



Thailand's maize seed market structure, conduct, performance

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Seed is one of the fastest-growing industries in the agricultural sector. Thailand's maize seed industry is one of the most developed and most advanced compared to other developing countries largely because of the country's programs of public and international organizations (i.e. Rockefeller Foundation, CIMMYT, USAID) carried out in the early years that included establishing the infrastructure for research and promoting the role of the private sector. Long-term investments in research and development by private companies accelerated the expansion of the industry. The success of the maize seed industry gives the basic rationale for this paper: learn lessons from it by analysing its structure, conduct and performance to provide recommendations for seed business development and policy recommendations for Thailand to become the leader in the region. The findings suggest that the maize seed industry in Thailand is oligopolistic and moderately concentrated. The business conduct of maize seed firms is pricing and product differentiation with customized varieties that are suitable to segmented markets. The business performance of the firms suggest that large multinational companies have a stronger market power than the local ones because of their strong capacity for product innovation. Nonetheless, small local companies can still profitably participate in the oligopolistic competition environment by effectively generating sales revenue using public varieties or through licensing. It is suggested that policies that enable local companies to strengthen their research capacity are needed to elevate their competitiveness. This would contribute to the sustainable development of Thailand's maize seed industry.

1. Introduction

Thailand is the third largest seed exporter in Asia (International Seed Federation, 2016), and maize contributes to the largest share of exports. The export value of maize seed from Thailand was about 43.8 million USD, topping all the other crops. Maize seed is exported to several countries in the region including Indonesia, Pakistan, Sri Lanka and Vietnam. The export volume in 2018 was more than 24 million tons

valued at about 73 million USD (Thai Seed Trade Association, 2019). The privatization, in 1991, of hybrid maize seed production and distribution stimulated long-term commitments of investment in research and development (R&D), particularly from multinational companies. The success of maize seed industry development has motivated the Government to position Thailand as the Seed Hub of the region. In 2006,

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the National Center for Genetic Engineering and Biotechnology (BIOTEC), established the Thailand Seed Cluster, which harnessed science and technology to promote the production of high quality and higher value seed. The goals of this program are (1) to provide farmers with good quality seed, (2) to increase the number and income of seed-producing farmers, and (3) to promote the seed industry's role in developing and exporting Thai-owned brand-name seeds. The Seed Cluster strategic plan was set in two phases: 2007–2011 and 2011–2016 (National Center for Genetic Engineering and Biotechnology, 2007; National Science and Technology Development Agency, 2011). Its components included (1) generating sustainable germplasm management, (2) using biotechnology (particularly molecular breeding) for crop improvement through a cooperation with the private sector, (3) developing disease diagnostics and providing support to small seed producers for high-value seed production, and (4) developing seed coating technology from natural products. An analysis of the seed industry carried out by the National Biotechnology Policy Committee under the Seed Cluster strategic plan suggested that Thailand had a high potential to become the region's leader in seed industry. This prompted the government to include the seed industry among the priority industries for promotion.

In 2013–2014, the Ministry of Agriculture and Cooperatives also set up the Seed Hub Project to promote research and production for tropical plant seed. The project also aims to produce sufficient quality seed, particularly of field crops and vegetables, for domestic use and export. The hub's strategic plan included promoting public-private partnership and increasing public support to farmer groups and small local enterprises. For example, the maize germplasm network has engaged private companies, public universities, the Department of Agriculture (DOA) and the National Corn and Sorghum Research Center (NCSRC) in the collection, characterization, and evaluation of genotype and phenotype and multiplication of seed. One of the public-private partnership activities was the Public-Private Yield Trial (PPYT) program, a multilocation field testing of maize varieties with the participation of public institutions, such as DOA, and private companies (Richmond, 2013).

Despite the success of the maize seed industry, which was chosen to be a prototype crop for the Seed Hub

project, there has been no significant advancement in the seed market. Small local seed business still has limited R&D capacity and lacks advanced technology. The lack of a biosafety laws and limited access to genetic materials of crops not indigenous to Thailand have hindered industry progress. Furthermore, investment in basic infrastructure such as institutional arrangements for human capacity building and modern agricultural technology, both by public and private sectors, is insufficient to drive Thailand to become a centre for seed industry (Isvilanonda, 2017).

The structure of the maize seed industry in Thailand has changed over time, from one consisting of several local small businesses that multiplied seed varieties developed by public institutes, to one with a few large companies dominated by consolidated multinational enterprises (Brown et al., 1985; Setboonsarng et al., 1991). The concentration of maize seed industry through merger and acquisition can be observed not only in the global market but also in developing countries (Fernandez-Cornejo and Just, 2007; Howard, 2009; Spielman et al., 2014; OECD, 2018). In the Structure, Conduct, Performance (SCP) model, market concentration is usually linked to firm behaviour (conduct) and industrial performance (Setiawan et al., 2013; Stiegert et al., 2009; Weiss, 1991). While increasing market power could negatively influence market efficiency and the benefits accrued by farmers and consumers, it also implies economies of scale in R&D (Fernandez-Cornejo and Just, 2007). Spielman et al. (2014) found that India's seed industry is concentrated, and the private companies have a significant role in varietal improvement. Public institutes, on the other hand, play an important role in providing traits, which attract little interest from the private sector. Similarly, in Thailand downy mildew resistance in tropical maize was developed by public institutes with the support of international organizations in the early 1970s; the trait is still used in the breeding programs of several seed companies (Napasintuwong, 2017).

While performances (i.e. profitability) of firms in concentrated markets may be expected (Stiegert et al., 2009), others have suggested it is unclear that performance, such as product price and innovation of the seed industry, results from market concentration (Fulton and Giannakas, 2001; OECD, 2018). Cromwell et al. (1992) suggested that seed industry performance could be evaluated both at firm-level and national-level



el, such as distribution and availability of good quality seed. Measurement of performance, competition and innovation in maize seed industry can be used to shape national agricultural growth strategies, set public research priorities, design private innovation incentives, construct public input provision programs, and encourage maize seed industry development and productivity-enhancing technology adoption (Spielman and Kennedy, 2016). The adoption of hybrid maize in Thailand has reached saturation level (Poolsawas and Napasintuwong, 2013); there remain the important questions of whether current market structure provides incentives for private companies to perform business conduct such as innovating new improved varieties and whether performance of small local companies is competitive compared with large multinational companies. Furthermore, given the increasing mergers and acquisitions in global seed companies, small local seed companies may face more challenges in developing competitive varieties with their limited access to international germplasm and limited capital.

A few studies have explored the business environment of Thailand's seed industry (Brown et al., 1985; Napasintuwong, 2017; OECD, 2018; Setboonsarng et al., 1991), but because of limited data availability, none of them focused on business performance of seed firms. This paper aims to analyse the seed industry with focus on maize and on the differences between multinational firms and local companies. Its main contribution is to provide key information on the industry structure, firm-level business conduct and performance of seed companies. The results can be used to design appropriate policy support for small local companies in the development of the seed industry of Thailand as well as other developing countries.

2. Methodology

The scope of maize seed industry in Thailand was given to field maize, excluding waxy corn and sweet corn. The companies included were private companies that not only multiply, distribute and market seeds (trading firms) but also engage in R&D or have some research programs and participate in technology development (i.e. technology firms). Their extent of research involvement could range from participating in field trials of public varieties to fully engaging in breeding, varietal and seed technology development.

Structure, conduct, performance framework

There are several indicators suggested by Lipczynski and Wilson (2001) and Carlton and Perloff (2015) to analyse market structure, conduct and performance. Due to limited publicly available data, industry experts from the Thai Seed Trade Association (THAS-TA), Seed Association of Thailand, NCSRC, and DOA were interviewed to obtain information on industry environment and firms' business practices. The information complemented the quantitative analysis.

Market structure

Market concentration, a measure of uneven distribution of market shares of firms in an industry, is one of the most common indicators used in empirical studies. Concentration Ratio (CR4) (or CR8) and Herfindahl-Hirschman Index (HHI) are often used to illustrate market structure and the market power of seed industry (Spielman and Kennedy, 2016; Fernandez-Cornejo and Just, 2007; Morris, 1998; OECD, 2018;). Because sales and volume of seed sold by individual companies in Thailand are not publicly available, seed sales volume (Aungsuratana et al. 2012, cited Department of Business Development) was used to estimate CR4 and HHI. The larger the concentration ratio of the four largest firms, the lesser or lower the level of competition. The interpretation of market concentration by HHI is based on the U.S. Department of Justice's Horizontal Merger Guidelines (U.S. Department of Justice, 2018). A market is considered moderately concentrated if the HHI is between 1,500 and 2,500 and highly concentrated if it is above 2,500.

$$CR_4 = \sum_{i=1}^4 S_i$$

where S_i is the market share of the four largest company i .

$$HHI = \sum_{i=1}^N S_i^2$$

where S_i is the market share of the company i and N is the number of companies.

Additionally, product similarity and differentiation are used to describe the structure of the maize seed



market. Production information from the Multilocation Public-Private Yield Trial (MPPYT) program of multiple geographical location field trials were used to compare product characteristics. The MPPYT is a cooperative hybrid corn trials program between public sector represented by Kasetsart University, National Corn and Sorghum Research Centre (NCSRC), and Department of Agriculture (DOA) and private seed companies (FAO, 2013). It covers pre-commercial and commercial elite hybrids voluntarily submitted by private seed companies to jointly, without bias, evaluate and compare maize hybrids available for commercialization (Richmond, 2003). The MPPYT conducted by the National Corn and Sorghum Research Center (NCSRC) have provided the maize seed industry with trusted results since 1987. Barriers to entry and exit and enabling environment are also discussed.

Business conduct

Seed business conduct included in this study covers product promotion and pricing strategy, price discrimination, collusion, quality assurance and product compensation (Pepall et al., 2008; Carlton and Perloff, 2015). Maize seed prices were obtained from an unpublished nation-wide market survey of two multinational seed companies. The information was provided through personal request. Price data of small local seed companies and of public suppliers were obtained from interviews with owners of seed companies and public officers. All seed prices are recommended prices for agrodealers and did not include discounts.

Business performance

Profitability is commonly used to measure business performance. In addition, it is assumed that seed companies' objectives include their market power or ability to control market power, efficiency and growth of business operation. Due to limited data especially of small firms, other performance indicators such as growth in market share and market value addition, customer and stakeholder satisfaction could not be generated. Seed companies' business data were obtained from the Department of Business Development (2018).

Market power: Price-Cost Margin (PCM)

If data on marginal cost cannot be obtained from

company financial reports, Price-Cost Margin (PCM) and accounting rates of profit on capital can be used to measure profitability of the companies (Lipczynski and Wilson, 2001). Lerner index is conceptually used to measure the monopolistic power. Given that the Lerner index $= \frac{P-AC}{P}$, and on the assumption that average costs are constant, the price-cost margin (PCM) is equal to the Lerner index. The PCM is defined as the ratio of profit to sales revenue and can be expressed as

$$PCM = \frac{P-AC}{P} = \frac{P \cdot Q - AC \cdot Q}{P \cdot Q}$$

where P is price, Q is quantity, and AC is average cost. The larger the price-cost margin, the greater the company's ability to raise prices above average costs, which implies higher monopoly power.

Efficiency: Current Asset Turnover Ratio

The current asset turnover ratio implies the efficiency or how well a company generates sales revenue from its current assets.

$$\text{Current Asset Turnover Ratio} = \frac{\text{Revenue}}{\text{Current Assets}}$$

Profitability: Accounting Rate of Profit

The accounting rate of profit may be used as a proxy for profitability when the data to calculate the economic rates of return are limited. Profitability reflects a firm's ability to generate returns. The accounting rate of profit on capital is defined as follows (Scherer and Ross, 1990):

Accounting Rate of Profit on Capital =

$$\frac{\text{Accounting Profit} + \text{Interest Payments}}{\text{Total Assets}}$$

Growth: sales growth, total asset growth

Business growth demonstrates a firm's ability to increase its size. Even at the same profitability level, increasing its size will increase the firm's absolute profit. A larger size can also bring economies of scale and market power, leading to an increase in future profitability. The growth is calculated from 2012, the year the market shares are used to calculate market concentration, to 2018. For companies that had been restructured or taken over during this period, the corporate data in 2012 were of the old companies.



Sales growth =

$$\frac{[\text{Net revenue 2019} - \text{Net revenue 2012}]}{\text{Net revenue 2012}} * 100$$

Total asset growth =

$$\frac{[\text{Total asset 2019} - \text{Total asset 2012}]}{\text{Total asset 2012}} * 100$$

3. Results and discussion

Market structure

Market concentration

The market structure of the maize seed industry in Thailand can be characterized as two-tiered. The first tier consists of a small number of multinational companies engaged in the upstream segment i.e. germplasm collection and conservation and breeding program to multiply, distribute and market seeds in domestic and international markets. These include five leading multinational companies. Four of them, Monsanto, Syngenta Seeds, Pacific Seeds, and Pioneer Hi-Bred, are subsidiaries of foreign companies. Only Charoen Pokphand (C.P.) Seeds¹ is a Thailand-parent multinational company. The second tier consists of many small local companies supplying specialised products. Fulton and Giannakas (2001) found that many local seed companies that developed seed for a specific geographical market had been taken over by multinational companies. The latest acquisition was

in early 2014, when Seed Asia, a local seed company that had a breeding program, was taken over by Limagrain in early 2014.

The CR4 and HHI calculated from market share obtained from Aungsuratana et al. (2012) (Table 1) were 76% and approximately 1,700, respectively. This suggests that the maize seed market is oligopolistic and moderately concentrated. Using the expert elicitation method of most adopted varieties in 2013/2014 cropping year, Napasintuwong (2017) found that CR4 and HHI of maize seed industry were 65% and 1,230, respectively. A more recent analysis of data, in 2016, found that CR4 and HHI of maize seed market in Thailand were 91% and 2,244, respectively (OECD, 2018). Although these studies use different sources of data and methods of obtaining the estimates, the results are consistent: both suggest that Thailand's maize seed market is oligopolistic and moderately concentrated. Evidently the global seed market has become more concentrated over the years, which can be attributed to the mergers and acquisitions. In 2015, Pacific Seeds was taken over by Advanta Seeds and in 2016, Monsanto was bought by Bayer and Syngenta Seeds by China National Chemical. Although these acquisitions did not change the number of key multinational companies in Thailand, their access to technology and broader germplasm collection would have boosted their capacity to compete in the local and international markets. Furthermore, although concentrated markets do not necessarily imply the

Table 1. Sales and market share of leading maize seed companies, 2012

Company	Sales (ton/year)	Market share (%)
Monsanto (Thailand)	4,718.80	23.500
Charoen Pokphand Seeds	4,216.80	21.000
Syngenta Seeds	3,202.80	15.950
Pacific Seeds	3,182.70	15.850
Pioneer Hi-Bred	2,841.30	14.150
Others	1,917.60	9.550
Total	20,080.00	100.000

Note: Pioneer Hi-Bred is a subsidiary of Dupont Pioneer

¹ Charoen Pokphand maize seed division was part of Charoen Pokphand Group, a large agro-conglomerate. It was operated under C.P. Seeds and moved to Charoen Pokphand Produce which consists of several businesses including fertilizers and crop protection chemicals.



presence of market power, they may create higher barriers to entry and impose a cost disadvantage to potential entrants and existing firms (Maisashvili et al., 2016)

Product differentiation/similarity

Table 2 compares the characteristics of pre-commercial and commercial maize hybrids in the market in 2018 (National Corn and Sorghum Research Center, 2019). The upper section of the table are the results of the MPPYT. Varieties were selected by participating companies as the best hybrids about to be released or have been released to the market. The varieties submitted by Kasetsart University were also available for licensing to local companies. The performance of the seeds from the MPPYT is apparently better than farmers' field trials, and seeds from the five largest multinational companies tend to outperform those of the local companies and new foreign subsidiaries.

Nakhon Sawan-3 (NS3) developed by DOA was a good representative of a commercial public maize variety. It is considered competitive to privately developed varieties (Napasintuwong, 2017). DOA gave the authorization to local companies to non-exclusively produce NS3 for commercialization so that numerous local trading companies, that do not engage in any R&D, have gone into the production of NS3 seeds with the technology transferred from the public sector. Although farmers have a wide range of seed products under different brand names and trademarks, the range of product differentiation is much narrower because the same or similar products are marketed under different brand names by small local companies. The comparison of varieties across seed companies reveals that product characteristics vary from yield and number of ears, to resistance to diseases, which resulted in performance ranging from rotten ear to farmers' preferred traits, such as low lodging and high standing, low moisture content and high shelling percentage. Each company tended to develop varieties suitable to specific market segments such as uplands, dry zones, drought-prone, downy mildew-prone (most private varieties are susceptible to this disease), and preferred size of seed for planting machines, which affect farmers' adoption choices. Generally, private varieties perform better than the public varieties especially on yield and resistance to

diseases but products are suitable to specific market segments such as climatic condition, geographical area, season, and harvesting technique (Napasintuwong, 2017); however, the public varieties (especially NS3) are more resistant to downy mildew disease and well-adapted to broader market segments.

The role of R&D, both by private companies and public institutes, is important to the development of seed business (Fernandez-Cornejo, 2004) and would be important for creating competitive products. As the seed market becomes increasingly consolidated, it could result in lower investments in traits such as varieties adapted to local conditions (Howard, 2015), and negative impacts such as limited farmers' choices of varieties (Schimmelpfennig et al., 2004). Thus, public support plays an important role in promoting product innovations and differentiation of products to meet farmers' needs, such as providing access to public germplasm or open source seeds, which discourage restrictions on intellectual property protections (Luby et al., 2015). Licensing, either exclusive, partially exclusive or non-exclusive, is one of possible models to promote private-private agricultural research (Fuglie and Toole, 2014). The result from this study shows that small local companies could remain relatively competitive in the same market with larger multinational firms and provide seeds needed for broad local adaptation, as in the case of NS3.

Barriers to entry and exit

A critical barrier to entry and exit is the initial investment. Technology in seed business, especially crop improvement, demands high investment cost. During the early stage of seed market privatization in the late 1970s to early 1980s, the initial investments in establishing research stations of multinational seed companies were about two to five times larger than that of the Thai-parent multinational company (presently, Charoen Pokphand Produce) (Suwantaradon, et al., 1989). Other key barriers to entry were research funding, human capacity in varietal improvement and access to germplasm. The multinational companies have a greater advantage over the small local companies in terms of capital and broad collection of genetic materials (Napasintuwong, 2014). During the 1980s, the early entrants also developed partnerships and strong linkages with international organizations


Table 2. Characteristics of maize seed varieties, 2018

From cooperative hybrids corn yield trial from 12 locations									
Company	Variety	Yield (kg/ha)	Height (cm)		Plant stand (number)	Rotten ear (%)	Ears/100	Moisture (%)	Shelling (%)
			Plant	Ear					
5 Largest multinational companies									
Charoen Pokphand	TSF1603	10,042.3	215.9	128.5	49.6	4.6	97.9	25.8	82.7
Charoen Pokphand	TSF1708	9,560.5	225.7	133.9	50.4	3.2	96.8	26.4	81.3
Charoen Pokphand	TSF1717	8,547.5	219.3	130.6	49.9	3.8	95.7	25.6	82.4
Charoen Pokphand	CP888	7,817.3	224.5	148.9	49.7	3.7	106.2	23.0	81.4
Monsanto	DK9950C	10,197.6	226.5	138.5	49.8	4.2	100.7	26.5	83.6
Monsanto	DK9919C	9,712.4	220.1	133.1	51.2	3.8	98.7	25.2	81.4
Pacific Seeds	PAC164	9,945.8	207.8	126.1	50.1	4.0	97.0	26.5	85.6
Pacific Seeds	PAC139	9,455.6	202.3	125.6	49.7	6.7	96.5	26.0	85.2
Pioneer	P4084	9,749.5	242.6	134.6	50.3	6.3	99.1	25.1	82.1
Pioneer	P3875	9,400.1	234.1	136.6	50.1	10.2	97.3	25.9	80.3
Pioneer	P3582	9,345.3	236.0	135.0	50.1	6.7	95.2	26.9	80.3
Syngenta Seeds	ST6275	9,949.6	225.8	147.0	50.4	6.0	100.6	25.8	84.3
Syngenta Seeds	STG246	8,560.8	233.9	150.3	51.1	3.1	97.6	25.8	81.3
Avg of multinational companies		9,406.5	224.2	136.1	50.2	5.1	98.4	25.7	82.5
Local and new foreign subsidiaries									
Fertilizer and Bioseeds	BD330	9,688.7	234.8	142.8	50.4	9.5	100.5	25.8	80.0
Fertilizer and Bioseeds	BD51450	8,890.7	203.9	117.3	50.4	3.0	98.9	26.3	82.7
Limagrain	LG36.769	9,327.4	220.4	136.2	50.8	3.9	94.9	27.0	81.9
Limagrain	LG38.778	8,804.4	229.6	134.8	50.8	3.7	98.2	25.7	80.5
Northern Seed	NTSX-	8,362.4	220.6	132.9	49.5	9.5	97.4	25.5	78.6
Northern Seed	NTSX-3S68	7,493.9	204.8	129.2	49.1	6.8	98.3	25.5	79.4
World Seeds	HB65	8,367.9	219.4	135.3	49.8	5.5	93.1	25.7	79.0
World Seeds	HB149	7,814.0	231.4	142.2	48.3	8.3	84.6	26.5	81.1
Avg of local companies		8,593.7	220.6	133.8	49.9	6.3	95.7	26.0	80.4
Public									
Dept of Ag	NS3	7,843.3	214.4	135.3	49.4	3.0	99.4	23.5	80.8
Avg of public		7,843.3	214.4	135.3	49.4	3.0	99.4	23.5	80.8
From 30 locations of farmers' field trials, 2018									
5 Largest multinational companies									
Charoen Pokphand	CP888	5,834.1	214.5	120.0	48.3	3.5	45.8	19.8	83.7
Syngenta Seeds	ST6275	7,492.8	215.5	116.9	50.6	2.1	48.4	21.1	87.1
Syngenta Seeds	STG246	7,023.3	218.0	118.9	50.5	4.2	47.2	22.1	85.1
Avg of multinational companies		6,783.4	216.0	118.6	49.8	3.2	47.1	21.0	85.3
Local and new foreign subsidiaries									
Fertilizer and Bioseeds	BD330	7,115.6	218.3	114.8	50.8	4.5	48.4	21.7	84.0
Fertilizer and Bioseeds	BD51402	6,501.5	204.3	111.1	50.4	3.3	47.9	19.9	86.7
Goldconda Asia	GT822	6,884.8	199.2	107.5	49.7	4.1	45.2	21.4	86.6
Goldconda Asia	GT722	6,771.3	202.2	108.7	48.9	5.1	44.5	21.7	85.6
KWS Seeds	KWST7013	7,104.8	210.6	109.3	49.5	3.8	43.6	21.7	87.1
KWS Seeds	KWST7014	6,644.3	213.3	117.0	48.4	3.9	44.9	21.1	86.5
KWS Seeds	KWST306	6,020.2	223.6	113.0	46.0	4.1	42.6	19.3	83.0
Limagrain	LG38.778	7,207.8	212.1	120.0	49.8	3.8	47.4	21.8	84.5
Limagrain	LG36.769	6,401.5	212.8	111.6	49.6	4.1	44.6	23.0	85.2
Northern Seeds	NTSX6A28	6,255.3	208.0	105.1	48.5	4.8	43.4	21.6	82.9
Northern Seeds	NTSX9S68	6,172.1	199.9	103.6	48.1	3.3	44.2	20.8	84.4
Avg of local companies		6,643.6	209.5	111.1	49.0	4.1	45.1	21.3	85.1
Public									
Dept of Ag	NS3	7,843.3	214.4	135.3	49.4	3.0	99.4	23.5	80.8
Kasetsart Univ	KSX6110	8,913.7	228.3	150.5	49.5	6.5	94.4	27.1	79.1
Kasetsart Univ	KSX6015	8,131.5	208.1	132.0	49.9	2.9	93.9	24.9	81.5
Avg of public		8,296.2	216.9	139.3	49.6	4.1	95.9	25.2	80.5

Source: National Corn and Sorghum Research Center, 2019

(i.e. CIMMYT, USAID), and public organizations (i.e. DOA, Kasetsart University) in breeding, yield trials, and extension (Brown et al., 1985; Ekasingh et al., 1999). These relationships would have favoured their business operations through their influences on regulations on seed standards and registration of



new varieties that make it difficult for new entrants especially small local companies to enter the market. On the other hand, as the market became consolidated by multinational companies, the barriers to entry did not pose much of a challenge for large multinational seed companies. For example, KWS, a large German seed company entered Thailand's maize seed market in 2015 when major maize seed companies have been operating for decades. Earlier, in 2014, Limagrain, a large French seed company, took over Seed Asia, a local company.

Large seed companies are often vertically integrated (e.g. with feed) and horizontally integrated (e.g. with agrochemicals). The integration can create more market power and stronger barriers to entry. For instance, seed companies that also have a feed manufacturing business can reap a higher market share from their seed products. Charoen Pokphand Produce used to buy higher price maize grain produced from their seeds (visibly orange) thus gaining more market share. Currently, there is a government program to promote maize cultivation after rice harvest in the dry season. Large seed companies that have an integration and those that have a business link with feed manufacturers that arrange to buy maize grains from their seed sales, are especially considered for government support, leaving other companies without access to the same support.

Enabling environment/regulations

Thailand's Board of Investment (BOI) has been providing incentives for companies that conduct research using biotechnology or engage in plant breeding, by providing 8-year and 3-year corporate tax exemption, respectively (Thailand Board of Investment, 2019). While large companies employing biotechnology in plant breeding can benefit from this support, small companies with limited capital but involved in plant breeding can also benefit from the support, although to a lesser extent. This policy gives both small and large companies the opportunity to enter the seed industry, which can make the industry more competitive.

Important regulations like the Plant Variety Act (PVA) or Seed Act and the Plant Variety Protection Act (PVP) are shaping the structure of the industry. The

PVA regulates the quality of seeds at all stages, from production to sales and distribution, including imports and exports. Registration of varieties is required for all commercial collections and sales of maize seeds, and only protects the rights to use the varietal names and trademarks. The production and sale of seeds of regulated plant varieties are subject to minimum quality standards, such as purity and germination rates for maize (98% and 75%, respectively) (Ministry of Agriculture and Cooperatives, 2006). The penalty for selling substandard seed is either a one year of confinement, a 2,000 THB fine or both. Enforcement, however, is non-stringent, which practically consigns the small local companies to the low-quality market segment. As it had been observed, for example, NS3 is sold at a much lower price by small companies than large companies with better quality seeds (discussed in the following section).

The PVP protects the rights-holders of newly developed plant varieties (following distinctness, uniformity, and stability or DUS principles) by giving the sole right to produce, sell or distribute, import, export, or possess them for the above mentioned purposes. However, it only protects varieties that have been developed after the regulation came into effect in 1999. Seed imports purely for the purpose of registering PVP are not considered R&D and the subject plant variety must be grown in Thailand for examination. Seed imports for the purpose of trials still require a permit, which has been a major obstacle due to the lack of cooperation between the authorities. It was found that most commercial maize varieties are not registered under PVP. This may be the result of the new varieties developed by large multinational companies being in the market for only a few years before these are replaced with newer products. In addition, for PVP to be granted, imported seeds for research must fulfil both PVP and PVA requirements, which invalidates the varieties bred and developed outside of Thailand by foreign companies.

Thailand's maize seed industry is oligopolistic, but product differentiation and market segmentation have lessened the market power of large companies, especially with public support in providing the parental lines without a royalty fee to small local companies.

Business conduct



Price discrimination

Price discrimination occurs when firms with monopolistic power, who know their demand curve and the willingness-to-pay of consumers, maximize their profit by setting different prices. The third-degree price discrimination or group pricing happens when firms quote the same price per unit to all consumers within a particular group, and consumers in a particular group decide how much to buy at the quoted price (Pepall et al., 2008). It was found that the same product variety is sold at the same price across groups of farmers regardless of their location. However, in some cases, such as during the drought season when farmers replant their crops and during the second cropping season (dry season), some companies lower the price to increase their market share. Furthermore, a quantity discount is given to dealers based on sales volume and on different credit period.

Table 3 shows hybrid maize seed prices by product groups. The grouping was constructed by market analysts of multi-national seed companies. The products in competitive pricing are lower in performance such as yield and offered at lower prices. Standard products are products that are suitable for broad market segments and usually have been in the market for a period of time. Premium products are products that offer farmers superior characteristics, such as long-period standability, high yielding, drought resistant and disease resistant; these are for specific market segments that are willing to pay a higher price. (In this group, seed treatment such as coating to prevent fungus and increase germination and yield are sold at premium price). The last group, newly released varieties, is sometimes priced relatively low to gain market recognition and then priced higher after one or two seasons. Local companies generally offer lower performance products at lower prices than multinational companies. There are numerous local companies that do not conduct any breeding program nor sell licensed products from other companies or private breeders. These companies are typically very small and depend solely on public varieties. NS3, for example, is sold at different prices and under different trademarks. The price of NS3 sold by the DOA is 70

THB/kg while prices of NS3 set by other companies typically depend on the quality of products, such as purity and germination rate. This pricing strategy suggests that farmers are segmented based on their production environment and their willingness to pay for quality. Most seed companies offer differentiated products at different prices for different market segments. The cost of seed is only about 10-20% of the cost of maize production², and the output depends heavily on the characteristics of varieties. Farmers who are willing to pay a higher price are those who expect higher product quality and yield. This suggests that competitive pricing may be a good market strategy for companies that offer lower product quality, although monopolistic pricing may also be another market strategy, especially by leading companies that have large market shares and a high capacity for product innovation.

Quality assurance and product compensation

As mentioned earlier, the PVA sets minimum standards for seeds. While large multinational companies operate a production control system from seed production to seed processing, small local companies have a weaker control system resulting in lower quality and sometimes sub-standard products. The standards such as germination rate of some large companies are set above the PVA standard to position their products in a premium market segment. When claims of poor quality (such as low germination rate) are lodged against the products of large companies, they usually take responsibility by compensating their customers fully or partially, depending on the situation, to secure customer loyalty. Small companies typically do not provide any compensation or acknowledge complaints about poor quality products; sometimes they also change the product name and packaging without any change in quality. Their strategy is to gain as much sales as possible without regard to long-term market loyalty.

Collusion

Collusion in the maize seed market is not obviously observed as products are differentiated. Nevertheless, a group of small producers in Phrow district in

² Estimated based on maize seed market prices and seed rate of 18.75 kg/ha, and a survey of the cost of maize production by the Office of Agricultural Economics, 2013.



Chiang Mai province producing NS3 agrees to set the price of their products at 120 THB/kg or higher. The member producers of this group benefit from complying with certain agreements such as sharing market information and facilitating PVA registration, which may be difficult for small companies to handle. The price is set so that the group can ensure quality control and that substandard seeds are not sold at a lower price in unauthorized markets.

Industry performance

The PCM reflecting the market power of the firms reveal that generally, the five largest multinational companies have more market power than the local companies or new subsidiaries (Table 4). Among the leading companies, Charoen Pokphand Produce has less market power than the foreign subsidiaries. From broader genetic materials, foreign companies gain a greater advantage over the local companies in developing improved varieties and superior products. Monsanto, Syngenta Seeds and Pacific Seeds may be considered innovative firms as they have released new varieties and filed for plant variety protection (Plant Variety Protection Office, 2019). Monsanto also licenses their hybrids to other companies such as Charoen Pokphan Produce. On the other hand, Limagrain, a large French seed company that took over Seed Asia in 2014, currently has a very small market share and much less market power than other local companies. This could be because the synergy of the two companies has yet to manifest, and their development of new products is behind the leading companies.

Typically, local companies depend highly on public variety development (NS3) and engage in R&D at a much lesser extent than large multinational companies. Golconda Asia and World Seeds have participated in the MPPYT (Table 2), implying that the companies also have conducted R&D. Although their market power is lower compared to foreign multinational companies, their PCM is better than other small local companies. In addition, as mentioned in the market structure section, the maize seed industry is segmented, and companies' pricing strategy shows differentiated products. Assuming that local companies operate in the same market segments, Golconda Asia has the largest market power in these segments among local companies and even larger

than some leading companies in other segments.

The accounting rate of profit on capital, which is the representation of profitability, shows that although local companies have less market power, their profits are satisfactory. Limagrain, however, is not profitable. Given that it has promising growth in assets, the company may take time after acquisition to bring the products from the application of their knowledge and advanced technology to the requirements of the Thai market. Companies that have high technological capacity appear to have relatively high profitability and strong market power.

Based on current asset turnover, companies can effectively generate sales from current assets by relying on public R&D and good public varieties, or by buying licensed products from large companies (e.g. Charoen Pokphand Produce licensed from Monsanto) or from other private breeders (e.g. Premier Seeds and World Seeds). Evidently these companies have a high current asset turnover compared to other companies, but their market power is limited. In the early stage, local companies may rely on the benefits from licensed products to generate profits and accumulate total asset, but in the long run they may need to invest more in R&D and have their own competitive products. The role of DOA and NCSRC in facilitating cooperative yield trials is crucial in bridging the gap between local companies and multinational companies. The local companies can learn from this program and exploit opportunities in the market through a better understanding and use of existing technology and competitors' available products.

In addition, business cooperation between public institutes and local companies can potentially be enhanced. Public research institutes (i.e. Kasetsart University) have provided basic research outputs such as pre-commercial parental lines to local companies (i.e. World Seeds) that have limited capital to conduct full R&D. Local companies can select potential products for their segmented markets and extend the research to multi-location field trials themselves. The results of seed companies' performance imply that small local companies, although with limited market power and efficiency, can profitably compete in the market with multinational companies. Overall, the maize seed industry is performing well, generating profits and efficiently generating returns from current


Table 3. Hybrid maize seed price in Thailand, 2019

Product group	5 Largest companies	Product	Price	Small local and	Product	Price
Competitive	Charoen Pokphand	CP801	87	Goldconda Asia	GT029	120
		CP888	141	Limagrain	TF222	150
	Pacific	Pac559	120	Premier	SA282	140
		Pac129	120		Premier56	80
		Pac139	139		Permier555	135
	Pioneer	P4084	150	World Seed	3355	120
		P4124	150		3399	120
	Syngenta Seeds	NK106	137			3377
		NK6172	137			
	Average			131.22	Average	
Standard	Charoen Pokphand	CP888n	171	Goldconda Asia	GT709	177
		CP301	171		GT722	177
	Monsanto	DK9955	178	KWS	KWS2211	168
		DK9901	178		KWS7304	175
		DK7979	178		KWS8933	179
	Pacific Seeds	Pac339	192	Limagrain	LG778	175
		Pac999	185	Premier	Permier246	170
		Pac777	185		Permier518	175
	Pioneer	30B80	180		Premier515	160
		P4546	189			
Average			180.70	Average		172.89
Premium	Charoen Pokphand	CP508	183			
		CP303	183			
	Monsanto	DK9898	182			
		DK9919	187			
		DK6818	183			
	Pacific Seeds	Pac779	190			
		Pac789	195			
	Pioneer	P3582	189			
		P4546	199			
	Syngenta Seeds	S7328	189			
Average			188.00	Average		n/a
New products	Charoen Pokphand	CP639	183			
		CP640	183			
		CP640	183			
	Monsanto	DK9950	182			
	Pacific Seeds	Pac278	192			
	Pioneer	P4554	180			
	Syngenta Seeds	S6248	189			
		NK6253	192			
		NK6275	197			
Average			186.78	Average		n/a
Public variety				Dept of Ag	NS3	70
				Mae-Sot Ag	NS3	120
				Coop		
				Phrow seed	NS3	120
				producer group		
				Small local enterprises	NS3	60
Average						92.5

Source: Unpublished seed companies' market survey

Note: KWS Seeds entered Thailand market in 2017, and Limagrain took over Seed Asia in 2014

NS3 is sold by small companies by different brands and trademarks from 45-120 THB/kg

Average price of maize grain in September - October 2019 = 8.38 THB/kg

Bank of Thailand exchange rate Q1-Q3, 2019: 1 Euro = 35.17 THB

assets. The market power of leading firms is higher than small firms, but considering different market segments, small firms can also acquire a high market power. This implies that the oligopolistic structure leaves room for competition for local companies. With

support from government in providing knowledge and pre-commercial lines and licensing from private breeders, the local companies can generate profit, accumulate growth in sales and assets and remain competitive in the market.



4. Conclusion

Following the success of the maize seed industry development in Thailand, the Government has set its sights at making the country the Seed Hub of the region. The analysis of the structure, conduct and performance of maize seed industry in Thailand

reveals that the industry is oligopolistic and moderately concentrated. The trend of the global seed industry is towards more concentration, with mergers and acquisitions by large multinational companies. This may affect the competitiveness and performance of local companies in the future. Although local companies, so far, have been able to generate profits effectively by relying on public released varieties

Table 4. Thailand's maize seed industry performance, 2018

Company	Price-cost margin	Accounting rate of profit on capital	Current asset turnover	Growth in sales (%)	Growth in total asset (%)
5 largest multinational companies					
Charoen Pokphand Produce	0.043	0.079	1.839	97.273	84.343
Monsanto Thailand	0.124	0.116	1.265	9.735	35.193
Pacific Seeds (Advanta Thailand)	0.299	0.252	0.938	100.195	140.268
Pioneer	0.210	0.109	0.780	0.353	45.888
Syngenta Seeds	0.173	0.118	0.714	42.340	135.656
Local companies and new subsidiary					
Goldconda Asia	0.148	0.103	1.019	532.645	1,933.747
Limagrain (Seed Asia)	-0.662	-0.143	0.437	- 36.721	60.626
Premier Seeds	0.087	0.112	1.977	8,210.708	4,586.091
World Seeds	0.095	0.091	1.536	36.739	758.739

Source: Calculated from Department of Business Development (2018)

Note: Growth rates are calculated from 2012 to 2018 except for Limagrain, growth rates are from 2013 to 2018.

Seed Asia was taken over by Limagrain in 2014.

Pacific Seed was taken over by Advanta in 2015.

Monsanto was taken by Bayer in 2016.

Syngenta was taken by China National Chemical in 2016.

Goldconda Asia operated as C.M. Seeds before 2017.

and licensed products, these may not be enough to sustain their profitability. Although local companies have had significant growth in sales and total asset during the past several years, it is suggested that they try to gain market recognition and profits by building up technological capability to generate competitive products, investing in their own R&D programs and taking part in collaborative research programs with public institutes. Small companies that have limited capital or new entrants may acquire licenses i.e. parental lines from research institutes to generate unique and competitive products. It is important for the government to upgrade the capacities of local companies so that they come up with innovations

and produce Thai-brand name products to compete with multinational companies. The future of the Seed Hub policy depends much on the capacity of Thai companies to remain competitive in the seed market. Aside from tax incentives, the institutional arrangements to support public-private R&D can further be improved. For example, as suggested by Fugle and Toole (2014), public sector may invest in basic research and transfer technology to private companies to develop into products; other strategies such as forming a consortium consisting of small local seed companies and public institutes to jointly develop products with traits adapted to specific segments, and government loans and grants to support potential



seed companies in building technological capacity should be considered.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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