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Maize Seed Production in Thailand: Costs, Returns, and Contract Participation

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ABSTRACT

Thailand has aimed at becoming a "Seed Hub" in the region given that it is the second largest exporter of seed of field crops in Asia. Maize contributes the largest share of seed exports and is the prototype crop for seed industry promotion. One of the goals of the Seed Hub policy is to develop and export high quality Thai brand-name seeds. The structure of the maize seed industry, however, is such that it is concentrated in a few Multinational Companies (MNCs), and the question remains as to whether national and local companies could give farmers the same benefits as the multinational companies. This study aimed at comparing costs and returns across groups of maize seed companies and determining factors associated with farmers' participation in contracts. The results show that despite a higher cost of production, overall, MNCs give farmers the highest net income because of a higher productivity and higher price they give to the farmers from complying with the strict requirements of the contract specifications, followed by national companies, while local companies give the least. Requirements in household labor, investment in irrigation, size of farm, land rent, and age are important factors in farmers' participation in different groups of seed companies.

Keywords: Choice model, Contract farming, Multinational companies, Production contract.

INTRODUCTION

Seed is one of the key components of the food supply chain. It is valued at about 37.23 billion US dollars globally (McDougall, 2017) and accounts for 11.92 billion US dollars of the global seed trade (International Seed Federation, 2019). Thailand is the 24th largest field crop seed exporter in the world and the second largest in Asia after China (International Seed Federation, 2019). From 62 selected countries, Thailand ranked 32nd in the world and fourth in Asia in terms of enabling business in the seed sector, which measured the inclusiveness and sustainable practices of seed sector from plant breeding, variety registration, and seed quality control (World Bank Group, 2017). In 2018, maize had the highest value among all seed exports from Thailand at about 72.33 million US dollars from a volume of 24,950 tons (Thai Seed Trade Association, 2019). It is one of the more important commodities, generating export revenue and contributing significantly to domestic grain production.

The importance of the seed sector prompted the government to establish, in 2006, the Thailand Seed Cluster to promote the production of high quality and high value seed. Its strategic goals are to increase the number and income of seed-producing farmers and promote the development and export of Thai-owned brand-name seeds (National Center for Genetic Engineering and Biotechnology, 2007; National Science

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and Technology Development Agency, 2012). The "Seed Hub Project" was implemented in 2013–2014 by the Ministry of Agriculture and Cooperatives to promote high quality seed for exports, especially maize, and elevate the country into the region's premier "Seed Hub". Under Thailand's 4.0 policy, seed is one of the key industries chosen to promote agricultural development supported by science and technology. Another key goal, aside from creating national brand-name seeds, is upgrading farmers' income from producing seeds rather than grain (by applying their skills in grain production). To meet seed standards imposed by most countries including Thailand and its trading partners, seed companies usually resort to entering into production contracts with seed outgrowers to ensure the quality of hybrid maize seed.

The maize seed industry is concentrated in a few Multinational Companies (MNCs), with an oligopolistic tendency (Napasintuwong, 2020; OECD, 2018) while numerous small- and medium-size national and local companies contribute to much smaller shares of the market. The multinational seed companies generally own exclusive rights to their varieties, while national and local companies have less capacity to innovate and rely primarily on improved germplasm from public research programs. Thus, different groups of seed companies have different degrees of access to proprietary breeding lines and advanced technologies, which influence their roles in contributing to national brand name products. For example, local companies depend primarily on public varieties while MNCs and some national companies invest in a breeding program or buy licenses for exclusive proprietary. Depending on the quality and proprietary right, seed production requires different management and control mechanisms, which in turn demand different obligations from both parties (Napasintuwong, 2019).

Contract farming is an agreement between a grower and a processor regarding the production of an agricultural commodity (Bellemare and Bloem, 2018). It has become increasingly common in food system transformation after the 1980s (Reardon and Timmer, 2012). Contract farming, especially in developing countries, typically involves small farmers. While farmers are contracted for producing output, firms retain responsibility for providing agricultural support services, technical advice, loans, quality control, and marketing, which might otherwise be inaccessible (Glover, 1984; Mishra *et al*., 2018; Sriboonchitta and Wiboonpongse, 2005). Formal contracts with smallholders offer potential advantages to growers including predictable income, enabling them to take risks in adopting innovation such as new technology, provision of inputs (Goldsmith, 1985), access to credit, appropriate technology, skill transfer, guaranteed and fixed pricing structures, and access to reliable markets (Eaton and Shepard, 2001). Although contracted growers become specialized, more productive, and better at managing risk, they continue to face potential problems. These include increased levels of risk, unsuitable technology, crop incompatibility, manipulation of quotas and quality specifications, domination by monopolies, and indebtedness and overreliance on advances (Eaton and Shepard, 2001).

Variations in contractual agreements such as in pricing and stringency of seed quality control system have been observed in seed production in Thailand (Sriboonchitta and Wiboonpongse, 2008). Outgrowers were also found to give different weights to the importance of contract attributes. For instance, potato seed growers consider price option and form of contract more important than contract duration and quantity; input supply arrangement and technical assistance more important than transportation and credit arrangements; and seed and product quality specifications more important than quality control mechanism and place of quality inspection (Abebe *et al*., 2013). Thus, it is hypothesized that farmers' demographic

requirements to fulfill the contracts influence their participation in different groups of seed companies.

Although there have been studies on maize seed production contracts in Thailand, most of them only show farmers' perceptions and impacts of risks faced by farmers (Ekasingh *et al*., 2012; Ekasingh *et al*., 2014; Martwanna and Lertrat, 2007; Sriboonchitta and Wiboonpongse, 2008; Sriboonchitta and Wiboonpongse, 2005). The vital role of smallholding farmers in producing good quality seed and contributing to the strength of the seed industry is indisputable. However, there is yet insufficient evidence to clearly show the impacts of seed production and technologies under different conditions of proprietary ownership on farmers and the participation of outgrowers in seed production contracts, especially across groups of companies.

This study aimed to: (1) Compare costs and returns of outgrowers across different groups of seed companies and (2) Identify factors that influence growers' participation in maize seed production of different groups of seed companies. The results from cost and return analysis would clarify the role of seed companies through its impact on the farmers' income while the results from contract participation analysis would suggest measures to further strengthen the seed industry.

MATERIALS AND METHODS

To compare costs and returns from maize seed production and to identify factors influencing participation in seed production across groups of seed companies, face-to-face interviews were conducted for the production of maize seed in 2014/2015 seed production seasons. The wet season crop was planted during March to June and harvested during June to September 2014; the dry season crop was planted during mid-September to December 2014 and harvested during January to April 2015. Farmers have a choice of sponsors (seed companies with which they could participate) in the seed production contracts. On the other hand, seed companies also have the prerogative to select their contract farmers. Selected locations covered areas where more than one sponsor was engaged in the 2014/2015 seed production seasons.

A multi-stage stratified sampling method was used for the seed outgrowers' survey. In the first stage, maize seed companies were selected and interviewed to identify areas of seed production. Outgrowers were classified by their contract i.e. with: (I) Multinational Companies (MNCs), (II) National companies, and (III) Local companies. All MNCs in Thailand (Napasintuwong, 2020) were included in the samples. These included Charoen Pokphand Produce (Thai-Parent MNC), Monsanto, Pacific Seeds, Pioneer Hi-Bred, Seed Asia, and Syngenta Seeds. National companies included agricultural cooperatives and small enterprises defined by the Office of Small and Medium Enterprises Promotion.[Office of Small and Medium Enterprises Promotion (2002) defined small, medium, large enterprises as those with fixed asset < 50 million THB, 50-200 million THB, and > 200 million THB, respectively.] The list of national maize seed companies was obtained from registered seeds (Thai Seed Trade Association, 2015), and companies were randomly selected. The selected national maize seed companies were Golconda, Premier Seeds, and World Seed. Three cooperatives, namely, Mae-Chaem Agricultural Cooperative, Mae-Sot Estate Cooperatives, and Mae-Ramat Estate Cooperatives produced seeds of public varieties and were included in the national companies. Three local companies operating at provincial or regional level and producing less than 1000 tons/year were selected. In the second stage, the districts were randomly selected from locations identified by the seed companies. A total of 12 districts in Suphan Buri, Chiang Mai, Lampang, Mae Hong Son, Phrae, and Tak provinces were identified. In the final stage, outgrowers were randomly selected from groups of

farmers identified by the seed companies (for MNCs and national companies) and networking sampling (for local companies due to rare population). The number of outgrowers from each district was, as much as possible, proportionally distributed across companies within the same province based on types of companies. This is a proxy for operational volume. MNCs and national and local companies were considered large, medium, and small, respectively.

As the locations of seed production are confidential, it is not possible to get the exact numbers of contracted outgrowers and the size of seed production areas. The sample size was approximated at 356-370 (Cochran, 1977; Yamane, 1967) assuming a 95% confidence level and 0.05 level of precision (e), and approximately 5,000 maize seed growers, [Number of seed growers was approximately 5,000 based on estimates of 40,000 tons of annual seed production, average farm size of 1.6 hectare, and average yield of 5.625 tons of grain (4.5 tons of seed) per grower]. However, because of the limitations in locating seed farmers, 334 farmers and 391 maize seed production fields were selected (95% confidence level and a precision level of 0.053).

Cost and Return Analysis of Maize seed Production

The duration of seed production (about 120 days) and the size of maize seed outgrowers (a quota of land and expected output) are givens, but the price of the output is fixed by the sponsor. Thus, the primary objective of an outgrower is short-term cost minimization and can be assumed as:

Total Cost (TC)= Variable Cost (VC)+Fixed Cost (FC)

Short run total profit= Total Revenue (TR)–VC–FC

Short run variable profit= TR-VC

Following Buckett (1988), in this study, fixed costs include land rent, depreciation of machinery (i.e. tractors, sprayers, planters, irrigation system i.e. pipes, nozzles, pumps) and depreciation of well (for on-site irrigation), and semi-fixed costs include fuel and repair of farm machinery.

$$\text{Depreciation} = \frac{\text{cost - salvage value}}{\text{ownership life}} \times \%\text{use on maize seed} \times \%\text{use in season}$$

In the short-run, the farmers' primary concern is staying in the business so that, even if they cannot cover fixed cost that must be paid regardless of the production volume, they will continue their operation as long as the short-run variable profit is positive (even if their short-run total profit is negative), because they can cover variable cost with some left to cover fixed cost (Kay *et al*., 2016). However, taking into consideration the long-term investment such as irrigation and machineries, farmers should not continue operating if the short-run total profit is negative (incurring loss in the long run). In other words, when income cannot cover all costs, the farmer incurs continuing loss. By stopping production and selling the fixed assets, fixed costs are eliminated.

To compare cost and return across three types of sponsors, an F-test for mean differences across three groups of sponsors was used to compare cost, revenue, and profit:

$$H_0: \mu_{local} = \mu_{national} = \mu_{MNC}$$
$$H_A: at\ least\ one\ \mu\ is\ different$$

Where, μ_{local} is the mean value of local companies; $\mu_{national}$ is the mean value of national companies, μ_{MNC} is the mean value of MNCs.

Choice Model of Participation in Contracted Seed Production

The process of contract participation is explained in Barrett *et al*. (2012). Each season, seed companies first select locations to avoid extra contractual sales and ensure area suitability to varieties. Different groups of sponsors differ in the complexity and extent of provision of contractual agreements i.e. market specifications such as

quality standard, resource specifications such as varieties and cultivation practices, and management specifications typically encompassing high degree of material and management inputs (Eaton and Shepherd, 2001; Sriboonchitta and Wiboonpongse, 2008; Ekasingh *et al*., 2012). In this regard, sponsors would have different criteria in selecting potential outgrowers based on requirements for seed quality. As more than one seed company operates in a sampling location, outgrowers would also choose sponsors based on contractual benefits such as in-kind credit, period of payment, and expected profit. A multinomial logit model was adopted for the participation of outgrowers in different groups of sponsors (e.g. MNCs, national companies, local companies) by assuming that outgrower, *n*, will maximize expected utility (profit) subject to constraints such as household labor availability, suitability of soil, and investment requirement for water and other inputs.

An outgrower would obtain a certain level of utility (profit) from participating in seed production for each group of sponsors, *j*, and will engage in seed production for the one that provides the greatest utility. The true utility that farmer *n* obtains from producing seed for sponsor *j* is U_{nj}, $j= 1, 2, 3$, and he will choose to produce maize seed for sponsor *i* if and only if $U_{ni}>U_{nj} \forall j \neq i$. Although the true utility of outgrowers is unknown, their farm and the farmers' characteristics, $x_{nj} \forall j$. can be observed. The representative utility, denoted as $V_{nj}= V(x_{nj}) \forall j$, depends on these observed variables. The true utility is decomposed as $U_{nj}= V_{nj}+\varepsilon_{nj}$, where ε_{nj} is assumed to be random. The probability that outgrower *n* produces maize seeds for sponsor group *i* (Train, 2009) can be written as

$$P_{ni}= \text{Prob}(U_{ni}> U_{nj} \forall j \neq i)$$
$$= \text{Prob}(V_{ni}+\varepsilon_{ni}>V_{nj}+\varepsilon_{nj} \forall j \neq i)$$
$$= \text{Prob}(\varepsilon_{nj}-\varepsilon_{ni}<V_{ni}-V_{nj} \forall j \neq i). \quad (1)$$

Given the joint density of random vector $\varepsilon_n= (\varepsilon_{n1}, \varepsilon_{n2}, \varepsilon_{n3})$, the cumulative probability in (1) can be written as:

$$P_{ni}= \int_{\varepsilon} I(\varepsilon_{nj}-\varepsilon_{ni}< V_{ni}-V_{nj} \forall j \neq i) f(\varepsilon_n)\, d\varepsilon_n . \quad (2)$$

Where, *I(.)* equals 1 when the expression in parentheses is true and 0 otherwise. ε_{nj} is assumed independently, identically distributed extreme value (iid), and the cumulative distribution of ε_{nj}-ε_{ni} follows the logistic distribution:

$$F(\varepsilon_{nj}-\varepsilon_{ni}) = \frac{e^{\varepsilon_{nj}-\varepsilon_{ni}}}{1+e^{\varepsilon_{nj}-\varepsilon_{ni}}}. \quad (3)$$

The logit choice probabilities of (3) is given as follows (Train, 2009):

$$P_{ni} = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}}. \quad (4)$$

The representative utility is specified to be linear in parameters: $V_{nj}= \beta' x_{nj.}$ Thus, logit choice probabilities in (4) is defined as follows:

$$P_{ni} = \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}}. \quad (5)$$

Parameter estimates from Equation (5) are interpreted as a pairwise comparison between the effects of changes in independent variable on alternative *i* and the base alternative. The change in probability that outgrower *n* produces maize seeds for sponsor *i* given a change in an observed variable x_{nk} is:

$$\frac{\partial P_{ni}}{\partial x_{nk}} = \frac{\partial\left(\frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}}\right)}{\partial x_{nk}} . \quad (6)$$

$$\frac{\partial \Pr(Y_i=j)}{\partial x_{nk}} = \Pr(Y_i = j)\,[\beta_k - \sum_{j=0}^{1} \Pr(Y_i = j)\,\beta_k].$$

The marginal effect of dummy variable x_k equals:

$$Pr(Y_i = 1|x, x_k = 1) - Pr(Y_i = 1|x, x_k = 0). \quad (7)$$

In this study, contract specifications such as loan, credit, technical assistance, and payment provision are not hypothesized to be the main factors associated with type of sponsors as there are differences across companies within the same group or they are the same across sponsors (i.e. none of the contracted outgrowers receives a loan but nearly all receive advanced input credits). The dependent and explanatory variables used in the multinomial logit model are summarized in Table 1.

Table 1. Variables in outgrowers' participation model.

Dependent variable	
Group of sponsors	Local, National, MNC
Independent variables	
Age	Age of head of the household (Years)
Seed Exp	Experience in maize seed production (Years)
Current sponsor	Experience in producing seed for current sponsor (years)
Irrigation investment	Investment cost in irrigation (USD ha^{-1})
Farm size	Size of maize seed farm (ha)
Land rent	Land rent (USD ha^{-1}) (for owned land, the value was estimated from rented price in the same neighborhood.)
Labor and machinery service cost	Cost of labor (USD ha^{-1})
Full-time HH	Full-time household members engaging in seed production (persons)
Land ownership	Land ownership (1= Own, 0= 0therwise)

RESULTS AND DISCUSSION

The demographics of maize seed outgrowers is summarized in Table 2. The average age of seed outgrowers is about 50 years, with more than seven years of experience in maize seed production. The experience of outgrowers of national companies is about 2-4 years longer than those of MNCs and local companies. However, outgrowers of MNCs have the longest experience in seed production with their current sponsors. [Due to some missing observations of experience with current sponsors of MNC, the average of years with current sponsor is longer than average year of seed production experience.] Over the years, seed companies have been relocating their seed production sites to areas suitable for new varieties and adjusting to changing climatic patterns. The MNCs usually leave the areas that have extra contractual sales problems so that outgrowers in these areas end up producing seeds for local or national companies. It is possible that the farmers' longer experience in producing seeds for the current MNC is because they prefer the MNC to the national and local companies. However, not all farmers are allocated the production quota even if they wanted to produce for MNCs. The MNCs allocate the quota to those they consider good farmers. As MNCs buy at higher prices than national and local companies, those selected to continue producing seeds for MNCs generally perform better and tend to be more responsible so that they stay longer with the same sponsor. Outgrowers who did not perform well for MNCs may continue to produce seeds for other companies. Thus, outgrowers for national companies have the longest experience in seed production, but have a shorter experience with their current sponsor.

As seed production is labor-intensive, one of the criteria in selecting seed outgrowers is that they have sufficient full-time household members engaged in seed production to ensure that they adhere to intensive seed production requirements. On average, two household members are engaged full-time and one other member part-time in seed production. The majority of outgrowers have primary school education, however, the proportion of outgrowers having higher education than primary school is higher among outgrowers for national companies and MNCs.

Costs and Returns of Maize Seed Production by Group of Sponsors

The main season for maize seed production is the dry season. The lower humidity is conducive to the production of better quality seeds, and there is less

Table 2. Thailand's maize seed outgrowers' demographics, 2014/2015.

Seed outgrowers' characteristics		Wet Season 2015				Dry Season 2014/15			
		MNC	National	Local	Overall	MNC	National	Local	Overall
		Mean (Std Dev)				Mean (Std Dev)			
Age (Years)		48.05 (10.90)	51.58 (8.94)	50.88 (11.28)	49.44 (10.36)	51.01 (9.44)	55.89 (7.31)	52.48 (7.8)	51.60 (9.21)
Experience in maize seed production (Years)		8.34 (5.31)	12.00 (5.63)	11.13 (5.99)	9.77 (5.69)	8.97 (5.53)	10.56 (6.32)	7.45 (3.92)	8.96 (5.55)
Experience in maize seed production for current sponsor (Years) [a]		9.86 (7.45)	5.10 (4.41)	8.83 (7.11)	8.07 (6.82)	8.31 (6.23)	3.85 (4.51)	5.83 (4.12)	7.65 (6.07)
Number of household members		3.84 (2.22)	4.23 (1.33)	4.38 (2.00)	4.01 (1.95)	3.73 (1.79)	3.41 (1.15)	3.10 (0.86)	3.64 (1.76)
Number of household members engaged in full-time seed production		1.96 (1.10)	2.35 (0.75)	2.25 (0.46)	2.12 (0.97)	2.01 (0.75)	1.96 (0.65)	1.93 (0.59)	2.00 (0.79)
Number of household members engaged in part-time seed production		1.41 (1.06)	1.13 (0.35)	1.33 (0.58)	1.32 (0.86)	1.45 (0.85)	1.22 (0.44)	1.00 (0.00)	1.37 (0.77)
		%							
Education	Primary school or below	87.50	93.55	25.00	72.27	79.92	96.3	100.00	81.92
	Above primary school	12.50	6.45	75.00	27.23	20.08	3.70	0.00	18.08
	Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Sample size (n)		56	31	8	95	240	27	29	296

[a] The sample size of experience in maize seed production for current sponsor of MNC was 50 and 229 in wet and dry seasons, respectively.

incidence of disease. From the survey, 296 farmers produced seeds in the dry season of 2014/2015 and 93 in the wet season of 2015; 57 farmers grew a crop in both seasons. Buying prices and revenues of seed outgrowers contracted by MNCs were significantly higher than those by national companies, and those contracted by national companies were higher than those by local companies in both seasons (Table 3). Buying prices typically depend on the quality, yield performance, and degree of difficulty in growing the hybrids. Total revenue in the dry season was, on average, also higher than in the wet season in all groups of sponsors. Output was not significantly different across the three groups of companies due to the wide variation. However, on average, MNC outgrowers generated a higher output among the three groups. The cost of fertilizers, pesticides, herbicides in the wet season was higher than in the dry season. The cost of irrigation investment by MNC outgrowers, especially in the dry season, was unsurprisingly higher than other types of sponsors (Table 4). Comparing across sponsors, the cost of fertilizers, pesticides, irrigation, and labor, including machinery services of MNCs' outgrowers was the largest and was significantly different across sponsors. This could be attributed to the higher quality and greater amount of inputs required by MNCs or the higher input prices set by MNCs and national companies. Inputs are usually provided to outgrowers as in-kind advanced credit. Seed cost, however,

Table 3. Revenue, cost and profit of maize seed production in Thailand, 2014/2015.

	Wet season 2015					Dry season 2014/2015				
	MNC	National	Local	Overall	F stat (p value)	MNC	National	Local	Overall	F stat (p value)
	Mean (Std Dev)					Mean (Std Dev)				
Output[a] (kg ha^{-1})	7,592.27 (7,386.95)	5,515.63 (2,600.67)	4,893.00 (2,148.15)	6,554.00 (5,966.32)	1.500 (0.239)	7,281.25 (5,085.06)	6,631.47 (2,108.23)	6,379.91 (3,565.90)	5,966.32 (4,600.85)	0.628 (0.534)
Output price (USD kg^{-1})	0.47 (0.09)	0.41 (0.08)	0.32 (0.02)	0.44 (0.10)	11.589*** (0.000)	0.45 (0.05)	0.45 (0.09)	0.29 (0.09)	0.44 (0.07)	94.797*** (0.000)
Total Revenue (USD ha^{-1})	3,005.35 (1,119.65)	2,245.40 (555.91)	1,989.76 (391.05)	2,703.40 (1,026.53)	8.339*** (0.001)	3,192.17 (1,259.87)	2,449.84 (886.07)	2,032.64 (889.44)	3,046.57 (1,260.49)	15.326*** (0.000)
Fixed/semi-fixed cost (USD ha^{-1})	544.87 (723.30)	284.92 (250.64)	186.46 (95.87)	538.75 (710.77)	2.557* (0.094)	614.85 (1,055.22)	423.98 (561.19)	260.98 (183.63)	589.79 (1,012.27)	2.029 (0.133)
Variable cost (USD ha^{-1})	2,250.09 (279.62)	1,842.23 (191.19)	1,541.32 (105.64)	2,057.31 (257.17)	42.099*** ((0.000)	1,995.55 (221.40)	1,840.20 (452.93)	1,866.52 (151.07)	1969.36 (263.90)	7.633*** (0.001)
Total cost (USD ha^{-1})	2,794.96 (775.47)	2127.15 (315.24)	1,727.78 (142.65)	2,487.17 (755.86)	15.879*** (0.000)	2,610.40 (1,078.20)	2,264.17 (721.17)	2,127.50 (237.79)	2,532.21 (1,046.11)	4.079** (0.018)
Est var profit (USD ha^{-1})	755.26 (1,154.04)	403.17 (587.87)	448.44 (405.06)	614.53 (1,058.26)	1.417 (0.258)	1,196.62 (1,279.18)	609.65 (995.12)	166.12 (902.18)	1,042.17 (1,287.82)	11.008*** (0.000)
Est total profit (USD ha^{-1})	210.39 (1,361.97)	118.25 (639.07)	261.98 (416.25)	184.67 (1,274.79)	0.082 (0.921)	581.77 (1,658.25)	185.67 (1,142.45)	-94.86 (920.68)	479.32 (1,638.04)	2.953* (0.054)
Est. var profit (USD HH^{-1})	1,504.25 (2,980.08)	574.70 (976.72)	470.86 (543.40)	1,024.89 (2,304.79)	1.736 (0.193)	1,536.46 (2,485.25)	384.53 (712.02)	142.93 (935.67)	1,176.70 (2,162.36)	7.245*** (0.001)
Est. tot profit (USD HH^{-1})	419.03 (3,309.17)	168.56 (1019.39)	275.08 (516.53)	307.98 (2,637.12)	0.090 (0.914)	747.00 (2,834.60)	117.11 (793.99)	-81.61 (951.50)	541.19 (2,477.74)	1.862 (0.157)
Obs	56	31	6	93		240	27	29	296	

[a] Ear weight; Based on Bank of Thailand exchange rate Q4 2014 to Q3 2015, 1 USD = 33.47 THB; ***, **, and *: Significant levels of 1, 5 and 10 percent, respectively.

Table 4. Fixed and semi-fixed costs and variable costs of maize seed production in Thailand, 2014/2015.

	Wet season 2015					Dry season 2014/2015				
	MNC	National	Local	Overall	F stat (p value)	MNC	National	Local	Overall	F stat (p value)
	Mean (Std Dev)					Mean (Std Dev)				
Farm size (ha)	1.99 (1.38)	1.43 (0.70)	1.05 (0.56)	1.67 (1.21)	3.471** (0.044)	1.28 (1.06)	0.63 (0.29)	0.86 (0.57)	1.13 (0.97)	7.087*** (0.001)
Irrigation investment (USD)	974.49 (1,455.27)	73.59 (103.25)	0.00 (0.00)	924.44 (1,429.45)	7.163*** (0.003)	639.45 (1,256.18)	259.67 (399.39)	44.97 (49.52)	594.86 (1,203.62)	4.452** (0.012)
Fixed/Semi-fixed cost (USD ha^{-1})	544.87 (723.30)	284.92 (250.64)	186.46 (95.87)	538.75 (710.77)	2.557* (0.094)	614.85 (1,055.22)	423.98 (561.19)	260.98 (183.63)	589.79 (1,012.27)	2.029 (0.133)
Land rent	85.35 (91.07)	174.94 (85.15)	158.72 (65.37)	101.64 (94.96)	10.994*** (0.000)	148.61 (140.77)	157.99 (103.77)	134.17 (41.40)	148.50 (134.87)	0.241 (0.786)
Machinery depreciation and repair	39.44 (84.31)	18.00 (36.43)	27.74 (30.51)	35.26 (77.19)	0.958 (0.415)	83.44 (397.00)	45.96 (75.67)	58.10 (70.00)	79.31 (371.74)	0.178 (0.837)
Irrigation equipment depreciation	420.08 (547.92)	91.99 (129.06)	0.00 (0.00)	401.85 (538.62)	7.046*** (0.000)	382.80 (517.45)	220.02 (381.76)	68.70 (72.23)	361.97 (505.66)	6.385*** (0.002)
Variable cost (USD ha^{-1})										
Fertilizer	836.73 (142.34)	704.49 (88.21)	721.28 (42.15)	777.68 (134.44)	12.444*** (0.000)	564.65 (105.49)	511.79 (74.77)	561.50 (68.88)	560.44 (102.78)	(3.388** (0.035)
Herbicide	118.61 (104.90)	89.66 (51.94)	94.19 (56.43)	107.91 (88.69)	1.143 (0.332)	85.81 (73.35)	79.66 (55.41)	85.34 (59.65)	84.88 (69.39)	0.092 (0.912)
Other chemicals[a]	188.90 (167.15)	71.90 (125.00)	41.51 (30.51)	136.42 (155.16)	7.519*** (0.002)	101.03 (67.20)	67.40 (53.37)	64.84 (56.34)	91.65 (110.18)	6.554*** (0.002)
Seed	70.08 (75.18)	101.33 (44.35)	88.70 (38.21)	83.25 (64.37)	2.362 (0.112)	61.59 (61.99)	115.33 (51.09)	111.37 (48.76)	75.10 (63.19)	16.911 (0.000)
Irrigation[b]	86.13 (57.17)	49.54 (27.25)	0.00 (0.00)	76.71 (56.10)	12.629*** (0.000)	163.67 (127.28)	147.62 (83.90)	90.25 (52.98)	155.13 (120.96)	5.001*** (0.007)
Labor[c]/Machinery service	949.64 (100.30)	825.32 (87.97)	595.64 (61.71)	835.05 (93.96)	47.364*** (0.000)	1,018.79 (89.16)	918.39 (428.94)	953.21 (78.49)	978.65 (153.31)	6.945*** (0.001)
Land preparation	282.84 (338.01)	119.39 (123.55)	73.08 (74.33)	208.20 (285.09)	4.400** (0.020)	702.31 (843.09)	197.26 (84.99)	347.18 (298.62)	541.44 (713.95)	7.309*** (0.001)
Spraying	176.94 (224.62)	129.21 (76.05)	194.28 (124.16)	170.94 (205.81)	0.775 (0.470)	231.34 (211.32)	83.47 (67.69)	217.64 (134.67)	213.18 (201.11)	6.881*** (0.001)
Detassling	99.55 (121.68)	183.13 (136.92)	43.60 (34.82)	100.34 (120.58)	5.879*** (0.007)	97.67 (96.36)	125.30 (96.30)	34.20 (27.31)	93.98 (94.60)	7.876*** (0.000)
Logging	28.09 (19.78)	28.84 (63.76)	31.61 (24.73)	28.59 (39.56)	0.022 (0.978)	36.11 (44.01)	28.71 (27.33)	52.68 (59.66)	37.02 (44.16)	2.309 (0.101)
Volunteer plant removal	33.34 (34.25)	9.23 (7.35)	17.99 (20.25)	25.35 (29.55)	7.824*** (0.002)	35.71 (45.03)	8.09 (5.61)	19.16 (23.39)	28.04 (38.28)	6.865*** (0.001)
Harvesting	169.44 (154.98)	269.94 (145.60)	199.56 (101.95)	181.72 (150.43)	4.518** (0.019)	172.62 (102.43)	498.75 (958.77)	171.97 (110.01)	243.44 (475.76)	14.301*** (0.000)
Loading	91.98 (181.77)	73.85 (38.31)	37.11 (44.62)	57.49 (108.31)	0.474 (0.627)	48.16 (83.11)	76.89 (51.01)	30.05 (20.03)	45.51 (59.16)	2.675* (0.071)
Total variable cost	2,250.09 (279.62)	1,842.23 (191.19)	1,541.32 (105.64)	2,057.31 (257.17)	42.099*** (0.000)	1,995.55 (221.40)	1,840.20 (452.93)	1866.52 (151.07)	1969.36 (263.90)	7.633*** (0.001)
Total cost (USD ha^{-1})	2,794.96 (775.47)	2127.15 (315.24)	1,727.78 (142.65)	2,487.17 (755.86)	15.879*** (0.000)	2,610.40 (1,078.20)	2264.17 (721.17)	2,127.50 (237.79)	2,532.21 (1,046.11)	4.079*** (0.018)
Obs	56	31	6	93		240	27	29	296	

[a] Other chemicals include pesticides, hormones, etc.; [b] Irrigation costs include irrigation fee (if any), fuel, electricity; [c] Including others i.e. field clearance, planting, thinning/replanting, watering Based on Bank of Thailand exchange rate Q4 2014 to Q3 2015, 1 USD = 33.47 THB; ***, **, and * Significant levels of 1, 5 and 10 percent, respectively.

was not significantly different in the wet season, but was significantly different in the dry season. The parental seeds are necessary inputs for hybrid seed production and may be considered as proprietary ownership of the firms. Seed companies usually provide parental seeds as in-kind advanced credit to outgrowers even without the outgrowers requesting them. The average cost of seeds of MNCs was the lowest, possibly because the MNCs' policy is to take control of the parental seed ownership and only charge outgrowers a part of the seed cost. On the other hand, national and local companies consider parental seeds as the cost that outgrowers have to bear. On average, the variable cost and total cost of growers for MNCs were higher than those of national companies and local companies.

Labor cost including family labor and machinery services in the dry season was higher than in the wet season (Table 4). However, as the cost of chemicals (fertilizer, herbicide and others) in the wet season is higher than in the dry season, this makes the average variable cost in the wet season higher than in the dry season. For high quality hybrid seeds, detasseling is important for proper pollination of hybrids while the removal of volunteer plants contributes to seed purity. These practices are crucial in seed production management and typically more stringent among MNCs and national companies. As a result, they take up a significant share of the labor cost incurred in seed production, especially among MNCs and national companies. Outgrowers for MNCs may also be more skillful in seed production so that the labor cost (hours of work) of these activities was less than that of the outgrowers of national companies. Martwanna and Lertrat (2007) also found that labor is a very important factor in the success of contracted seed production of all crops; it becomes more challenging when wages increase. According to the study by Ekasingh *et al*. (2014), fertilizer takes the largest share of the cash cost (more than double the labor cost) among contracted maize seed outgrowers. However, the present study shows that labor cost, particularly among MNCs and national companies, takes the largest share of all maize seed production costs, suggesting that the labor requirements for high quality seed production are of critical importance. The difference in the findings could be attributed to the non-cash cost of household labor not being explicitly calculated in their study.

Fixed and semi-fixed costs in the dry season were found to be higher than in the wet season. Water sufficiency is an important factor in seed production. To attain the expected yield, MNCs generally prefer farmers who face no risk of water shortage. The investment in irrigation system and depreciation of irrigation equipment (Table 4) of MNCs' outgrowers, thus, was significantly much higher than those contracted by the national companies and higher than those by local companies. The higher cost in the dry season is distinguished for irrigation investment and irrigation equipment depreciation. This implies that outgrowers invest more in the dry season to be able to produce quality seed and increase their chances of being chosen by seed companies in this favourable season. Land rent in the dry season is also higher than in the wet season. This also indicates that land and soil quality in the dry season has higher value for seed production than the wet season. Short-run cost (variable and total) of maize seed production for MNCs was the highest, followed by national companies and local companies, respectively, in both seasons. However, in the dry season, the national companies had a slightly smaller short-run variable cost than the local companies. The short-run variable profit and short-run total profit for MNCs were also the highest in both seasons. In the dry season, which is the main seed production season, national companies yield significantly higher total profit and variable profit than local companies. However, in the wet season, variable profit and total profit for local companies were not significantly different

across sponsors. The outgrowers of local companies, nevertheless, incur a loss from seed production in the dry season. In the short-run, farmers can still produce seeds for local companies as variable profit remains positive and can cover variable cost; however, if they continue producing seed for local companies, they invariably incur a continuing loss and should stop production, especially in the dry season. The results suggest that farmers would benefit most from producing seeds for MNCs, followed by national companies and local companies. However, they may prefer local companies in the wet season as they gain more benefit from growing for them than from national companies. Even more so if they develop a long-term relationship with local seed companies.

Most studies have shown that contract farming enables farmers to obtain a higher yield and get a higher profit (Mishra *et al*., 2018 and 2016; Minot and Ronchi, 2014). Nevertheless, a contract does not always guarantee a higher income. It also requires knowledge of, and certainty about, the terms of the contract, which influence the participation in a contract to make it attractive and beneficial (Bellemare and Bloem, 2018). In Thailand, Sriboonchitta *et al*. (1996) found that contracted maize seed production generated an income superior to that from other contracted crops. Overall, contracted maize seed production in Thailand provides good profit for farmers. This study does not compare it with other crops or with non-contracted production as all maize seed is produced under contracts. Nevertheless, compared to maize grain production (Photchanaprasert *et al*., 2015), this study shows that, on the average, the profitability of seed production provides farmers with a higher net income. However, it also depends on the season and the sponsors. To reiterate, contracted farmers for local companies could incur losses in the dry season. They may consider selling fixed inputs and invest the proceeds in irrigation, which was shown to improve the profitability. Alternatively, they may switch to an alternative enterprise.

Characterizing Seed Outgrowers' Participation in Maize Seed Production Schemes

Tables 5 and 6 show coefficient estimates and marginal effects of multinomial logit

Table 5. Coefficient estimates of multinomial logit model of participation in maize seed production in Thailand, 2014/2015 (Local= Base).

Variable	National		MNC	
	Coeff (β)	Std err	Coeff (β)	Std. Err.
Const	-2.8787	1.8230	1.8745	1.3421
Age	0.0362**	0.0258	-0.0097**	0.0200
Seed Exp	0.1852*	0.0546	-0.0608**	0.0472
Current sponsor	-0.2422*	0.0670	0.0953**	0.0495
Irrigation investment	0.00008***	0.0002	0.00008***	0.0001
Farm size	0.0035***	0.0063	0.0012**	0.0053
Land rent	0.0011***	0.0009	0.0011***	0.0009
Labor and machinery service cost	-0.0002***	0.0001	0.000007***	0.0000
Full-time HH	0.3164	0.3264	-0.0901	0.2598
Land ownership	1.3991	0.5368	0.4166	0.4093
Log likelihood	-221.11076			
Number of seed farms	365			

*** Significance at 1% level, ** Significance at 5% level, * Significance at 10% level.

Table 6. Marginal effects of multinomial logit model of participation in maize seed production in Thailand, 2014/2015.

Variable	Local		National		MNC	
	dy/dx	Std err	dy/dx	Std err	dy/dx	Std err
Age	0.0005***	0.0017	0.0035***	0.0015	-0.0039***	0.0022
Seed Exp	0.0032***	0.0040	0.0184***	0.0037	-0.0217***	0.0055
Current sponsor	-0.0054***	0.0043	-0.0252***	0.0043	0.0307***	0.0059
Irrigation investment	-0.000007***	1.00E-05	0.0000003***	1.00E-05	0.000007***	1.00E-05
Farm size	-0.0001***	0.0005	0.0002***	0.0003	-0.00006***	0.0005
Land rent	-0.0001***	0.0001	0.000004***	0.0000	0.00009***	0.0001
Labor and machinery service cost	0.000001***	0.00E+00	-0.00002***	1.00E-05	0.00002***	1.00E-05
Full-time HH	0.0045**	0.0220	0.0305**	0.0186	-0.0350**	0.0282
Land ownership	-0.0444**	0.0355	0.0746**	0.0289	-0.0303**	0.0449

*** Significance at 1% level, ** Significance at 5% level, * Significance at 10% level.

participatory model. [The multicollinearity test was performed for all independent variables by variance inflation factor (VIF). VIF of all independent variables were below 2, which suggest no multicollinearity problem. All correlation coefficients were also less than 0.39 in absolute except for between "Seed Exp" and "Current Sponsor" which was 0.58. However, to avoid omitted variable bias both variables were included. They were found to be significantly correlated with the independent variable.] Compared to local companies, higher investment in irrigation and a larger farm increase the probability of being contracted by national companies and MNCs. Also, compared to local companies, older and more experienced farmers are more likely to be contracted by national companies, but less likely by MNCs (Table 5). The results from Table 6 suggest that age and experience in seed production increase the probability of being contracted as outgrowers of local and national companies, but younger outgrowers and those with less experience in seed production are more likely to be contracted by MNCs. A likely explanation is that MNCs see younger farmers as better able to adapt to the rigorous farm practices that they require and, even with less experience in seed production, they may be more skillful. Outgrowers with a longer experience who are contracted by their current sponsor are more likely to be contracted by MNCs, but less likely to be contracted by local and national companies. In one area, farmers typically prefer MNCs to national and local companies. However, they may not be selected or may be allocated a quota less than the potential production capacity of their total farm area. If younger and less experienced growers are selected by the MNCs, they would more likely continue to be contracted by the current MNCs. On the other hand, older farmers and those who have a longer seed production experience may be so attached to old practices and are left with local and national companies, if they cannot get a quota from the MNCs. These farmers would have a shorter experience with their current sponsors. The results are consistent with Ekasingh *et al*. (2014) and Martwanna and Lertrat (2007), i.e. experienced seed outgrowers in general think that producing a newly introduced variety is not difficult and in any case they could get technical assistance from seed companies, unlike other crops such as potato and tomato, of which farmers generally have had experience and knowledge prior to the contracts. This also endorses our result that a strong technical support, which is an important aspect of MNCs' contract, can

upgrade the skills of young and less experienced farmers who, with their perceived ability to comply with the more rigorous farming practices, are then preferred by them.

Outgrowers who have little or no investment in irrigation system are more likely to be contracted by local companies. Households with more members working full-time on seed production are more likely to be contracted by local and national companies, but less likely by MNCs. Nevertheless, households that incur a higher cost of labor (including family labor and machinery service) increase their probability of being contracted by MNCs and local companies, but decrease their probability of being contracted by national companies. The likely reason is that seed production for MNCs is more labor intensive and that local seed companies tend to contract farmers who are less labor efficient (low labor productivity).

Increasing farm size increases the probability of being contracted by national companies, but decreases the probability of being contracted by MNCs or local companies. A very large farm may not be preferred by MNCs as they have strict requirements for maize seed production. On the other hand, national companies generally have fewer extension staff to supervise and lend technical advice to contract growers and tend to prefer farmers with larger farms and fewer seed outgrowers. The local companies operate at a much smaller scale and thus their outgrowers are allocated a smaller farm area. Higher land value (rent including opportunity cost of using land) increases the opportunity of an area becoming a seed production location for MNCs and national companies. Farmers who own land are more likely to be contracted by national companies and less likely by MNCs and local companies. The likely reason is that areas of seed production by MNCs are much larger than those by national companies, and it may not always be possible to find areas where farmers own the land. Local companies, on the other hand, have a much lower volume of production and operate at the local level. They most likely contract fewer growers and allocate quota to the larger farmers (compared to national companies especially in the dry season) who do not own the farm land.

Previous studies identified factors influencing participation in contracts (Dubbert, 2019; Simmons *et al*., 2005), but none evaluated the dynamics of participation in contracts of the same commodity across groups of sponsors. This study recognizes that there are variations in contract specifications across groups of sponsors. As all maize seed production in Thailand is contracted (some are informal), participation focuses on alternative groups of sponsors.

CONCLUSIONS

The success of the seed sector has prompted Thailand to position itself as the Seed Hub of the region. Maize has the largest export value among all seeds and is the prototype crop under the Seed Hub policy. The policy aims at improving the income of farmers and developing Thai brand name products. Previous study has shown that the structure of the maize seed industry is concentrated in MNCs. This study reveals that farmers gain the most benefit when contracted with MNCs, followed by national and local companies. Only when they are under contract by local companies in the dry season, farmers incurred short-run losses. However, farmers cannot always participate in MNC contracts even if they wanted to. The intensive system used in seed production, investment in irrigation, labor requirements, younger age, and land value were significant factors for farmers to be contracted by MNCs. Contract specifications such as farm management requirements and quality standards of output, which in turn require, for example, more investment in irrigation and higher labor intensity, would have indirectly

contributed to the selection of farmers and acceptance of contract by farmers. As a strategic measure, seed production should aim at technical standards of quality, and protection of proprietary rights similar to MNCs, which would improve productivity, price, and profitability for farmers. This implies that national companies should continue using science and technology and develop their own proprietary technology. These will facilitate the development and creation of national brand name seeds. The strategy will facilitate the achievement of the goal of improving the income of farm households..

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تولید بذرذرت در تایلند: هزینه ها، بازده‌ها، و مشارکت در قرارداد

و. ناپاسینتوونگ

چکیده

هدف تایلند تبدیل شدن به یک "مرکز بذر" در منطقه است و هم اکنون دومین صادرکننده بزرگ بذر محصولات کشاورزی در آسیا است. ذرت بیشترین سهم را در صادرات بذر دارد و گیاه اصلی برای رونق صنعت تولید بذر است. یکی از اهداف سیاست تبدیل شدن به یک "مرکز بذر"، تولید و صادرات بذر با نام تجاری تایلندی با کیفیت بالا است. در شرایط فعلی، ساختار صنعت بذر ذرت به گونه‌ای است که در چند شرکت چند ملیتی (MNCs) متمرکز شده و این پرسش مطرح است که آیا شرکت‌های ملی و محلی می‌توانند مزایایی مشابه شرکت‌های چند ملیتی به کشاورزان بدهند یا خیر. هدف پژوهش حاضر مقایسه هزینه ها و بازده ها در همه گروه‌های شرکتهای بذر ذرت و تعیین عوامل مربوط به مشارکت کشاورزان در قراردادها است. نتایج نشان می دهد که با وجود هزینه تولید بیشتر، به طور کلی، شرکت‌های چند ملیتی درآمد خالص بیشتری به کشاورزان میدهند و علت آن بهره‌وری بالا و قیمت بالاتری است که به لحاظ رعایت الزامات سختگیرانه مفاد قرارداد به کشاورزان پرداخت می شود. در این مورد شرکت های ملی در مرحله بعد قرار دارند. این در حالی است که شرکت های محلی کمترین درآمدخالص را پرداخت می کنند. عوامل مهم مشارکت کشاورزان در گروه های مختلف شرکت های بذرشامل نیاز به نیروی کار خانگی، سرمایه گذاری در آبیاری، اندازه مزرعه، اجاره زمین، و سن کشاورزان است.