are any actors in the supply chain that possess market power. The results in this study could have been more conclusive if we could have included the processor and wholesaler stages in the analysis. Furthermore, the results of this study could be enriched through longer time series data that contain both upward and downward trends in prices, as the current series only shows the former. This study highlights that the direction of price transmission tends to go from farmers to retailers and a change in farmer's price does not affect the retailer's price. More research in the dairy sector in other Asian countries is needed to clarify whether this pattern also prevails there.

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CHAPTER 6

General discussion

6.1 Introduction

The dairy industry in Malaysia consists of 86% small scale farmers who own between 10 and 29 heifers. Local dairy farming contributes around 5% to the Malaysian milk self-sufficiency level. The Malaysian government aims to increase this level of self-sufficiency to 10% by 2020. Accordingly, various efforts have been done in order to increase the milk production. Recently, the dairy sector was selected by the Malaysian government as an Entry Point Project (EPP) under the National Key Economics Area program. This EPP aims to reduce Malaysia's dependence on imported fresh milk by boosting the local milk production.

The overall objective of this thesis was to analyse the sources of inefficiency in the Malaysian dairy supply chain. The overall objective was split into four sub-objectives. Chapter 2 measured input-specific technical inefficiency for dairy farmers in Malaysia as well as the factors that determined these inefficiencies. Chapter 3 examined the marketing channel choice of dairy farmers using a transaction cost approach, Chapter 4 measured the technical, allocative and scale efficiency of the Dairy Industry Service Centre (PPIT) and investigated the relation between these efficiencies with firm's characteristics and socio-economics of PPIT managers. Chapter 5 analysed the price transmission in the fresh milk supply chain. This chapter proceeds by first, synthesizing the main findings of the four research chapters. Second, this chapter discusses methodological and data issues. Finally, this chapter presents the implications of the thesis to business and policy makers, makes suggestions for future research and provides the main conclusions of this thesis.

6.2 Synthesis of results

The main contribution of this thesis is that it analysed the sources of inefficiency along the Malaysian dairy supply chain. This thesis did not focus on the efficiency of one single actor, but of several actors along the entire supply chain. Findings are useful for policy makers, related agencies and farmers to identify the sources of inefficiency at various levels and by suggesting potential improvements of these efficiency levels of the dairy sector.

In this thesis, the analyses of technical inefficiency (Chapter 2) and marketing channel selection (Chapter 3) focused on the farm stage where farmers are the decision makers. On the other hand, the analysis of technical, allocative and scale efficiency (Chapter 4) focused on the main milk marketer in milk distribution in Malaysia which is the PPIT. The analysis of price transmission covered three stages in the Malaysia dairy supply chain; farmers, PPIT and retailers (Chapter 5). Figure 6.1 shows the structure of the thesis based around the Malaysian dairy supply chain.

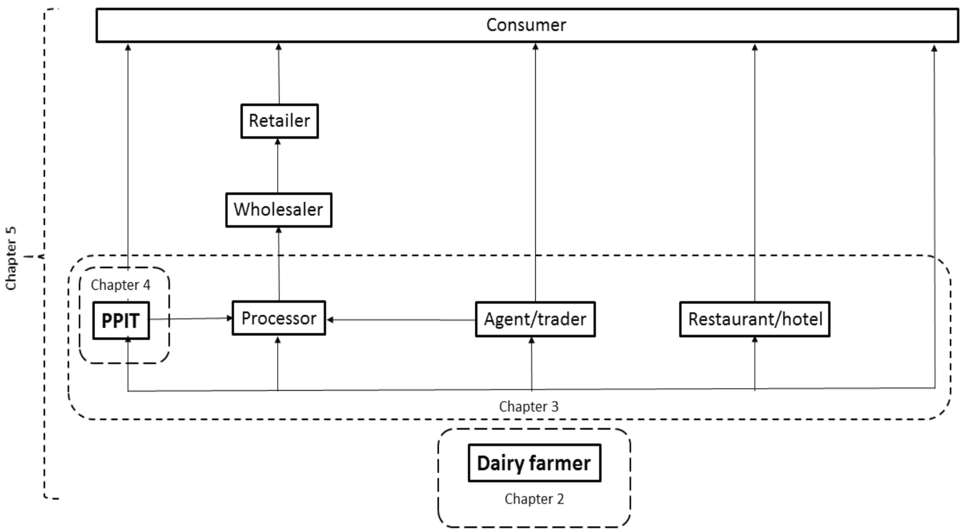

Figure 6.1 Structure of the thesis

Chapter 2 analysed the input-specific managerial and program inefficiency between two production systems (intensive and semi-intensive) of Malaysian dairy farms. The study concluded that technical inefficiency is mainly associated with overuse of inputs such as land, labour and feed. For example, in both the intensive and semi-intensive system, land is overused around 59% and 62% respectively. The inefficiency in the use of land may be explained by the routines of farmers, as farmers who have land may be hesitant to use it for other activities. In practice, farmers purchase feed or obtain it from abandoned land. Farmers could be more efficient if they could reallocate inefficiently used land for other productive activities without decreasing milk production. This result is in line with the findings of Lass and Gempesaw (1992), who shows that Massachusetts dairy farms are relatively inefficient because they used too much land. Furthermore, Chapter 2 and Chapter 4 find similar outcomes for technical efficiency. In Chapter 4, the score of technical efficiency of PPITs suggests that PPITs also overused inputs. PPITs can, on average, reduce their input use by 21% and still produce the same level of output. In addition, Chapter 4 finds that the allocative efficiency scores are lower than the technical efficiency scores suggesting that PPITs are less good at choosing the proper input mix given the prices they face. The absence of competitive pressure might be the source of why the PPIT are not efficient in terms of choosing an optimal mix of input at given prices. This is plausible since PPIT do not only produce milk, but also provide services and other support functions and each PPIT is not conducting the same set of activities and with the same intensity.

High transaction costs can hinder farmers to participate in the market efficiently and to switch between marketing channels when needed. In general, Malaysian dairy farmers have three marketing channels to sell their milk which are trough PPIT, direct selling and intermediaries. Farmers are free to choose amongst these marketing channels, however, choosing a right marketing channel is crucial for farmers because different marketing channels are associated with different levels of costs and revenues (Soe et al., 2015). Information, negotiation and monitoring costs imply that there are inefficiencies in the market which implies that farmers cannot choose to switch to another marketing channel without significant additional costs. In an efficient market, there is no cost for farmers to switch between marketing channels. For example, in Chapter 3, farmers expect to receive the price they want without a heavy negotiation in the PPIT and intermediaries marketing channels; therefore they are more likely to choose PPIT and intermediaries as their marketing channels. Negotiation costs can cause high transaction costs and thus, lower the efficiency of operation. Moreover, with regard to trust in buyers, farmers are less likely to choose direct selling. This can be explained as PPITs and the intermediaries marketing channel offer a formal contract to the farmers. Therefore, farmers know they will receive the pre-determined price. Without formal contract, farmers risk a situation where the buyer will break the informal contract, involving more transaction cost and leading to inefficiency in the market. The opportunity costs and risks associated with selling is relatively low if farmers use contracts because contracts stabilize many aspects of the sale (McLeay and Zwart, 1998). Moreover, results show that farmers are less likely to choose direct selling if they expect any delay of payment. Delay in payment can cause high transaction costs, rendering operations less efficient. This finding is in line with the results of Boger (2001) on Polish hog market that suggests that producers in general enjoy immediate cash payment.

Results of Chapters 2, 3 and 4 provided evidence that socio-economic variables, including farmer or PPIT manager demographics such as experience and age and farm/firm characteristics such as type of farming system and location can affect the technical inefficiency of farms and PPITs and also the marketing channels selection by dairy farmers. In Chapter 2, age of farmers in the intensive system had a positive relation with technical inefficiency of labour. This result suggested that older farmers are *ceteris paribus* less efficient than younger farmers. They are likely to be more conservative and less willing to adopt new practices (Coelli and Battese, 1996). This result is similar to the findings of Singbo and Oude Lansink (2010) and Idiong (2007). However, findings from other studies suggested that older farmers may be able to exploit their experience and knowledge to use inputs more efficiently (Lapar et al., 2005; Otieno et al., 2012). In addition, Chapter 3 suggested that older farmers are less likely choosing PPIT as their milk buyer. In Chapter 2, the results showed that experience has a negative relation with the technical inefficiency for variable other expenditures. As expected, experience helps farmers to better estimate the cost of other expenditures. This result is similar with the findings of Bozoğlu and Ceyhan (2007), who found that the number of years in vegetable farming led to a higher technical efficiency. More experienced farmers are more likely choosing PPIT, possibly since they are more comfortable to have a transaction with PPIT. Gabre-Madhin (2001) and Bellemare and Barrett (2006) have shown that successful repeated contracts, gained through long-term marketing relationships, enhances trust, an important element in market exchange.

Finance from government is positively associates with technical inefficiency for feed (Chapter 2); furthermore, results from Chapter 3 suggest that finance from government is negatively associates with the likelihood of choosing intermediaries marketing channel. This might happen when farmers use finance from government not specifically for purchasing feed, but also for non-productive activities. Other studies also found that the motivation of farmers to work efficiently is lower when they depend to a higher degree on subsidies (Zhu and Oude Lansink, 2010). The results from Chapter 3 show that farmers with finance from government are more likely to be loyal to their buyer which is PPIT. Therefore, finance from government is associated with higher technical inefficiency and it also serves a barrier for farmers to switch to the intermediaries marketing channel. The number of portable milking machines is negatively associates with technical inefficiency for land and other expenditure (Chapter 2). Indeed, having more portable milking machines can reduce technical inefficiency as it speeds up milking greatly compared to traditional manual methods. This result is similar to a study by Castro et al. (2012) who find that use of an automatic milk machine can increase milk production. Results in Chapter 3, suggest that farmers are likely to choose direct selling and intermediaries marketing channels if these marketing channels could provide farm services such as a portable milking machine at low cost. Farm services that are provided by direct selling and intermediaries can lower the transaction cost as well as marketing distribution inefficiency.

Asymmetric price transmission occurs when price decreases are transmitted along the supply chain with a different speed and/or magnitude as price increases (Bakucs et al., 2013). The presence of imperfect competition where one of the actors exhibit strategic behaviour in price setting might be the reason of asymmetric price transmission in the Malaysian dairy supply chain. If price signals do not reach the supply chain actors uniformly, this situation may result in market inefficiency and suboptimal resource allocation. The results in Chapter 5 show that price changes at the retail stage tend to transmit to PPIT and farms in the short run. However, price changes at the farm and PPIT stage do not affect retail price. Conversely, price changes at the farm stage do impact the PPIT price in the short run. The literature has shown similar results regarding the existing of asymmetric price transmission for dairy product (Bor et al., 2014; Capps Jr and Sherwell, 2005; Lass, 2005; Serra and Goodwin, 2003).

6.3 Methodological and data issues

A variety of methods and data sources were used to achieve the specific objectives of this thesis. This section provides a brief discussion on the potential shortcomings of the methodologies and data used in the four research chapters.

This thesis used quantitative methods throughout Chapters 2-5. Methods used include mathematical programming (Chapter 2 and 4) and econometric models (Chapter 2, 3, 4 and 5). Data were collected from various sources. Primary data were collected from 200 farmers for Chapter 2 and 3 using a structured questionnaire administered face to face; for Chapter 4, data were collected from managers of PPIT using a second structured questionnaire conducted via e-mail and follow-up phone calls. In Chapter 5, secondary time series data were used obtained through the Department of Veterinary Services and Ministry of Domestic Trade, Cooperatives and Consumerism Malaysia.

Chapter 2 and 3 used data from a structured questionnaire with farmers. A trained interviewer assisted each farmer in filling out the questionnaire in order to avoid potential misinterpretations of survey questions. The reliability of data elicited directly from farmers hinges on the absence of recall bias—bias stemming from participants not remembering previous events or omitting crucial details. In order to reduce the potential impact or recall bias, missing or implausible (i.e. too low) milk sales were replaced by the amount of milk sales provided by the farmers to the Department of Veterinary Service (for Chapter 2). Given budgetary and practical constraints, this was the best option. For Chapters 2, 3 and 4, cross-sectional data was used as the available time and resources did not allow for collecting panel data. For Chapter 3, we did not elicit farmers' perception regarding the marketing channels that they did not deliver to. The resulting missing values were imputed by predictions from bivariate probit models. Omitting these observations would have drastically reduced our sample size for estimation.

Chapter 4 used data from a structured questionnaire. A survey was conducted among the managers of PPIT. The questionnaire was sent out to all the PPIT in Malaysia through e-mail and combined with a follow-up phone call in order to maximise participation. The PPIT manager could decide to have the interview either by phone of to fill in the document file by themselves. PPIT could not provide the latest value of buildings (for their operation); computation of this value based on the original purchase value could not be done since most of the buildings were built more than 20 years ago. Hence, buildings could not be incorporated as an input in the DEA models. Analysis of Chapter 5 required time-series data. It proved to be impossible to get price data at all stages of the dairy supply chain. For instance, big processors in Malaysia such as Dutch Lady Milk Industries Berhad were reluctant to share their price information. Therefore, wholesale and processors price were not obtained. Another challenge for the price transmission analysis was the limited period on which data were available at the retail stage. Thus, monthly prices of dairy milk were only available from January 2013 onwards.

In Chapter 2, the input-specific technical efficiency was measured using multi-directional efficiency analysis (MEA). MEA was introduced by Peter Bogetoft and Jens Leth Hougaard (1999), who provided an axiomatic foundation for certain types of benchmark selection used in DEA. MEA is a combination of Peter Bogetoft and Jens Leth Hougaard (1999) benchmark selection with the mathematical program of DEA. The advantage of using MEA instead of the well-known Data Envelopment Analysis (DEA) is that MEA selects benchmarks such that the input reductions are proportional to the potential reduction in each input separately (Asmild and Matthews, 2012). From the finding of Chapter 2, we can confirm that this approach was useful as an in-depth technique to estimate input-specific (in)efficiency. In addition, the bootstrap truncated regression model was used to investigate the impacts of farmers' socio economics and farm characteristics on input-specific technical inefficiency scores. The literature employed a wide range of methods to introduce external variables into the efficiency analysis, such as Tobit and Truncated regression. Simar and Wilson (2007) noted that the traditionally used approaches are invalid due to serial correlation of non-parametrically derived inefficiency estimates and proposed the single and double bootstrap truncated regression method.

In Chapter 3, a multivariate probit regression model was used to determine factors affecting marketing channel selection. This model accounts for situations in which farmers simultaneously use more than one marketing channel for selling milk. Indeed, the main advantage of the multivariate probit model is that it does not require a prior assumption regarding selection patterns. This is helpful because farmers could simultaneously pursue more than one marketing channel (Baskaran et al., 2013). The likelihood ratio test of the null hypothesis of independency among the marketing channel choice was rejected (at the critical

5% level) indicating that there is dependency among the marketing channel choice. This suggests that the multivariate probit model rather than a series of univariate models was an appropriate tool for assessing factors influencing the marketing channel selection by dairy farmers. The shortcoming of the multivariate probit model is that it does not provide insight into factors determining how much farmers sell through each channel.

In Chapters 2 and 4, technical, allocative (only in Chapter 4) and scale (only in Chapter 4) efficiency were measured using cross-section data and Data Envelopment Analysis (DEA). Literature suggests two categories of approaches to measure efficiency, i.e. a parametric approach (Stochastic Frontier Approach (SFA)) and a non-parametric approach (DEA), although recent years also saw an upsurge of new semi-parametric approaches (e.g. (Horrace and Parmeter, 2011). SFA is a parametric technique that uses econometric estimation of a predefined specification of the production frontier. DEA involves the use of linear programming methods to construct a piece-wise linear envelopment frontier over the data point such that all observed points lie on or below the production frontier. Furthermore, the frontier nature of the production function allows any productive inefficiency to be captured (Singbo and Oude Lansink, 2010). Studies by Wadud and White (2000) and Latruffe et al. (2004) find that the results obtained using the two approaches are quite similar.

In Chapter 5, the aim was to investigate whether price increases at retail stage are fully transmitted to the farm stage. The vector autoregression (VAR) model was employed to analyse the price transmission between farm, PPIT and retail stage in the dairy supply chain using monthly prices of fresh milk. The Johansen test results showed that there is no cointegration between retail, PPIT and farm prices in the long-run; therefore the vector autoregressive error correction model (VECM) could not be used. In order to determine the direction of the price transmission in the short-run, a Granger causality test was applied.

6.4 Implications for business, policy and future research

Business implications

At the farm stage, the results from Chapter 2 suggest that Malaysian dairy farmers can improve their input management skills by following the best practise of farms on the production frontier. In addition, farmers could be encouraged to attend training or courses on specific skills relevant for dairy production such as bookkeeping management using current technology. This holds in particularly for dairy farmers who did not have the chance to go to school, as the results from Chapter 3 indicate that they can improve their ability to understand and fulfil the requirements set by different marketing channels.

Direct selling and intermediaries marketing channel could offer farm services to farmers in order to encourage them to sell their milk to these channels. These marketing channels could facilitate farmers to buy portable milking machine, e.g. through financing facilities, as results in Chapter 2 suggest having more portable milking machines can reduce inefficiency of land and other expenditure for both systems.

Findings from Chapter 4 indicate that a higher market share is associated with a higher level of technical efficiency of PPIT. Market share can be increased by mergers with other PPIT; however merging is not possible due to the regional organisation of PPIT. Thus, PPIT should consider to collaborate more effectively among them for example by sharing the production resources and doing marketing activities together. In addition, it is possible to reallocate their input mix efficiently without any resort to new technology, therefore access to current technology and price information is needed.

Policy implications

The findings in Chapter 2 suggest that policy makers could introduce a specific policy aimed at switching dairy farmers from the semi-intensive to the intensive system. This policy could be based on the findings of Chapter 2 which shows farmers in the intensive system have a higher potential of production than those in the semi-intensive system. Policy makers could also improve the semi-intensive system through the research and development on production that is tailored to the semi-intensive setting. Findings in Chapter 2 and 3 suggest that finance from government is associated with lower technical efficiency and suggests it poses a barrier for farmers to choose intermediaries marketing channel. Furthermore, the government should formulate a policy to enhance the adoption of portable milking machines as it also can reduce the inefficiency as indicated in Chapter 2.

Government agencies or extension services could create awareness among farmers of the benefits of having a contract to reduce the delay in payment and create trust among buyers and sellers, thereby lowering transaction costs. Moreover, findings in Chapter 3 suggest that policy makers could consider establishing dairy cooperatives in Malaysia as some studies (Abdulai and Birachi, 2009; Staal et al., 1997) suggest that collective action can reduce the bureaucratic hurdles and may provide farmers better access to information about regulations. Various farm support programs may be established to foster specialisation in dairy farming as they become more specialised, their bargaining power will increase (Gong et al., 2006).

With regard to age, findings from Chapter 2 show that older farmers are more inefficient in managing labour, while findings from Chapter 4 show that older PPIT's managers are more efficient in allocating the resources given the input prices. These results suggest that policy makers should motivate the young generation to be involved in dairy business by offering them low interest loan as to reduce the high start-up costs. At the same time, extension services could also guide them at the initial establishment of their business. Older PPIT managers who are more efficient could share their experience through courses to young managers.

With regard to the location of PPIT, findings in Chapter 4 suggest that PPIT's located near to city centres are *ceteris paribus* more efficient. As it is often impractical of near impossible to relocate the PPIT, however, good roads that improve access could also help in improving their performance. Therefore, the results of this thesis suggest policy makers to provide better road infrastructure.

Implications for future research

Further research can be performed to complement and extend the conclusions drawn from this thesis. The findings of this thesis emphasize the sources of inefficiency in the Malaysian dairy supply chain. Future work could focus on measuring technical and allocative inefficiency of production over time and explore more explanatory variables that explain the technical and allocative inefficiency scores. Data for example milk sales needs to be collected in a better fashion by DVS in order to facilitate future analyses of the sector/region. As Chapter 2 analysed input-specific technical inefficiency, further research may be carried out to explore measures of cost and allocative inefficiencies. Results from Chapter 4 imply that there is an opportunity for PPIT to raise their level of cost efficiency especially in terms of allocative efficiency. As PPIT's are conducting different sets of activities, a more comprehensive model should be considered which takes account of the different activities of PPIT.

Results in Chapter 5 suggest that retailers might have market power. Hence, more research aimed at investigating market power in the supply chain will be needed uncover whether retailers really distort the price paid for milk, as this study focused mainly on the existence of asymmetry. In addition, a better understanding of the entire supply chain would be obtained if future studies explore the price transmission for all actors in the supply chain including the import stage.

6.5 Main conclusions

The main objective of this thesis was to analyse the sources of inefficiency in Malaysian dairy supply chain. The main conclusions derived from this thesis are:

1. Land, labour, herd size, feed and others expenditures can be reduced by, on average 60, 50, 50.5, 54 and 52.5% in Malaysian dairy farming, while still producing the same level of output (Chapter 2).
2. Land is the most managerially inefficiently used input among the inputs for intensive and semi-intensive systems (Chapter 2).
3. Intensive farms are more managerially and program efficient than their semi-intensive counterparts; hence in general, the intensive system has an overall better performance than the semi-intensive system (Chapter 2).
4. Transaction costs (information, negotiation and monitoring costs) are associated with the selection of marketing channel by Malaysian dairy farmers (Chapter 3).
5. Socio-economic factors of farmers such as age, experience and education influenced the selection of marketing channel. Older farmers are *ceteris paribus* less likely to sell their milk to the PPIT; however, more experienced farmers are, *ceteris paribus* more likely to choose PPIT as their marketing channel (Chapter 3).
6. Farmers make their marketing channel choice simultaneously, i.e. farmers who sell their milk to PPIT are less likely to sell their milk directly to customers and intermediaries, while farmers who choose direct selling are more likely to also choose intermediaries as their marketing channel (Chapter 3).
7. On average PPIT can save 21% of quantity of inputs while maintaining the current production (Chapter 4).
8. On average, PPIT can reduce 46% of operational costs in order to be allocatively efficient (Chapter 4).
9. In the Malaysian dairy chain, price signals at the retail stage transmit upstream to PPIT and farms and also downstream from farms to PPIT, but not vice versa (Chapter 5).

10. Older farmers in the intensive system are associated with a higher technical inefficiency for labour (Chapter 2) and they are less likely to sell their milk to the PPIT (Chapter 3).
11. More experienced farmers in the intensive system are associated with a lower technical inefficiency for other expenditures (Chapter 2) and prefer to choose PPIT as their marketing channel (Chapter 3).
12. PPITs located closer to a city, have a higher technical, allocative and scale efficiency (Chapter 4).
13. Finance from government to farms is associated with a higher technical inefficiency in the semi-intensive system (Chapter 2) and farmers who obtained finance from government are less likely to sell their milk to through intermediaries (Chapter 3).

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Summary

Acknowledgements

About the Author

Training and Supervision Plan

Summary

Demand for dairy products in the South-East Asian region (including Malaysia) has doubled over the past decade. Currently, Malaysia relies heavily on imports to fulfil its domestic demand. Although milk production increased over the past decade, the growth was insufficient to meet the growing domestic demand for fresh milk. This situation requires an improvement not only at primary production but also at other stages in the Malaysian dairy supply chain. Therefore, analysing the sources of inefficiency in the dairy supply chain is needed in order to find out how more can be achieved with less inputs required. There is no study so far that comprehensively investigates the sources of inefficiency in the Malaysian dairy supply chain. The finding of this study can provide guidance for several Malaysian stakeholders such as the Department of Veterinary Service (DVS), the Dairy Industry Development Centre (PPIT) and national and local policy makers to improve the efficiency level of the dairy sector and achieve the ambitious target of becoming self-sufficient by 10% as well as reducing dependency on imported dairy products. This thesis analyses the sources of inefficiency at the farm stage (Chapter 2), at the marketing channel level (Chapter 3), at the level of the main milk marketer in Malaysia, PPIT (Chapter 4) and from a whole supply chain perspective (Chapter 5). Chapter 1 introduces the situation in the Malaysian dairy supply chain.

Chapter 2 measured input-specific managerial and program inefficiency of Malaysian dairy farmers between two systems—the intensive and semi-intensive system—and also assessed the impact of farmers' demographic and farm characteristics on this technical inefficiency. For this study, multi-directional envelopment analysis was first used to estimate both managerial and program inefficiency. Second, a bootstrap truncated regression was used to analyse the farmer's demographics and farm characteristics influencing the input-specific managerial technical inefficiency. Data were collected from a survey among 200 dairy farmers from 4 regions which are Johor, Melaka, Negeri Sembilan and Selangor. Results suggested that

all inputs such as land, labour and feed are overused. Farmers can produce the same level of output while saving all inputs. This study also found that the intensive farms are more managerially efficient than the semi-intensive farms for all inputs, except labour and other expenditure. The findings indicate that technical inefficiency of land is high for intensive and semi-intensive systems. Moreover, the program inefficiency score of the intensive systems are very close to zero indicates that the intensive system is considered best practice in general.

Chapter 3 investigated factors influencing the choice of marketing channel selection by Malaysian dairy farmers using a multivariate probit model. Results indicate that the variable of price expectation has a positive relation with the likelihood of using PPIT, and price expectation and farm service has a positive relation with the likelihood of using intermediaries. While, delay in payment and trust in buyer are negatively associated with the likelihood of using direct selling and price fluctuation is negatively associated with the likelihood of using intermediaries. Results also indicate that farmers who choose PPIT are less likely to choose direct selling and intermediaries, while farmers who sell their milk to direct selling, might sell to intermediaries marketing channel as well. The results further identified other socio-economic and farm characteristics that influence the choice of marketing channel.

Chapter 4 analysed the technical, allocative and scale efficiency of PPIT in Malaysia. A data envelopment analysis (DEA) was used to measure technical, allocative and scale efficiency and truncated bootstrap regression was used to investigate the factors affecting technical, allocative and scale efficiency. The findings in this chapter suggest that PPIT can reduce their input of production by 21% and still can produce the same level of output. While, 54% of the average of allocative efficiency score indicates that there is a room for increasing of production by 46% by suitable reallocating inputs given the inputs price. This results can be explained as PPIT is not a profit orientated organization, they used any inputs that might give them high production regardless the price of inputs. Furthermore, the results of Chapter 4 suggest that

PPIT were relatively good at utilizing all resources, but failed to choose the proper input mix given the prices they faced.

Chapter 5 analysed price transmission in the dairy supply chain. The study used vector autoregression (VAR) to investigate the relationship between farm, PPIT and retail prices. The results showed that price changes at the retail stage tend to transmit to PPIT and farms in the short run (i.e. within one year). However, price changes in farm and PPIT stage would not affect retail price. While, price change in farm stage would change the PPIT price in the short-run. These results suggested that retailer might have market power to set up the price since farm and PPIT will follow any changes made at retail stage. In addition, the results showed that an absence of long-run relationship between retailer, PPIT and farm.

Chapter 6 provided a synthesis of the main findings, and a reflection on the methodologies and data used in Chapters 2-5 as well as discussion of the implications for business, policy and future studies. The main conclusions of this thesis are summarized as follows:

1. Land, labour, herd size, feed and others expenditures can be reduced by, on average 60, 50, 50.5, 54 and 52.5% in Malaysian dairy farming, while still producing the same level of output (Chapter 2).
2. Land is the most managerially inefficiently used input among the inputs for intensive and semi-intensive systems (Chapter 2).
3. Intensive farms are more managerially and program efficient than their semi-intensive counterparts; hence in general, the intensive system has an overall better performance than the semi-intensive system (Chapter 2).
4. Transaction costs (information, negotiation and monitoring costs) are associated with the selection of marketing channel by Malaysian dairy farmers (Chapter 3).
5. Socio-economic factors of farmers such as age, experience and education influenced the selection of marketing channel. Older farmers are *ceteris paribus* less likely to sell their

milk to the PPIT; however, more experienced farmers are, *ceteris paribus* more likely to choose PPIT as their marketing channel (Chapter 3).

6. Farmers make their marketing channel choice simultaneously, i.e. farmers who sell their milk to PPIT are less likely to sell their milk directly to customers and intermediaries, while farmers who choose direct selling are more likely to also choose intermediaries as their marketing channel (Chapter 3).
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10. Older farmers in the intensive system are associated with a higher technical inefficiency for labour (Chapter 2) and they are less likely to sell their milk to the PPIT (Chapter 3).
11. More experienced farmers in the intensive system are associated with a lower technical inefficiency for other expenditures (Chapter 2) and prefer to choose PPIT as their marketing channel (Chapter 3).
12. PPITs located closer to a city, have a higher technical, allocative and scale efficiency (Chapter 4).
13. Finance from government to farms is associated with a higher technical inefficiency in the semi-intensive system (Chapter 2) and farmers who obtained finance from government are less likely to sell their milk to through intermediaries (Chapter 3).

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About the author

Nurul Aisyah Binti Mohd Suhaimi was born in Besut, Terengganu, Malaysia, in October 1983. She obtained her Bachelor and Master Degrees at Universiti Putra Malaysia, Selangor, Malaysia, in Agribusiness in 2005 and 2010 respectively. After successfully completing her studies, she started to work as a lecturer at the Faculty of Agricultural Biotechnology, Universiti Sultan Zainal Abidin, Terengganu, Malaysia. In February 2014, she started her PhD studies at the Business Economics Group of Wageningen University & Research. Her PhD research focused on analyzing the sources of inefficiency in the Malaysian dairy supply chain. The research was fully funded by the Ministry of Education, Malaysia. During her PhD research, she followed her education programme at the Wageningen School of Social Science (WASS) and she followed various courses in the field of economics and business.

Along her academic career, she has developed a strong background specialized in efficiency analysis and price analysis.

As of 2018, Nurul has started as a lecturer in Faculty of Bioresources and Food Industry at Universiti Sultan Zainal Abidin, Terengganu, Malaysia.

Journal contributions:

Mohd Suhaimi, N. A. B., de Mey, Y., & Oude Lansink, A. (2017). Measuring and explaining multi-directional inefficiency in the Malaysian dairy industry. *British Food Journal*, 119(12), 2788-2803.

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Nurul Aisyah Binti Mohd Suhaimi
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Advance Agriculture Business Economics (BEC 30306)	WUR	2014	6
Organisation of the Agribusiness (BEC 31306)	WUR	2014	6
Economic Models (AEP 30806)	WUR	2015	6
B) General research related competences			
WASS Introduction course	WASS	2014	1
'Input-specific managerial and program inefficiency in the Malaysian dairy industry: A multi-directional efficiency analysis'	EWEPA Conference, London	2017	1
'A transaction cost analysis of Malaysian dairy farmers' marketing channel selection'	EAAE Conference, Italy	2017	1
BEC PhD meeting	WUR	2014-2018	3
PhD Research Proposal writing	WUR	2014	4
C) Career related competences/personal development			
Techniques for Writing and Presenting a Scientific Paper	WGS	2015	1.2
Scientific Writing	Wageningen in'to Languages	2016	1.8
Theory and Practice of Efficiency & Productivity Measurement: Parametric Efficiency and Productivity Analysis	WASS Summer School	2015	3
Total			**34**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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