7-2019

Catching up with the 'core': The nature of the agricultural machinery sector and challenges for Chinese manufacturers

M. T. SAFDAR

Terry VAN GEVELT
Singapore Management University, tvangevelt@smu.edu.sg

The Journal of Development Studies

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/fjds20

Catching Up with the 'Core': The Nature of the Agricultural Machinery Sector and Challenges for Chinese Manufacturers

M.T. Safdar & Terry van Gevelt

To cite this article: M.T. Safdar & Terry van Gevelt (2020) Catching Up with the 'Core': The Nature of the Agricultural Machinery Sector and Challenges for Chinese Manufacturers, The Journal of Development Studies, 56:7, 1349-1366, DOI: 10.1080/00220388.2019.1632435

To link to this article: https://doi.org/10.1080/00220388.2019.1632435

The Journal of Development Studies, 2020
Vol. 56, No. 7, 1349–1366, https://doi.org/10.1080/00220388.2019.1632435

Catching Up with the 'Core': The Nature of the Agricultural Machinery Sector and Challenges for Chinese Manufacturers

M.T. SAFDAR* & TERRY VAN GEVELT**
*Centre of Development Studies, Department of Politics and International Studies, University of Cambridge, Cambridge, UK, **Department of Politics and Public Administration, University of Hong Kong, Hong Kong, Hong Kong SAR

(Original version submitted March 2018; final version accepted June 2019)

ABSTRACT *The current era of globalisation has been accompanied by China's rise as a major economic actor. Chinese firms are expanding their presence globally and are seeking to 'catch-up' with firms in developed countries across different sectors. This paper uses China's agricultural machinery sector as a vehicle to examine the challenges faced by firms from developing countries in their effort to catch-up with 'core firms'. Chinese firms operating in the sector struggle to compete with a small number of dominant core firms based in developed countries. These core firms are sectoral leaders with a global presence. They are continuously strengthening their competitive advantage using diverse strategies, including: investing in R&D, focused acquisitions and developing relationships with actors internal and external to agriculture. The challenge of catching-up for Chinese firms in the sector has further increased as developed countries seek to protect firms in strategic sectors like agriculture. By examining the changing nature of the agricultural machinery sector, and the role of core firms, the paper highlights the substantial barriers facing Chinese firms in their efforts to catch-up. This paper has important implications, as it shows that even if firms from developing countries enjoy state-support, they will increasingly struggle to catch-up.*

1. Introduction

The current epoch of capitalist globalisation has seen the re-emergence of China as a major global power. Concomitant with China's impressive growth has been an increase in the number of large domestic firms. Across many sectors, these firms seek to catch-up with dominant 'core' firms that capture the higher value-added segments of the market (Duysters, Cloodt, Schoenmakers, & Jacob, 2015; Zheng, Wei, Zhang, & Yang, 2016). As part of its 'Made in China 2025' policy, China has identified the agricultural machinery sector as one of its focus areas with plans to consolidate the sector through the development of five globally competitive firms (ITA, 2015). We use the case of China's agricultural machinery sector as a vehicle to examine the challenges faced by Chinese (and other developing country) firms in their efforts to catch-up with core firms.

Despite China being the largest manufacturer of agricultural machinery globally, the sector remains fragmented with Chinese firms struggling to compete with a small number of dominant core firms based in developed countries. These core firms have emerged through an intense process of consolidation and continue to further strengthen their competitive position by investing heavily in research and development, both in developed countries and in large developing countries including China, India and Brazil.

Correspondence Address: M.T. Safdar, Centre of Development Studies, Alison Richard Building, 7 West Road, CB3 9DT, Cambridge, UK. Email: mts36@cam.ac.uk

These core firms are increasingly responding to changing demands of farmers at the apex of shifting agricultural value chains and positioning themselves as integrated solution providers through the development of strategic relationships with leading input suppliers and the strategic acquisition of technology firms that help them provide services in emerging areas, such as precision agriculture and data-driven agricultural solutions (Reibel, 2018). In addition to the further consolidation of the sector by core firms, one of the main mechanisms through which Chinese firms have traditionally sought to catch-up with core firms – the acquisition of firms based in developed countries through mergers and acquisitions (M&As) – has become increasingly constrained due to hostility from developed countries in sectors deemed as strategic for national security (Mullen, 2016).

By examining the changing nature of the agricultural machinery sector, we bring to light the non-trivial barriers facing Chinese firms in their efforts to catch-up with core firms. These are important findings, as they suggest that even if firms enjoy significant state-support, firms based in developing countries will increasingly struggle to catch-up and remain near the bottom of the value-chain.

This article is organised as follows. In Section 2, we draw on the global business revolution (GBR) framework to examine the impact that globalisation has had on the agricultural machinery sector and identify the mechanisms through which core firms have come to dominate the sector. In Section 3 we provide an overview of the agricultural machinery sector in China. In Section 4 we systematically analyse the challenges facing Chinese firms in their efforts to catch-up with core firms. In Section 5, we discuss our findings and reflect on the broader implications our findings have on industrial policy in developing countries. Section 6 concludes.

2. Globalisation and the agricultural machinery sector

Globalisation has had a profound impact on the structure of the global economy over the last three decades. To understand how these changes have affected the agricultural machinery sector, we draw on the global business revolution (GBR) framework and analyse how corporate concentration, system integrators and the cascade effect have structured the global industrial sector in general, and the agricultural machinery sector more specifically (Nolan, 2001, 2007, 2014).

2.1. The global business revolution framework

Using insights from heterodox economics and the literature on global value chains, the GBR framework identifies four features that help to understand the evolving nature of competition in different sectors of the global economy: corporate concentration, systems integration, the cascade effect, and the external firm. When applied to individual sectors of the global economy, the GBR framework allows for us to understand what structural changes have taken place across value chains and the effect that these changes have on industrial policy and firm-level upgrading in developing countries.

To date, the GBR framework has been used extensively in analysing firm-level catch-up in sectors as diverse as commercial aircraft (Nolan, Jin, & Chunhang, 2008), the car industry (Nolan, 2012; Nolan & Zhang, 2014), beverages (Nolan 1999; Nolan et al., 2008; Nolan & Zhang, 2014), white goods (Liu, 2005), as well as coal (Nolan & Rui, 2004) and oil (Beyazay-Odemis, 2015; Zhang, 2004). These case studies have found that firms from developed countries dominate the higher-value added segments of these sectors and have highlighted the challenges facing firms from developing countries that operate within the same functional areas.

While the GBR framework is a useful analytical framework to undertake detailed sectoral case studies of the global economy, it has some limitations. Firstly, unlike the Global Value Chain (GVC) literature, the GBR framework does not explicitly address issues of upgrading for supplier firms within value chains. Secondly, the GBR framework can be criticised for being deterministic. Thirdly, studies employing the GBR framework have to date displayed both sectoral and geographic biases. Finally, the theory underlying the GBR framework has been argued to have received inadequate attention.

2.2. Corporate concentration

Increased industrial concentration can be viewed as a function of capitalism. For Marx (1983), the driving force of this concentration was competition among firms contributing to a reduction in the cost of production. In the capitalist system, larger firms have an advantage over smaller firms because of their ability to take advantage of economies of scale in production and to reduce costs of production through incorporating technological improvements in the production process. This difference in costs helps large firms to either take over smaller firms contributing to consolidation or, in other cases, smaller firms to cease to operate due to a lack of competitiveness. What has emerged in recent decades is intense oligopolistic competition between large firms in different sectors (Chandler & Hikino, 1997; Nolan & Zhang, 2014). The advantages enjoyed by large firms in both scale and scope have continued to contribute to a situation where many smaller companies have either been acquired by larger firms or have ceased to exist (Chandler, 2005; Keen, 2011).

High levels of concentration are the norm and the process has arguably increased in pace in the last decade. For example, Pryor (2001) finds that the average degree of concentration in individual industries in the United States has increased since the 1980s. Multinational enterprises (MNEs), especially those based in developed countries, are the drivers of this consolidation.[1] The number of MNEs has increased from around 35,000 in the 1990s to approximately 100,000 in 2018 (UNCTAD, 2018). Despite the proliferation of MNEs, a small number of firms dominate. The size of the largest MNEs continues to increase and in 2016 the 100 largest firms had a combined sales revenue of almost 10 per cent of global GDP (UNCTAD, 2018).

Growth in concentration has been driven by a sustained increase in mergers and acquisitions during the past two decades (Nolan, 2014). Firms are using mergers and acquisitions (M&As) as a means of strengthening their competitive positions in their core businesses while seeking to rationalise non-core operations. Leading firms operating in different sectors of the global economy are increasing their market share and growing through M&As (Gereffi, 2014). In 2015, global M&As reached a record level of US$ 5 trillion. Consolidation since the turn of the millennium can be gauged from the fact that the total value of announced mergers and acquisitions globally stood at US$ 20 trillion in the period from 1985–2000. In the post-2001 period, despite the global financial crisis, the value of announced M&As more than doubled to US$ 42.7 trillion (Thomson Reuters, 2018). One of the hallmarks of the current era of consolidation is the increasing importance of mega-deals. In 2016, transactions of greater than US$ 1 billion accounted for around 64 per cent of deals, while in 2017 they accounted for almost 58 per cent of deals (Bloomberg, 2017).

Growing concentration has been accompanied by substantial concentration in innovation and technological progress, with a small number of firms in each sector accounting for a significant proportion of total research and development (R&D) spend. Despite increasing investment in R&D by firms from a small number of developing countries, the drivers of technological progress remain embedded in core firms based in developed countries. These firms leverage investment in technical progress as a major source of competitive advantage (Nolan, 2014). The European Union regularly compiles a ranking of the top 2,500 global firms based on their R&D spend. The Industrial R&D Investment Scorecard (IRIS2500) represents around 90 per cent of total spend on R&D by companies worldwide. In 2017, these firms collectively invested US$ 803.5 billion on R&D. While developing countries account for more than 80 per cent of the global population, there are only 606 firms from low- and middle-income countries and they collectively account for only 15 per cent of R&D spending (IRI, 2018). The IRIS 2500 shows a picture in which technical progress, as measured by resources devoted to R&D, is dominated by a small number of firms based largely in developing countries. The top 100 firms account for 53 per cent of R&D investment, while the bottom 100 companies represent 0.3 per cent of R&D investment. There is a high level of geographical concentration among major R&D investors. Firms based in the US, EU and Japan account for 79 per cent of total R&D investment (IRI, 2018).[2]

2.3. System integrators

The high level of concentration in many sectors of the global economy means that there are a small number of globally competitive core firms that dominate. These core firms have emerged as systems integrators[3] and are at the apex of extended global supply chains. As the winds of creative destruction have swept through the global economy, these core firms have divested non-core operations to focus on core operations. Core operations include product development, final assembly, manufacturing, R&D, marketing and finance (Nolan & Zhang, 2014).

Core firms have moved beyond the traditional boundaries of the firm as they plan, coordinate and regulate activities of the different actors across the value chain. These system integrators form the centre of a complex set of relationships with external suppliers. The competitive advantage of system integrators is increasingly predicated on their ability to co-ordinate and optimise the actions of these suppliers. This ability to coordinate an increasing array of activities within the value chain often gives these firms substantial bargaining power (Nolan, 2002). As production becomes more modular and complex, the ability of core firms to integrate knowledge is crucial as they seek to maintain their competitive position in the face of fierce competition.

2.4. The cascade effect

As mentioned above, system integrators have continued to develop closer relationships with first-tier suppliers. Their procurement scale allows them to coordinate the actions of suppliers within their network (Chandler, 2005). Rather than one-off interactions, the relationship between core firms and first-tier suppliers is one of repeated interactions. This is especially true in the case of high-technology products. As core firms seek to rationalise suppliers and try to reduce transaction costs while maintaining their competitive position, there is an intense and sustained pressure on suppliers to reduce their costs contributing to consolidation within the supplier network (Brusoni, Prencipe, & Pavitt, 2001; Gereffi, 2014). Systems integrators are likely to select the most capable suppliers amongst the pool of suppliers, and foster long-term relationships that can be transplanted across different regions of the world. These long-term relationships are likely to develop with suppliers who have the technological and managerial capability to meet the increasing demands of core firms.

Consolidation among system integrators has a ripple effect across the supply chain contributing to consolidation within each segment of the chain. This results in first-tier suppliers merging and consolidating as they seek to enhance their core capabilities to meet the requirements of system integrators. These first-tier firms in turn pass this pressure on to their supplier network thereby contributing to increasing concentration across the various segments of the supply chain, resulting in a cascade effect (Nolan, 2001, 2014; Nolan et al., 2008; Nolan & Zhang, 2014).

2.5. The external firm

The actions of systems integrators are not confined to the traditional boundaries of the firm but they are at the centre of the external firm (Nolan, 2014). Like a conductor, systems integrators direct the actions of external actors that are a part of extended value chains. The actions of lead firms within these chains is like industrial planning and they select only those suppliers to work with them that are the most capable (Nolan, 2001). While traditional boundaries of lead firms might have ‘hollowed out’ (Nikolova, 2007), systems integrators are at the heart of a vast network of inter-connected firms and can be viewed as the external firm.

2.6. The agricultural machinery sector

The agricultural sector has been affected profoundly by globalisation over the past three decades and the resultant consolidation of the sector by core firms. Indeed, a small number of firms with a global presence, the majority of which are based in developed countries, have come to dominate the sector

(Fuglie et al., 2011). As population and the demand for food increases, this select group of core firms is likely to be responsible for many of the innovations that will result in further improvements in agricultural productivity. Like core firms in other sectors of the global economy, increasing concentration within the agricultural sector results in major challenges for firms from developing countries that seek to compete at the global level. This consolidation is most evidence in the agriculture biotech/agro-chemical sector where there have been multiple mega-mergers/acquisitions[4] between core firms in the sector (FT, 2017).

Downstream, a shift is also taking place in the ownership structure of farms, especially in developed countries and in some major agricultural exporters in the developing world, such as Brazil. In the United States, consolidation of farmland is taking place as the labour force continues to move out of agriculture (Berry, 2015). It is not only the United States that is seeing the emergence of large consolidated farms, as other developed areas such as Europe and Australia, as well as emerging net-agricultural exporting countries in South America and the Black Sea region are likely to follow a similar pattern (Smit, 2012). Consolidation downstream has been possible in part because of technological developments which have taken place upstream in the agricultural inputs sector. These innovations are increasingly allowing for the use of sophisticated information technology-based solutions[5] to be utilised in the farming sector. Not only are these solutions aimed at saving labour costs, but they can potentially allow operators to remotely control multiple farm operations (Anderson, 2017).

2.6.1. The logic of agricultural mechanisation. There has been a sustained increase in the adoption of labour-saving technologies over the last five decades (Clarke, 2008). Agricultural mechanisation in today's developed countries is one of the major achievements of the twentieth century and has played a major role in augmenting farm-level productivity. While the process of farm-level mechanisation is most advanced in the developed world, increasing labour shortages, rising demand for agricultural commodities, and sustainability concerns among major agriculture producers and exporters has contributed to an increased demand for mechanisation in the developing world (Hazell, 2008). Increased mechanisation[6] of on-farm operations, such as land preparation, harvesting and threshing, has contributed to the intensification of agricultural production systems thereby contributing to the increasing production of commodities (Pingali, 2007). Economic growth in major markets, such as China and India, coupled with the commercialisation of agriculture in the developing world is providing further impetus for increasing mechanisation in developing regions (Smit, 2012; Drake, 2015).

2.6.2. The structure of the agricultural machinery sector. Technological advancement and intense oligopolistic competition between large firms has contributed to increasing concentration in the agricultural machinery sector (Reibel, 2018). The sector is also affected by market forces and the cyclicality of agriculture (Bjornson & Klipfel, 2000). Government policies have had a major impact on the structure of the farm machinery sector. In 2015, total global sales of agricultural machinery were more than US$121 billion. Production, trade and sale of agricultural machinery is concentrated in North America and Western Europe, with both regions accounting for 50 per cent of production volume and 48 per cent of sales volume. In terms of unit sales, India and China are the two largest markets for agricultural machinery, however most farmers in these markets remain cost conscious and opt for low-cost and low-technology products (VDMA, 2015).

Agricultural machinery manufacturers can be divided between full-line[7] manufacturers, who produce a complete line of equipment, and more specialised single-line producers. The last three decades have seen major changes in the structure of the agricultural machinery sector with the wide-scale acquisition of single-line manufacturers by full-line manufacturers. The extent of consolidation in the sector can be gauged from the fact that while there has been a sustained increase in the global stock of agricultural machinery, there has been a reduction in the number of full-line manufacturers (Fuglie et al., 2011; Reibel, 2018).

Core farm machinery manufacturers have increased their dominance in the last two decades and the top four firms have progressively increased their market share from 28 per cent to 50 per cent of global sales, while competition at the lower-end of the market has increased (Fuglie et al., 2011; Patten, 2012). It is highly likely that changes taking place in the wider agricultural sector and the broader global economy will contribute to further consolidation in the agricultural machinery sector (Smit, 2012). While developing countries and emerging markets are important growth areas, the US and the European Union still account for a major portion of the revenue of core firms. Table 1 shows revenues of the top five global farm machinery manufacturers and the share of revenue generated from the farm machinery sector. It also shows the regional breakdown of sales revenues from the different geographic regions where these firms operate.

Table 1. Major agricultural machinery manufacturers by total revenue

Firm	Country of Origin	Net Sales (2017) (US$ billions)	Share of agricultural equipment in revenue (%)	Region wise Share in Sales (%)[a]
John Deere	USA	29.74	67.8[b]	US & Canada: 57 Rest of the World: 43
CNH Industrial N.V.	Italy/the Netherlands	27.94	41	Europe/Middle East/ Africa: 52.3 NAFTA: 22.8 Latin America: 11 Asia/Pacific: 13.8
AGCO	USA	8.306	100	North America: 22 South America: 13 Europe/Middle East: 56 Asia/Pacific/Africa: 9
Kubota	Japan	14.73[c]	79.7[d]	North America: 30.1 Europe: 12.1 Asia: 53.7 Others: 4.1
CLAAS	Germany	4.45	100	Europe: 82 Rest of the World: 18

Source: Author's own based on company reports (AGCO, 2018; CNH Industrial, 2018; Deere & Company, 2018; CLAAS, 2018; Kubota, 2017).
Notes: [a]Percentages are based on sales revenues across all divisions that the firms operate in; [b]John Deere reports combined revenues of the agriculture and turf division; [c]Revenue are for fiscal year 2016; [d]Figure includes revenues of industrial machinery used for construction and engines as well.

2.6.3. Reinforcing barriers to entry. Core firms continue to expand their R&D presence in developing countries, especially in emerging consumption centres. On average, the core firms spend more than 4 per cent of their annual revenues on R&D. These research centres are developing products that are in-sync with requirements of farmers in developing countries who are likely to be more cost conscious and have smaller land holdings. For example, John Deere – a core firm – has introduced low-cost and low-powered tractors aimed at rice growers in Southeast Asia, where average landholdings are small. Within the developing world, John Deere's global footprint is most visible in emerging economies and almost all manufacturing facilities in the developing world are in Brazil, India and China, where the company operates a total of 18 plants. The firm has a R&D centre in India where it has developed a cheaper tractor which is being used in India and exported to multiple markets (Rayappa, Tigges, Ghimire, & Mallik, 2015). CNH Industrial, another core firm, has also significantly enhanced its research activities in emerging markets. The company

currently has nine R&D centres in Brazil, India, China and South Africa. CNH Industrial's R&D centre in South Africa is aimed at developing machinery aimed at the African market. The third major player in the farm machinery sector, AGCO, has opened a Future Farm and Global Learning Centre near Lusaka, Zambia to provide on-farm training and expand their product line to meet customer requirements. With extremely low mechanisation rates and a large population working in agriculture, sub-Saharan Africa is seen as an emerging market by the major farm machinery manufacturers (AGCO, 2017). AGCO also operates a dedicated R&D centre in India and in 2015 AGCO opened a new manufacturing facility in China, which includes advanced R&D facilities. Like the other two core firms, AGCO has invested in manufacturing facilities in Brazil, China and India. The company currently operates 13 manufacturing plants in these countries, with the majority of facilities being located in Brazil and China. In India, AGCO products are manufactured by Tractor and Farm Equipment Limited (TAFE), with whom AGCO has a cross shareholding agreement. R&D expenditure by the top 5 firms is shown in Table 2.

Table 2. R&D spending by major agricultural machinery manufacturers

Company	R&D spending 2016/17 (US$ Millions)	Estimated R&D spending on agricultural machinery (US $ Million)[a]	Global ranking (IRIS Scorecard)	R&D Intensity[b]
John Deere & Sons	1,621	1,099	112	5.2
CNH Industrial	1,040	413.9	166	3.5
AGCO	409	409	407	4
Kubota	431	284	335	2.7
CLAAS	263	263	510	5.9

Source: European Commission, 2017 'EU R&D Scoreboard' available at: http://iri.jrc.ec.europa.eu/scoreboard17.html.
Notes: [a]For firms where a breakdown of R&D investment by divisions is not available, the percentage of revenues generated by the agricultural machinery division has been used to estimate the share of R&D resources invested in the agricultural machinery division; [b]R&D intensity is the ratio of the firm's expenditure on R&D to the firm's sales revenue.

Besides investing heavily in R&D activities, the leading farm machinery manufacturers also exercise substantial control over the supply chain. Their high volume of purchase in different locations across the globe means that the leading farm machinery manufacturers have substantial bargaining power with respect to their suppliers. Rather than arms-length transactions, the relationship between core firms and many of their suppliers is one of repeated transactions where suppliers are required to share proprietary information in order to access the supply chains governed by these core firms. For example, in 2012 John Deere spent US$18 billion on procurement with a supplier base of 24,000 vendors. To avoid disruptions in the supply chain, John Deere not only monitors first-tier suppliers, but also second and third-tier suppliers (Christopher, 2018). The firm works extremely closely with around 1,000 first-tier suppliers and has extremely stringent criterion that these suppliers need to adhere to in areas of quality, cost management, delivery, technical support and relationship management (Deere & Company, n.d.). This close interaction is pivotal in helping John Deere manage a complex supplier network and achieve just-in-time production while keeping inventory costs low (Narasimhan, Schoenherr, & Sandor, 2013).

CNH Industrial is also deeply involved in ensuring that first-tier suppliers meet the company's increasingly stringent sustainability guidelines. The company has more than 5,300 direct suppliers globally and in 2015 spent almost US$ 11 billion on purchases from direct material suppliers. CNH Industrial works closely with a small group of 150 first-tier strategic suppliers that account for 60 per cent of the total procurement spend. While the company works primarily with local suppliers that account for 95 per cent of procurement in individual countries, it is highly likely

that much of this purchase, especially critical components, are procured from local affiliates of global suppliers. CNH Industrial launched a Supplier Partnership Programme in 2013 to rationalise the supply chain and develop long-term relationships with key suppliers of critical components and technologies. This can be seen as the emergence of modular relationships between CNH and first-tier suppliers. These relationships are built on a high degree of explicit coordination between CNH and downstream suppliers. This coordination is especially important in the case of high-technology products that require substantial technical know-how and codifiability in information (CNH Industrial, 2017). Turning to AGCO, the company spent a total of US$ 7 billion in 2014 on procurement. Direct purchases accounted for around US$ 5 billion of the total amount and while AGCO has more than 6000 suppliers, only 178 of these suppliers represented 80 per cent of AGCO's total spend on procurement. Concentration in the supply chain is likely to increase as AGCO aims to focus its attention on working with 250 suppliers who represent 90 per cent of total purchases (Kase, 2015; Theissen, Stone, & Schwarz, 2015).

The core firms have taken the role of system integrators as their products incorporate an increasing array of subsystems designed and produced by leading suppliers/vendors. The substantial volume of purchase gives these firms substantial power at the apex of extended value chains and increases the competitive advantage that they enjoy over manufacturers from developing countries.

Core firms have also adopted strategic acquisition strategies and entered into strategic alliances with other leading agricultural input manufacturers aimed at developing integrated farm solutions and utilising big data to transform all facets of agriculture. These core firms are following strategies that expand their industry boundaries. The changing nature of agriculture is also highly visible in the acquisition strategies of these firms with acquisitions focusing on start-ups that can provide the technological capacity to improve farm operations by connecting farm machinery, irrigation systems and soil and nutrient sources, with information on weather, crop prices and commodity prices (Porter & Heppelmann, 2014).

This is illustrated in the acquisition strategy of John Deere, which is a pioneer in promoting precision agriculture. John Deere has successfully moved from a farm machinery manufacturer to one that provides value added agricultural services using real-time data (Perlman, 2017).[8] In 2017, the company acquired Blue River Technology, a start-up based in Silicon Valley that utilises robotic technology and machine learning to ensure optimal use of farm inputs (Deere & Company, 2018). The company also acquired Monosem, a European manufacturer of precision planting equipment in 2016 to further expand its presence in the area. John Deere has also entered into data sharing agreements with leading life sciences/agro-chemical firms including Bayer, BASF and Dupont-Pioneer (Pham & Stack, 2018). John Deere has expanded its presence in emerging markets with the aim to incorporate data-based solutions for farmers. In 2014, the company acquired Auteq Telematica, a Brazilian technology specialist focusing on the sugarcane sector (Deere & Company, 2014). Similarly, the company also teamed up with Syngenta to develop sugarcane planting machinery in Brazil. The planting machinery developed by John Deere is in-sync with the requirements of Syngenta's sugarcane programme (Syngenta, 2012).

Other core firms have also focused their attention on incorporating precision agriculture technologies and on developing strategic relationships with major input suppliers. AGCO, the third largest farm machinery manufacturer, signed a deal with the Climate Corporation, a subsidiary of Monsanto, to incorporate precision planting technology in its planters and in 2017 announced the acquisition of Precision Planting Equipment LLC from the Climate Corporation. The company has been working with other suppliers to deliver solutions that are aimed at improving farming operations. For example, AGCO collaborates with a number of firms including Trimble, TopCon and NovAtel to provide open agricultural equipment guidance systems (AGCO, 2016). Besides the relationships fostered with new technology-based firms, AGCO has also been collaborating with major agrochemical firms, including Monsanto and Dow DuPont. In emerging markets, AGCO has expanded its presence in the

sugarcane value chain by acquiring Santal, a specialised firm based in Brazil manufacturing sugarcane harvesters and other equipment. The company has also forward integrated into grain holding and storage by acquiring GSI, a US-based leading grain storage firm. In 2016, AGCO expanded its presence by acquiring Denmark-based Cimbira, a manufacturer of seed and grain handling equipment (AGCO, 2017). The company is presenting itself as an integrated service provider that can not only provide physical machinery but can also meet data analytics requirements of farmers with mixed equipment suppliers (Pham & Stack, 2018).

CNH has also focused substantial attention towards promoting precision agriculture and improving farmers' access to information, especially in developed markets. CNH has had a long-term strategic partnership since 2003 with Trimble, a leading developer of GPS and precision guidance technology in the US. For Trimble, the relationship means access to CNHs extensive distribution system, while for CNH it means providing highly integrated services to customers and improving high-tech product offerings. Further evidence can be gauged from the licensing agreement between CNH Industrial and The Climate Corporation aimed at incorporating precision planting technology in CNH planters. Developing solutions for remote farming has also emerged as an area of interest for the largest farm machinery manufacturers. The company is also actively pursuing the development of autonomous machines that are being developed in partnership with Autonomous Solutions Incorporated (ASI), a robotics and automation firm based in the US. A further sign of the increasing importance of strategic partnerships in the move towards mainstreaming data driven solutions across farm operations: CNH has recently announced a joint development programme with Microsoft to improve technological services through data collection (Reuters, 2018).

3. The agricultural machinery sector in China

The Chinese government has identified the agricultural machinery sector as one of the focus areas in its Made in China 2025 document. Specifically, the Chinese government has set out a plan to consolidate the sector through the development of five globally competitive firms. The focus of the government on the agricultural machinery sector is largely influenced by the country's ongoing transformation from a traditional, labour intensive sector towards a sector that is more mechanised (Wang, Yamauchi, Otsuka, & Huang, 2016).[9] Such a shift requires moving from traditional small-to-medium sized machinery towards larger, technologically advanced and more powerful machinery (Patton, 2015).

There are several reasons behind this shift. Liberalisation of the country's land tenure system has made it easier to rent or lease land from those who migrate to urban areas (Davis, Bailey, & Chudoba, 2010; Yu & Wu, 2018). Demand for improved diets, concerns around food security along with efforts to improve rural incomes have prompted the government to identify agriculture as a sector for consolidation (Kim, 2018). To this end, the Chinese government is also cautiously supporting the emergence of mechanised, technology intensive large cooperatives and it has taken measures to reform property rights and take advantage of economies of scale (Wang et al., 2016).

An efficient farm machinery sector is seen as vital to achieve the goals of rural revitalisation and increased intensification of production. For example, Kim (2018) notes a commitment to upgrade and transform the farm machinery sector and increase localisation of staple farm machinery. This is a continuation of earlier policy documents that laid out in the government's vision to promote agricultural growth through sustained mechanisation and the creation of larger firms. The government has supported the growth of the farm machinery sector by offering generous subsidies. From 2004 to 2015 the central government allocated RMB 143.5 billion (US$ 22.9 billion) in subsidies for purchasing farm machinery, which was used to purchase 35 million farm machinery units (MOA, 2017; Reuters, 2015). The government has also sought to aid mechanisation by promoting machinery rental centres in rural areas and financial instruments for machinery leasing (Wang et al., 2016).

3.1. Structure of the farm machinery sector

On the back of generous state subsidies, over the last decade the farm machinery manufacturing sector has witnessed double digit growth rates and China has emerged as the largest global farm machinery manufacturer. In 2017, sales revenue of firms above designated size[10] was RMB 429 billion (US$ 61 billion) (MIIT, 2018). Average annual growth rate in the sector exceeded 15 per cent during the decade from 2004 to 2014.

Despite this rapid growth, unlike the global farm machinery sector, the domestic market remains fragmented. Estimates suggest that the five largest firms in the sector account for less than 25 per cent of the domestic market share (US Commercial Service, 2017) with the largest domestic farm machinery manufacturer having sales of US$ 3.8 billion in 2017 (Farmer Daily, 2018). At a time of intense consolidation in the global farm machinery sector, the number of firms engaged in the domestic sector above designated size has increased from 181 in 2008 to 2,429 in 2017 (Yuqing, 2018; Zhang, 2015) and there are almost 10,000 firms reported to be engaged in the sector. Additionally, there are more than 100 overseas farm machinery manufacturers operating in the domestic market. Most small producers in the sector continue to mass produce low-end equipment using technology from the 1970s. The sector also suffers from the use of backward manufacturing technologies and low productivity (CANN, 2018).

Tractors and harvesters are the main products produced in the domestic farm machinery sector with sales of these two product categories accounting for a significant share of sectoral revenue (Yunhong, 2018). Within these two product categories, a small number of domestic manufacturers have been designated as 'backbone enterprises'. In tractor manufacturing, 17 firms have been given this status whereas 19 firms are classified as backbone enterprises in harvester manufacturing (Yuqing, 2018). Many of these firms have achieved scale economies, however, fragmentation remains a problem, especially in low-end products (NBS, 2017).

State-owned enterprises at the national and provincial levels remain the leading actors in the domestic farm machinery sector. Of the five major tractor and harvester manufacturers, the state is the majority or the minority shareholder in four. Of the firms with SOE shareholdings, the market leader is YTO, which is a subsidiary of the China National Machine Industry Corporation (Sinomach). In 2017, its revenue from agricultural machinery was approximately US$ 934 million with YTO being the market leader in the tractor segment selling 47,000 units (YTO, 2018). The other three firms are Zoomlion, Shandong Shifeng Group Co. Ltd. And Changzhou Dongfeng Agricultural Machinery Ltd. (Davis et al., 2010; Wang & Kimble, 2013). The sole private firm in the five major manufacturers is Lovol, which began operations in 1998 and has expanded its presence in Europe through acquisitions. The firm generates around 47 per cent of revenues from the agriculture sector and in 2016, total revenue was US$ 1.43 billion (IBIS World, 2018; EMIS, 2018). Together, these five firms have a market share of less than 32 per cent in tractor sales. Meanwhile, in the high-powered machinery sector, foreign firms accounted for approximately 80 per cent of the market (Patton, 2015; Tishi, 2018).

The share of local firms has increased in exports; however, it is local affiliates of foreign core firms that account for a substantial portion of the export market. Domestic firms primarily export low-power agricultural equipment to developing countries in South-east Asia, Sub-Saharan Africa and Central Asia and the unit value of exports remains low. In 2016, the value of tractor exports from China stood at US$342 million and small tractors (between 30 to 40 hp) formed the bulk of Chinese exports. Higher capacity tractors (100 hp and higher), which command a higher price, have a relatively small share (8.5 %) in exports (CIN, 2017).

As illustrated in the Table 3 below, it is not only in tractors that the difference between Chinese agricultural machinery and agricultural machinery produced in developed countries is visible. Machinery exported from China commands a far lower average per unit value than Germany and the United States.

Table 3. Exports of selected agricultural machinery products

Machinery	Country	2016 Export Value (US$)	2016 No. of Units	2016 Average Unit Value (US$)
Tractors	China	324,764,960	41,138	7,895
	Germany	3,131,365,489	134,789	23,232
	USA	1,770,906,086	51,725	34,237
Soil Prep. Machinery (Aggregate)	China	585,110,077	N/A	N/A
	Germany	1,182,323,881	N/A	N/A
	USA	599,054,890	N/A	N/A
Soil Prep./Cultivation Machinery	China	287,761,788	2,021,984	142
	Germany	710,966,769	N/A	N/A
	USA	285,412,375	65,109	4,384
Spare Parts	China	228,468,553	92,315,042	2
	Germany	377,701,642	44,972,059	8
	USA	236,195,131	49,985,653	5
Harvesting & Grading Machinery (Aggregate)	China	1,538,011,362	N/A	N/A
	Germany	3,239,975,260	N/A	N/A
	USA	2,867,566,079	N/A	N/A
Harvesting and Baling Machinery	China	275,395,641	191,487	1,438
	Germany	1,933,314,832	70,254	27,519
	USA	1,213,383,072	22,203	54,650
Spare Parts	China	358,432,072	94,588,404	4
	Germany	692,735,442	61,275,255	11
	USA	659,860,976	66,578,890	10

Source: Author's own based on UNCOMTRADE Data, available at: https://comtrade.un.org/ (UN Comtrade, n.d.).

4. Challenges

The substantial concentration across the agricultural supply chain has important implications for Chinese manufacturers who seek to catch-up with the leading systems-integrators. As discussed previously, two of the main mechanisms through which core firms have developed and maintain their consolidation of the market and role as system integrators is through research and development and through strategic acquisition and cooperation.

4.1. Research and development

Local firms, such as First Tractor Co. Ltd. (YTO) have recently started manufacturing more sophisticated, high powered machinery. Despite these advancements, the technology employed still lags the products of core firms. This is also evident when examining the rated capacity of major products. For example, YTO, the leading domestic tractor manufacturer's highest power capacity is 220 hp. Both these machines pale in comparison to core firms, who manufacture tractors of up to 600 based on sales revenues across hp. Competition at this top-end of the market is relatively low and products command a premium. This is as more powerful and sophisticated equipment is likely to be procured by larger farmers and entities, such as rural and machinery cooperatives (Patton, 2015). Local firms are trying to catch-up with core manufacturers in this segment. They, however, continue to operate far from the technology frontier and lack the products to compete with core firms.[11]

This is also the case in the harvester segment. Harvesters manufactured by large domestic firms lag in performance and innovation in comparison with products from core firms. Local firms lack technological innovations that have become ubiquitous in the products manufactured by core firms.

Innovation capacity of local manufacturers remains low, even though the market share of backbone firms, such as Lovol, has increased. As with tractors, the demand for more powerful harvesting equipment of greater than 300 hp cannot be met by local producers and this segment remains dominated by core firms (CANN, 2018). Among the top five large local firms, only Zoomlion offers a comprehensive range of harvest, planting and crop protection machinery (Zoomlion, 2017). Low value addition remains a problem and the sector continues to have a fragmented, chaotic structure with large firms not being strong enough and small and medium-sized firms not being specialised enough (ITA, 2015; MIIT, 2015a). While the technology profile of products manufactured by leading domestic firms has improved, it is generally considered equivalent to that of core firms in the 1990s (Fang, 2015).

Research and development at the sectoral-level remains limited. Focusing only on above designated size firms, there are only around 200 firms that have invested in R&D capabilities and the R&D spending of leading Chinese manufacturers is not at the same scale as the R&D spending of core firms (Farmers Daily, 2018). As local firms invest insufficiently in R&D, they are likely to continue to be unable to meet modern requirements and the demand for more sophisticated machinery is likely to continue to be met only by core firms.

4.2. Acquisitions and strategic cooperation

The government's emphasis on developing domestic farm machinery manufacturing and the lack of local expertise has meant that leading Chinese firms are increasingly looking outward. For example, YTO, acquired the French tractor manufacturer McCormick and expanded its presence in Eastern Europe and established manufacturing facilities in Poland, Serbia and Belarus (YTO, 2018). Lovol has been more ambitious in its expansion in developed countries and in 2015 the company acquired Matermacc, a manufacturer of precision planters. This followed the acquisition of the Italian tractor manufacturer Arbos in 2014 and Goldoni, a specialised Italian single-line tractor manufacturer in 2016. These acquisitions reflect the global ambitions of large Chinese manufacturers. The acquired firms are, however, minor players in the sector but they do provide innovation skills that were lacking in the acquiring firms.

Lovol has also been active in incorporating data analytics in its product portfolio (Han, Wang, Jia, & Gu, 2016) and has been moving towards a business model which is closer to that of core firms. Taking advantage of the skillset available in the information technology sector in China, Lovol entered into an agreement with Baidu to jointly develop autonomous farm vehicles. The firm launched its online agricultural solution suite iFarming in 2016. Lovol also entered a strategic cooperation with the University of Bologna and IBM to develop smart agriculture solutions (Lovol, 2016).

As in sectors such as the car industry, Chinese manufacturers are engaging in a strategy of learning by doing. Local firms have developed joint-ventures with leading systems integrators, such as the joint venture between Same Deutz-Fahr and Shandong Changlin. Instead of engaging in joint ventures, however, core firms are increasingly taking a more direct route and operating fully owned subsidiaries. For example, John Deere manufacturers agricultural equipment in four fully owned facilities located in China. Additionally, core firms have been developing their own strategic relationships to enhance their presence in rural areas. In 2015, AGCO entered into a strategic partnership with the ecommerce giant Alibaba to market the company's products on the firm's rural online platform, Rural Taobao. AGCO has resultantly achieved high localisation rates and more than 70 per cent of the components used in the firms Changzhou plant are locally sourced (Gui, 2017). Other core firms, like CNH Industrial have entered into strategic partnerships with large agricultural input suppliers, such as Sinochem. Under their agreement with Sinochem, CNH Industrial provides farm machinery and technical support to new farmers. The initiative is part of Sinochem's strategy to popularise modern agricultural practices among farmers in the country (Sinochem Agriculture 2017). Core firms have also launched products to tap into the nascent

precision agriculture market which is quickly gaining traction as the government focuses on achieving sustainable agriculture intensification.

4.3. Made in China 2025

In response to the afore mentioned challenges, the government has identified the farm machinery sector as one of the focus areas of the 'Made in China 2025′ initiative. The government aims to create five globally competitive national champions in the farm machinery sector with revenues exceeding RMB 15 billion (US$ 2.25 billion) by 2025 (ITA, 2015). Local firms are envisaged to achieve a market share of 90 per cent by 2020. By 2025, the initiative aims to ensure a substantially higher share of domestic firms in the high-end equipment segment of the market and to replace the import of such machinery with domestic production. The five national champions will lead the vanguard of these plans to capture the high-end segment of the market, both domestically and globally through a strategy of 'going out' (MIIT, 2015b).

The initiative calls for augmenting R&D capabilities of domestic firms and a rationalisation of the sector's structure. In manufacturing, the plan calls for upgrading existing manufacturing technologies and improvements in metallurgy (CBBC, 2015). There is cognisance that improving core industrial technologies, including transmission systems, engines and electronic controls, is essential to improve the competitiveness of local firms. Improvements in agricultural productivity are envisaged through precision agriculture and the deployment of sophisticated machinery using information technology (MIIT, 2015b).

While ambitious, the fragmented nature of the farm machinery sector in China remains a hurdle. Even among leading domestic firms, there is resistance towards restructuring and mergers. Furthermore, the role of core firms manufacturing locally in the sector remains unclear. Most core firms operating in China have 100 per cent ownership of local subsidiaries. While reverse engineering the existing products of core firms is possible, the ability of leading domestic firms to innovate remains questionable. This is as the resources invested by leading domestic firms are far less than the resources invested by core firms. The situation is further complicated by recent tensions in the global trade system. These tensions present both opportunities and threats to leading local firms. On the one hand, it could lead the government to accelerate efforts towards sectoral consolidation. On the other hand, it could mean greater concessions to the core firms in order to ensure that the momentum of growth is maintained. This would likely dilute the impact of the Made in China 2025 initiative and strengthen the position of core firms.

One of the main strategies used by Chinese firms in other sectors has been to achieve rapid catch-up through acquisitions. This strategy seems to be increasingly problematic as governments in developed countries become more stringent in dealing with any attempts by large Chinese firms to acquire firms in the farm machinery sector, which is considered a strategic area. This is likely to constrain the ability of large local manufacturers to meet the objectives set out in the Made in China 2025 Initiative and evolve into globally competitive firms that can challenge the core firms. A comparison between core firms and the Chinese agricultural machinery sector is provided in Table 4.

Table 4. Comparison between core firms and Chinese agricultural machinery manufacturers

Variable	Core firms	Chinese firms
Consolidation	High	Low
R&D Investment	High	Low
Geographic Presence	Global	Local, now expanding primarily in developing countries
Acquisitions	Strategic	Limited acquisition activity
Strategic Partnerships	High	Limited
Production	Integrated service providers	Stand-alone/low-end machinery
Services	Data driven value-added services	Arms-length transactions with minimal services

Source: Authors' own.

5. Conclusion

We have highlighted the substantial concentration that exists in one segment of the agriculture input node of the supply chain: agricultural machinery. Dominated by a handful of core firms, the structure of the agricultural machinery sector poses substantial challenges for large firms from China and other developing countries that seek to expand their presence in the sector and compete successfully at a global level. The core firms, all of them based in developed countries, continue to sustain their competitive advantage by levering the substantial economies of scale they enjoy in procurement. They work with a small number of first-tier suppliers who can meet their demands. They invest substantial resources in research and development activities to foster and maintain their advantage, not only in developed countries but also in large emerging markets like Brazil, India and China. These firms have expanded their presence in emerging areas like precision agriculture and in recent years they have further strengthened their advantage in the area by acquiring a wide array of firms working in the area. Utilising data driven solutions and through strategic partnerships with different stakeholders, core firms are increasingly emerging as integrated service providers for farmers.

Despite China being the largest manufacturer of agricultural machinery in the world, it has no domestic global champions in the sector. The sector remains largely fragmented and while there are a few large domestic firms that have expanded their presence globally, they do not operate at the frontiers of technology and continue to produce low-value products while core firms further consolidate their presence in the high value-added segments. Core firms have enhanced their presence in the domestic market and are in the process of developing strategic partnerships with local companies. Even in the presence of a supporting national government and domestic policy environment, large domestic firms face significant challenges in catching-up with core firms and it is unclear whether China can create globally competitive firms in the sector.

Our findings are of great policy relevance regarding industrial policy and upgrading. By using the case of Chinese agricultural manufacturing as a vehicle, our findings suggest that even if firms in developing countries enjoy significant state-support, they are likely to struggle to catch-up with core firms. This is as core firms continue to strengthen their competitive position through investing heavily in research and development and actively responding to changing consumer demands through the acquisition or development of strategic relationships with leading suppliers and technology firms.

Acknowledgements

We would like to thank the anonymous reviewer for the valuable input which has helped improve the paper substantially. Data used in this article will be made available upon reasonable request by contacting the corresponding author.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. Concentration is most visible in advanced technology sectors and strongly branded sectors (Nolan, Zhang, & Chunhang, 2007).
2. In 2015 and 2016, out of 157 firms which invested more than US$ 1 billion in R&D activities, 124 were based in the US, EU and Japan (IRI, 2017).
3. System integrators are in many ways similar to ‘lead firms’ as defined in the global value chains literature.
4. The largest deal in this sector is the US$ 130 billion merger between US-based Dow Chemicals and DuPoint. This is followed by Monsanto’s acquisition by Germany-based Bayer AG.

5. An example of such a technological solution is the rising use of drones for agriculture operations that are incorporated with advanced sensors and digital imaging capabilities. This technology is argued to help farmers increase fields while reducing crop damage (Anderson, 2017). Precision farming is another technological solution that allows for improvements in the sustainability of farming systems (Zarco-Tejada, Hubbard, & Loudjani, 2014).
6. According to Clarke (2008), a farmer using mechanical power can produce enough food to feed 50 people whereas a farmer using draught power can only produce enough food for 6 people.
7. Full line manufacturers produce a complete line of equipment including tractors, combines, tillage and planting equipment.
8. John Deere was the first company to attach GPS sensors to tractors and other farm machinery in the 1990s (Pham & Stack, 2018).
9. This is evident by looking at changes taking place in the domestic market. From 2000 to 2015, the category of medium-and-large sized tractors exhibited a compound annual growth rate of 13 per cent while the category of small tractors grew only by 2 per cent per annum (NBS, 2017).
10. Designated size refers to industrial firms with revenue of greater than RMB 20 million.
11. Backbone firms are innovating to take advantage of agricultural subsidies that have been re-oriented towards larger firms capable of manufacturing powerful 'smart tractors' (Wang & Goh, 2018). While local firms intensify efforts to develop such solutions, products offered by core firms meet the subsidy criteria and are likely to continue dominating this highly lucrative segment of the market.

References

AGCO. (2016, August 18). *AGCO collaborates with other industry leaders to bring more high tech solutions for customers*. Retrieved from BusinessWire https://www.businesswire.com/news/home/20160818005400/en/AGCO-Collaborates-IndustryLeaders-Bring-High-Tech-Solutions

AGCO. (2017). *2016 annual report*. Duluth: Author.

AGCO. (2018). *Form 10-K of AGCO corporation*. Duluth: Author.

Agri, S. (2017, August 29). *Sinochem SBU of agriculture signed a strategic cooperation agreement with CNH industrial*. Retrieved from Sinochem http://www.sinochem.com/en/s/1569-4171-100674.html

Anderson, C. (2017, November 12). *Drones go to work*. Retrieved from Harvard Business Review https://hbr.org/cover-story/2017/05/drones-go-to-work

Berry, W. (2015, March 19). *Farmland without farmers*. Retrieved from The Atlantic https://www.theatlantic.com/national/archive/2015/03/farmland-withoutfarmers/388282/

Beyazay-Odemis, B. (2015). *The nature of the firm in the oil industry: International oil companies in Global Business*. London: Routledge.

Bjornson, B., & Klipfel, J. (2000). Farm equipment industry performance: Past and future. *International Food and Agribusiness Management Review*, *3*, 71–84.

Bloomberg. (2017). *Global M&A market review: Financial rankings*. New York: Bloomberg Finance L.P.

Brusoni, S., Prencipe, A., & Pavitt, K. (2001). Knowledge specialization, organizational coupling, and the boundaries of the firm: Why do firms know more than they make? *Administrative Science Quarterly*, 46(4), 1185–1200.

CANN. (2018). China's agricultural machinery industry to be solved "growth troubles" (zhōngguónóngjī gōngyè dài jiě "chéngzhǎng de fánnǎo"). China Agriculture News Network, China Association of Agricultural Machinery Manufacturers (CAAMM), Retrieved from http://www.caamm.org.cn/hygz/1519.htm

CBBC. (2015). *MADE IN CHINA 2025: China manufacturing in the 21st Century – Opportunities for UK-China partnership*. London: China-Britain Business Council.

Chandler, A., & Hikino, T. (1997). The large industrial enterprise and the dynamics of modern economic growth. In A. Chandler, F. Amatori, & T. Hikino (Eds.), *Big business and the wealth of nations* (pp. 24–58). Cambridge: Cambridge University Press.

Chandler, A. (2005). *Shaping the industrial century: The remarkable story of the evolution of the modern chemical and pharmaceutical industries*. Cambridge, MA: Harvard University Press.

CIN. (2017, May 16). *China's agricultural machinery industry's exports fell in 2016*. China International News. Retrieved from CINIC.org.cn http://www.cinic.org.cn/xw/tjsj/386576.html

Christopher, M. (2018). *The mitigation of risk in resilient supply chains*. Paris: International Transport Forum Discussion Papers, OECD Publishing.

CLAAS. (2018). *2017 annual report*. Harsewinkel: CLAAS Group.

Clarke, L. (2008). *Farm power and mechanization in developing countries, an overview with an emphasis on Sub-Saharan Africa*. Rome: Food And Agriculture Organisation.

CNH Industrial. (2017). *2016 sustainability report*. London: CNH Industrial N.V.

CNH Industrial. (2018). *FORM 20-F of CNH INDUSTRIAL N.V.* London: CNH Industrial N.V.

Davis, G. W., Bailey, D., & Chudoba, K. M. (2010). Defining and meeting the demand for agricultural machinery in China: A case study of John Deere. *International Food and Agribusiness Management Review*, *13*, 97–120.

Deere & Company. (2014). Deere Completes Acquisition of Auteq Telematica, Deere & Company. https://www.deere.com/en_US/corporate/our_company/news_and_media/press_releases/2014/corporate/2014dec4-corporaterelease.page

Deere & Company. (2018). *2017 annual report*. Moline: Deere&Company.
Deere & Company. (n.d.). Achieving Excellence. John Deere Supplier Network. Retrieved from https://jdsupply.deere.com/apps/ae/docs/brochure_inserts/.../english_brochure.pdf
Drake, D. M. (2015). Farm machinery: A changing path to feed the world. In J. C. John & R. Bryson (Eds.), *Handbook of manufacturing industries in the world economy* (pp. 229–244). Cheltenham: Edward Elgar Publishing Limited.
Duysters, G., Cloodt, M., Schoenmakers, W., & Jacob, J. (2015). Internationalisation efforts of Chinese and Indian companies: An empirical perspective. *Journal of Economic and Social Geography*, 106, 169–186.
EMIS University. (2018). Lovol Heavy Industry Co., Ltd. (雷沃重工股份有限公司)(China). ISI Emerging Markets Group.
European Commission. (2017). *The 2017 EU Industrial R&D Investment Scoreboard*. doi:10.2760/912318
Fang, W. (2015, July). Current status and developmenttrends of China's agricultural machinery industry. *Training and Study Tour for Agricultural Machinery Distributors in Asia and the Pacific*. Beijing: UN Centre for Sustainable Agricultural Mechanisation. Retrieved from http://www.un-csam.org/ppta/2015distr/4.pdf
Farmers Daily. (2018, January 7). *China agricultural machinery: There is happiness in the middle of the worry [Zhōngguó nóngjī: Yōu zhōng yǒuxǐ]*. Retrieved from China Agricultural Machinery Distributor Association http://www.camda.cn/html/57386.html
FT. (2017, October 13). BASF to pay €5.9bn to buy 'significant parts' of Bayer seed business. *Financial Times*.
Fuglie, K. O., Heisey, P. W., King, J. L., Pray, C. E., Day-Rubenstein, K., Schimmelpfennig, D., & Karmarkar-Deshmukh, S. L. (2011). *Research Investments and market structure in the food processing, agricultural input, and biofuel industries worldwide*. Washington, DC: U.S. Dept. of Agriculture, Economics Research Service.
Gereffi, G. (2014). Global value chains in a post-Washington consensus world. *Review of International Political Economy*, *21* (1), 9–37.
Gui, N. (2017, September 4). *Personalized customization will become an important brand strategy for agricultural machinery enterprises [Gèxìng huà dìngzhì jiāng chéngwéi nóngjī qǐyè zhòngyào pǐnpái zhànlüè]*. Retrieved from China Association of Agriculture Machinery Manufacturers http://www.caamm.org.cn/zfzc/1348.htm
Han, W., Wang, J., Jia, G., & Gu, Q. (2016). Foton Lovol International Heavy Industry Co., Ltd. Service for information demand. In J. Wang, M. Kosaka, & K. Xing (Eds.), *Manufacturing servitization in the Asia-Pacific* (pp. 17–40). Singapore: Springer.
Hazell, P. B. R. (2008). *An assessment of the impact of agricultural research in South Asia since the green revolution*. Rome: Science Council Secretariat.
IBIS World. (2018). *Farming machinery manufacturing in china*. IBIS World Industry Report.
IRI. (2017). R&D Ranking of the world top 2500 companies. Economics of Industrial Research and Innovation, European Commission. Retrieved from http://iri.jrc.ec.europa.eu/scoreboard17.html
IRI. (2018). R&D Ranking of the world top 2500 companies. Economics of Industrial Research and Innovation, European Commission. Retrieved from http://iri.jrc.ec.europa.eu/scoreboard18.html
ITA. (2015). *2015 ITA agricultural equipment top markets report: China*. USA: International Trade Administration, US Department of Commerce.
Kase, T. (2015). *A case study in global supply chain risk management: How AGCO implemented an SCRM solution to save millions, spend matters research*. Retrieved from http://spendmatters.com/research/a-case-studyinglobal-supply-chain-riskmanagement-how-agcoimplemented-an-scrm-solution-to-save-millions/
Keen, S. (2011). *Debunking economics: The naked emperor dethroned?* New York, NY: Zed Books.
Kim, G. (2018). *China's annual agricultural policy goals: The 2018 no. 1 document of the CCCPC and the state council*. Beijing: USDA Foreign Agricultural Services.
Kubota. (2017). *2017 Kubota report: Business and CSR activities*. Tokyo: Kubota Corporation.
Liu, L. (2005). *China's industrial policies and the global business revolution: The case of the domestic appliance industry*. London: Routledge.
Lovol. (2016, November 1). *Three countries and six parties signed a contract, Lovol Arbos released the first intelligent agricultural solution in the agricultural machinery industry [Sānguó liùfāng qiānyuē léi wò ābō sī fābù nóngjī hángyè shǒu gè zhìhuì nóngyè jiějué fāng]*. Retrieved from China Association of Agricultural Machinery Manufacturers http://www.caamm.org.cn/qydt/845.htm
Marx, K. (1983). *Capital: A critique of political economy; Volume I*. London: Lawrence & Wishart.
MIIT. (2015a, May 22). *Agricultural machinery equipment field interpreted in the "Made in China 2025" planning series ["Zhōngguó zhìzào 2025" guīhuà xìliè jiědú zhī nóngyè jīxiè zhuāngbèi lǐngyù]*. Retrieved from Ministry of Industry and Information Technolohgy of the People's Republic of China http://miit.gov.cn/newweb/n1146285/n1146352/n3054355/n3057585/n3057589/c3617223/cont
MIIT. (2015b). *Agricultural machinery industry development plan (2011–2015) [Nóngjī gōngyè fāzhǎn guīhuà (2011~2015 nián)]*. Beijing: Ministry of Industry and Information Technology People's Republic of China. Retrieved from Ministry of Industry and Information Technolohgy of the People's Republic of China http://www.miit.gov.cn/n1146295/n1146562/n1146650/c3074194/content.html
MIIT. (2018, February 24). *The agricultural machinery industry achieved steady growth in 2017 (2017 Nián nóngjī gōngyè shíxiàn wěndìng zēngzhǎng)*. Retrieved from Ministry of Industry and Information Technology of the People's Republic of China http://www.miit.gov.cn/n1146312/n1146904/n1648362/n1648364/c6068607/content.html

MOA. (2017, March 1). *Agriculture in China III*. Retrieved from Ministry of Agriculture and Rural Affairs of the People's Republic of China http://english.agri.gov.cn/overview/201703/t20170301_247343.htm

Mullen, J. (2016, February 3). *ChemChina offers $43 billion for Switzerland's Syngenta*. Retrieved from CNNMoney http://money.cnn.com/2016/02/03/investing/chemchinasyngenta-takeover-offer/index.html

Narasimhan, R., Schoenherr, T., & Sandor, J. (2013, July–August). How do you extend the frontiers of supply management excellence and build a solid competitive advantage? *Supply Chain Management Review*, 10–15.

NBS. (2017). Major agricultural machinery at year-end. *China statistical yearbook 2016*. National Bureau of Statistics of China. Retrieved from http://www.stats.gov.cn/tjsj/ndsj/2016/indexeh.htm

Nikolova, N. (2007). Outsourcing. In *The Blackwell encyclopedia of sociology* (pp. 3351–3354). London: Wliey.

Nolan, P. (1999). *Coca-cola and the global business revolution: A study with special reference to the Eu*. Cambridge: Judge Institute of Management Studies.

Nolan, P. (2001). *China and the global business revolution*. London: Palgrave.

Nolan, P. (2002). China and the global business revolution. *Cambridge Journal of Economics*, *26*, 119–137.

Nolan, P. (2007). *Capitalism and freedom: The contradictory character of globalisation*. London: Anthem.

Nolan, P. (2012). *Is China buying the world?* Cambridge: Polity Press.

Nolan, P. (2014). *Chinese firms, global firms: Industrial policy in the age of globalisation*. New York, NY: Routledge.

Nolan, P., & Zhang, J. (2014). Globalisation and industrial concentration: The challenge for firms from developing countries. In P. Nolan (Ed.), *Chinese firms, global firms: Industrial policy in the era of globalisation* (pp. 43–63). London: Routledge.

Nolan, P., Jin, Z., & Chunhang, L. (2008). The global business revolution and the cascade effect: The challenge for firms from developing countries. *Cambridge Journal of Economics*, *32*, 29–47.

Nolan, P., & Rui, H. (2004). Industrial policy and global big business revolution: The case of the Chinese coal industry. *Journal of Chinese Economic and Business Studies*, *2*, 97–113.

Nolan, P., Zhang, J., & Chunhang, L. (2007). *The global business revolution and the cascade effect*. Palgrave: Basingstoke.

Patten, A. (2012). *AGCO corporation*. Fort Worth: The M.J. Neeley School of Business Educational Investment Fund.

Patton, D. (2015, October 1). *Machinery makers smell opportunity as China's farms think big*. Retrieved from Reuters https://www.reuters.com/article/us-chinaagriculture-machinery/machinery-makers-smell-opportunity-as-chinas-farms-think-bigidUSKCN0RV5QJ20151001

Perlman, C. (2017, May 15). From product to platform: John Deere revolutionizes farming. Retrieved from HBS Digital Initiative Digest https://medium.com/harvardbusiness-school-digital-initiative/from-product-to-platform-john-deere-revolutionizes-farming14dc8b4e791f

Pham, X., & Stack, M. (2018). How data analytics is transforming agriculture. *Business Horizons*, *61*, 125–133.

Pingali, P. (2007). Agricultural mechanization: Adoption patterns and economic impact. In R. Evenson & P. Pingali (Eds.), *Handbook of economics* (Vol. 3, pp. 2779–2806). London: Elsevier.

Porter, M. E., & Heppelmann, J. E. (2014, November). How smart, connected products are transforming competition. *Harvard Business Review*.

Pryor, F. L. (2001). New trends in U.S. industrial concentration. *Review of Industrial Organization*, *18*, 301–326.

Rayappa, K., Tigges, R., Ghimire, S. R., & Mallik, A. (2015). The tug of war between developed and emerging market origin companies. *Competition Forum*, *13*, 174–179.

Reibel, J. (2018, August 29). *Farm equipment*. Retrieved from Manufacturer consolidation reshaping the Farm Equipment marketplace https://www.farmequipment.com/articles/15962-manufacturer-consolidation-reshaping-the-farm-equipmentmarketplace

Reuters. (2015, February 9). *China to direct farm machinery subsidies to growers of key crops*. Retrieved from Thompson Reuters https://www.reuters.com/article/chinaagriculture-subsidies/china-to-direct-farm-machinery-subsidies-to-growers-of-key-cropsidUSL4N0VJ3NM20150209

Reuters. (2018, February 1). *BRIEF-CNH industrial and Microsoft announce new strategic partnership*. Retrieved from Reuters https://www.reuters.com/article/briefcnh-industrial-and-microsoft-annou/brief-cnh-industrial-and-microsoft-announce-new-strategic partnership-idUSFWN1PR08K

Smit, H. (2012). *Agricultural machinery ahead of the field: From fixed assets to flexible service*. Utrecht: Rabobank International.

Syngenta. (2012). *Annual review 2011*. Basel: Syngenta International AG.

Theissen, J., Stone, J., & Schwarz, H. (2015). *Supply chain risk management at AGCO Corporation* (p. 41), SIG Global Executive Summit 2015, Huntington Beach.

Tishi, X. (2018, January 11). *2017 tractor market overview and 2018 forecast [2017 Nián tuōlāj shìchǎng zòngshù yǔ 2018 nián yùcè]*. Retrieved from http://www.sohu.com/a/216099319_752975

UN Comtrade. (n.d.). UNComtrade database. Retrieved from https://comtrade.un.org/

UNCTAD. (2018). *World investment report 2018: Investment and new industrial policies*. New York: United Nations.

US Commercial Service. (2017). *China city & industry report: A guide for us exporters*. Beijing: Asia Briefing

VDMA. (2015). *Agricultural machinery economic report 2015*. Frankfurt: Author.

Wang, H., & Kimble, C. (2013). Innovation and leapfrogging in the Chinese automobile industry: Examples from Geely, BYD, and Shifeng. *Global Business and Organizational Excellence*, *32*, 6–17.

Wang, L., & Goh, T. C. (2018, January 9). *China's machinery production projected to grow steadily over the next four years*. Retrieved from IHS Markit https://technology.ihs.com/599272/chinas-machinery-production-projected-to-grow-steadilyover-the-next-four-years

Wang, X., Yamauchi, F., Otsuka, K., & Huang, J. (2016). Wage growth, landholding, and mechanization in Chinese agriculture. *World Development*, *86*(86), 30–45.

YTO. (2018). *First Tractor Company Limited Annual Report 2016*. Hong Kong: First Tractor Company Limited.

Yu, J., & Wu, J. (2018). The sustainability of agricultural development in China: The agriculture–environment nexus. *Sustainability*, *10*(1776), 1–17.

Yunhong, D. (2018, January 19). *Gao Yuanen: The high growth rate of the agricultural machinery industry continues, and it will usher in a new high tide before 2035 [Gāoyuán'ēn: Nóngjī hángyè gāowèi dī zēng sù yá/nxù,2035 nián qián jiāng yíng lái xīn gāocháo]*. Retrieved from China Agricultural Machinery Distribution Association http://www.camda.cn/html/57832.html

Yuqing, L. (2018). Agricultural machinery manufacturing industry analysis industry structure upgrade prospects can be expected [Nóngyè jīxiè zhìzào yè fēnxī hángyè jiégòu shēngjí qiánjǐng kěyǐ yùqí]. Retrieved from https://www.qianzhan.com/analyst/detail/220/180212-93923c23.html

Zarco-Tejada, P. J., Hubbard, N., & Loudjani, P. (2014). *Precision agriculture: An opportunity for EU farmers - Potential support with the CAP 2014-2020*. Brussels: European Union.

Zhang, J. (2004). *Catch-up and competitiveness in China*. London: Routledge.

Zhang, J. (2015). The status and thinking of the development of agricultural machinery industry in China [Wǒguó nóngjī gōngyè fāzhǎn de xiànzhuàng jí sīkǎo]. *Jiangsu Agricultural Mechanization (2015-02)*.

Zheng, N., Wei, Y., Zhang, Y., & Yang, J. (2016). In search of strategic assets through crossborder merger and acquisitions: Evidence from Chinese multinational enterprises in developed economies. *International Business Review*, *25*, 177–186.

Zoomlion. (2017). *Zoomlion heavy industry science & technology limited annual report*. Zoomlion Heavy Industry Science & Technology Ltd.