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The Pork Value Chain in China: Strategies for Improvement

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Abstract

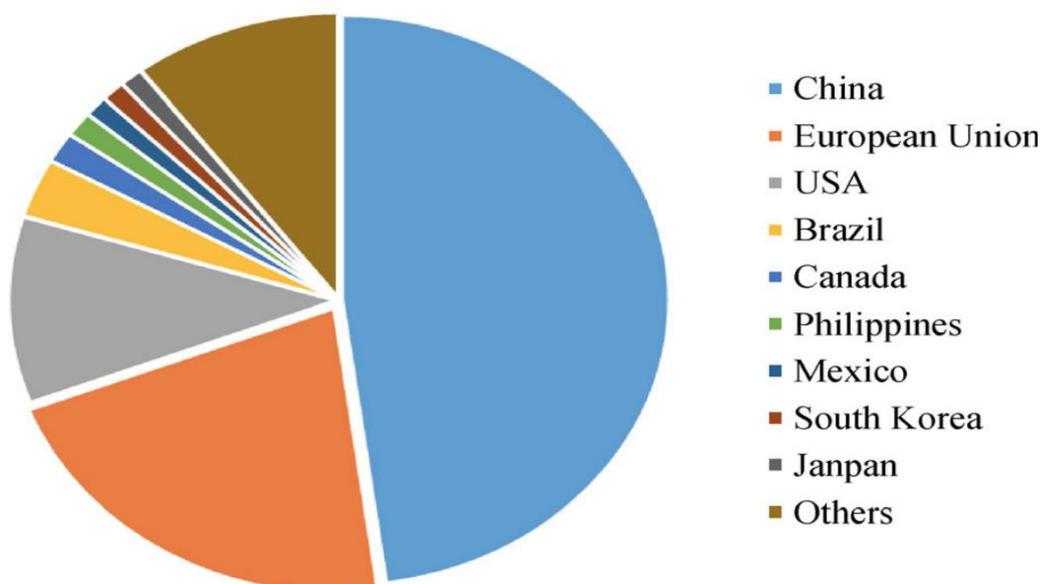
China is a developing country with a large pork production industry and high consumption volumes, but the increasing demand for high quality pork poses challenges to the pork value chain in China. The aim of this paper is to assist industry development by conducting a pork value chain analysis, identifying the key constraints, and suggesting a series of strategies for improving the performance gap. The China pork value chain is described over the past twenty years through secondary data sources and reference to two case studies in Beijing and Shanghai. Three mapping dimensions are explored, including value, cost, and sustainability. The analysis indicates that the pork value chain in China is not performing well and needs improvement. By moving towards industrialised farming and slaughterhouses, pork safety and quality management, and reducing feed costs, China could be able to avoid potential pork surpluses or deficits at the provincial level and reduce GHG emissions. Meanwhile, the improvement of vaccinations and disease resistance may further reduce the risk of cyclical fluctuations in pork production. Additional value on pork products through packaging and certification may further shift market segments from wet markets to modern retailing as well as increase opportunities in the export market.

Key words: pork industry; value chain; China; farming; slaughtering; GHG emissions

Introduction

Pork consumption in China

Intensive livestock industries have developed globally as a result of the increasing consumer demand for high-quality and low-cost animal protein. While the population of China is 18 per cent of the total world population, the consumption of pork in China accounts for approximately 50 per cent of the total pork produced globally (Figure 1). The huge demand for pork in China indicates the importance of an efficient pork production sector, and the reliance of China on global trade. China faces opportunities and challenges, in particular, with regard to food security, in the international agriculture market due to this dependence on international trade (Zhu, 2016).

Figure 1. Global pork consumption 2018

Source:(Food and Agriculture Organization, 2020)

Pork production in China

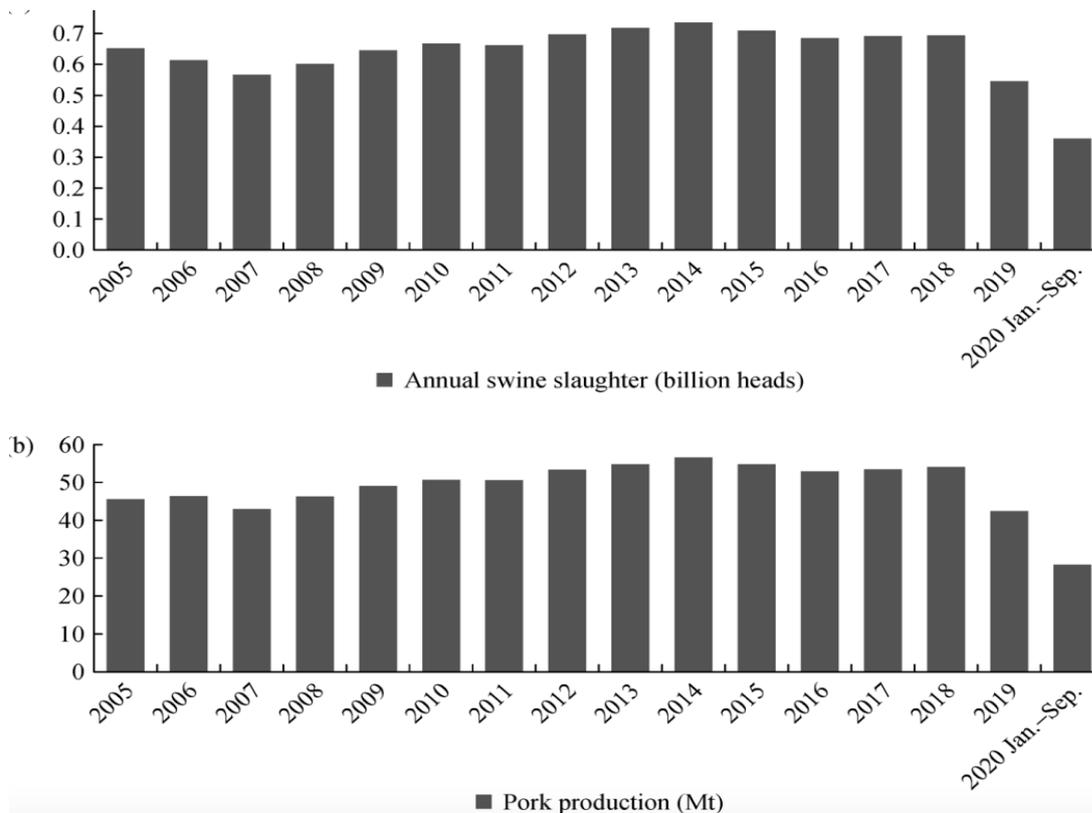
With China's economic development, the gross domestic product of China increased rapidly due to the transformation of agriculture from a Soviet-type centrally planned economy to a market-oriented economy, and these changes led to a growth in per capita income (Zhang et al., 2021). Consequently, the consumption of food shifted from grain to higher-protein products.

Also, rapidly developing urbanisation has affected the economic structure of agriculture, and the demand for chilled pork has increased with the increase in urban populations (Zhong et al., 2020). Despite the fact that this economic scale would benefit the expansion of the pig industry, domestic pork production still cannot fulfill the increased demand in China (Figure 2). The annual pig meat production remained relatively stable between 2005 and 2018, while there was a significant decline between 2018 and 2020 as a result of African Swine Fever in 2019 and the impact of COVID-19 in 2020 (You et al., 2021).

Pork imports into China

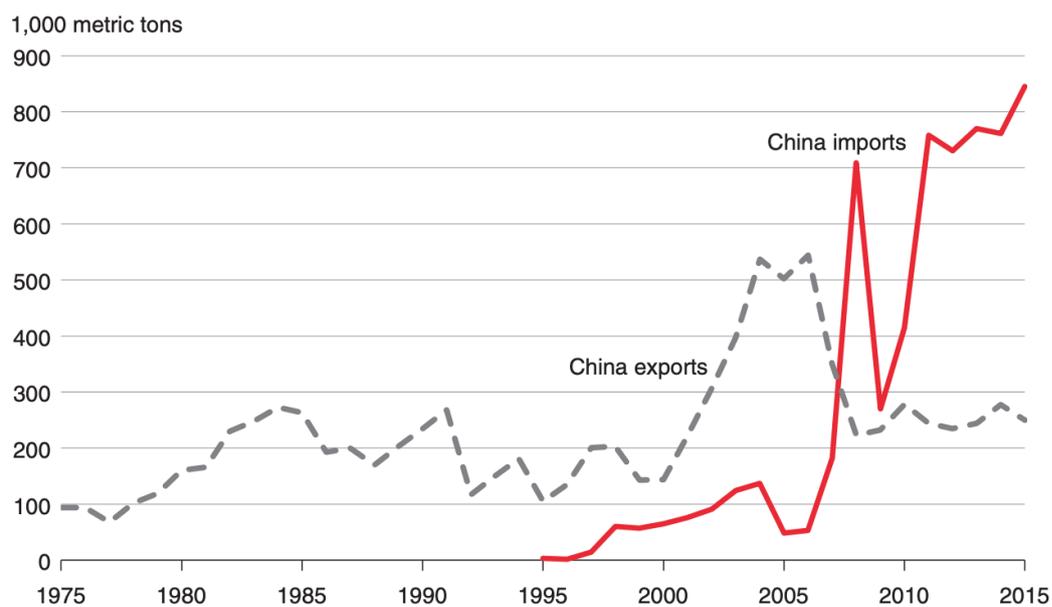
The Chinese pork industry produces a large amount of pork but, with high feed costs, low labour productivity, increased production costs, and constraints on land use, production cannot meet consumer demand. China remains a leading importer of pork (Fabiosa et al., 2005). In Figure 3 is shown Chinese pork trade from 1975 to 2015, indicating a large volume of pork importation from 2011, which is likely to continue to increase in the future. Further, since rising production costs lead to a higher domestic pork price than the global price, imported pork tends to be more attractive to processors, and food-service buyers in China.

Figure 2. The annual pig slaughter from 2005 to 2020 in China



Source: (National Bureau of Statistics of China, 2020)

Figure 3. China pork trade from 1975 to 2015



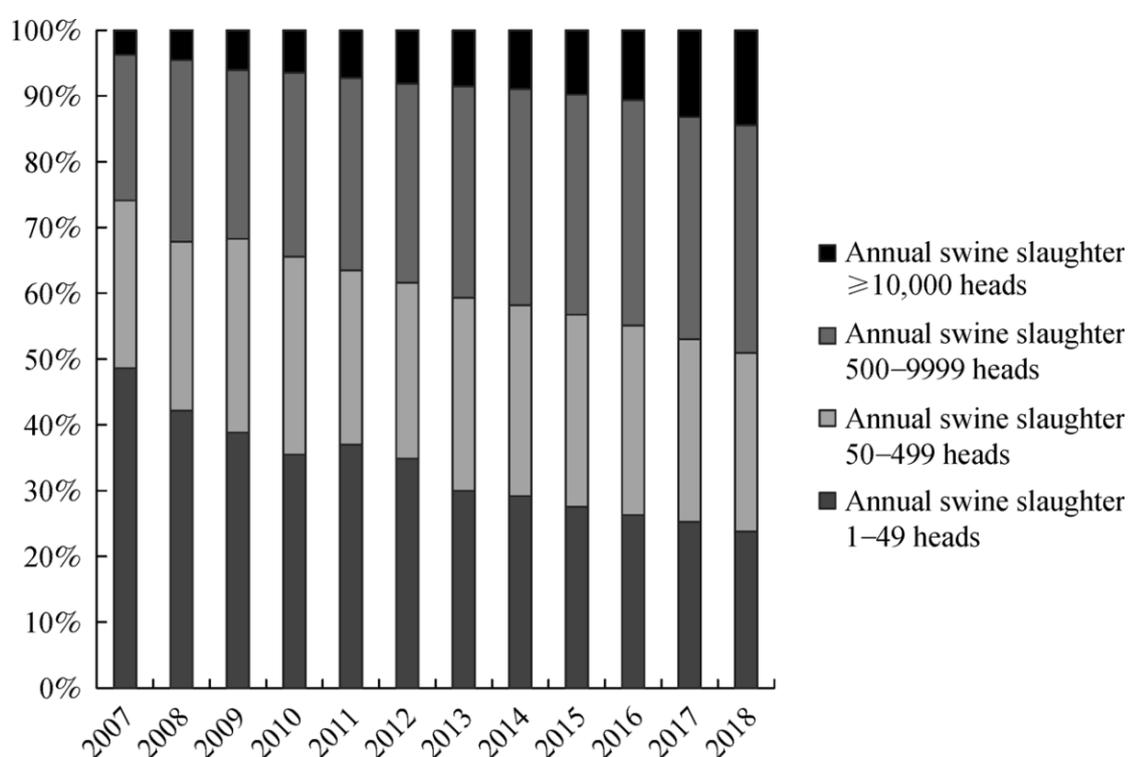
Source: (United States Department of Agriculture, 2017)

Industry Challenges

Low production efficiency

The growing demand for pork, caused by new urbanisation and labor scarcity, cannot be met by the traditional production system, which is small-scale, backyard production. Although industrialised production models are rapidly replacing these small-scale models, the number of smallholders (< 500 heads) still account for half of the total of pork producers in China, and there are 2-3 head per household in more than 80 per cent of rural households (Figure 4). These household pigs not only take longer to reach slaughter weight due to low nutrient diets, but also have a relatively high resource use (Yu & Abler, 2014).

Figure 4. Pig producer scales in China from 2007 to 2018

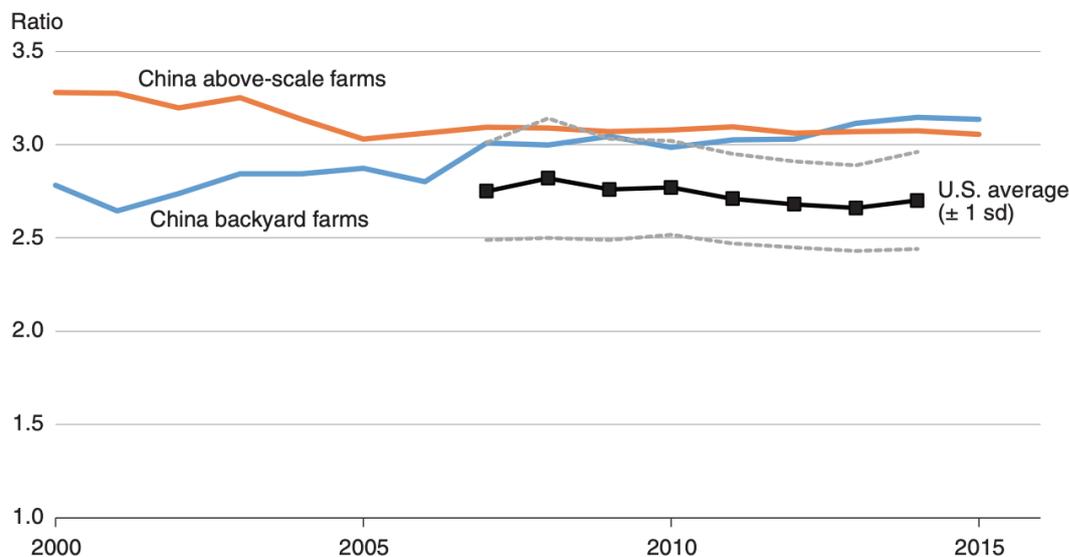


Source: (China animal husbandry and veterinary yearbook, 2018)

Shortage of feed ingredients

In China, a large amount of water is needed to produce grain for livestock feed, and more than 70 per cent of imported crops, such as soybean, barley, and maize, are used for livestock feed. This reflects the conflict between livestock and human feeds, and the significant shortage of feed crops in China. Furthermore, the low efficiency of feed use in pork production in China further adds to the shortage of feed ingredients. In Figure 5 is shown the relatively high volume of feed concentrates consumed in both China's large-scale and backyard farms in order to obtain final weight in the last stage of production (Faust et al., 2018).

Figure 5. Feed conversion ratio in China 2015



Note: Feed conversion ratio = (feed concentrate used)/(finished hog weight – piglet weight). U.S. average is for conventional finishers. The standard deviation reported by Stadler (2015) was used to calculate an interval to show the variation in the U.S. average.

Source: (National Development and Reform Commission People's Republic of China, 2015)

Unsafe pork supply

The increase in the number of small-sized pig farms (50-499 head), poor management, and incomplete regulations all result in exposing pigs to risks, such as treating diseased pigs without veterinarian care, feeding pigs with household waste food, and inadequate disposal of dead pigs. Furthermore, the excessive use of antibiotics by the majority of pork producers may cause another issue for human health (Zhang, 2012).

Livelihood and poverty

In rural regions, most pork production still relies on backyard pig farms, and most women are backyard pig farmers who are more vulnerable to pork price fluctuations. With the rise in urbanisation, most young people migrate to the cities and only middle-aged or older farmers stay in backyard pig farms. This means there is less available labour and less land to build pigpens and grow crops on due to the government requisitioning more and more farmland (Jennifer et al., 2022). As a result, most farmers who stay in rural areas cannot afford the high investment and often give up pig farming, which has a more negative impact on the livelihood of older farmers than younger ones because they rely more on pig rearing for their livelihood.

Sustainable pork production

Livestock production can be considered an important factor in greenhouse gas emissions (GHG), and

China has agreed to reduce its share of global livestock emissions, in order to meet the Sustainable Development Goals adopted by the United Nations in 2015. However, there has been rapid growth in greenhouse gas emissions (GHG) from pig production in China, reaching 35.21 MT based on household pork producers, which accounts for 45 per cent of the total GHG emissions from pig production and 10 per cent of the total GHG emissions from livestock production in 2020 (Wei et al., 2023).

Other challenges

The spread of African swine fever (ASF) in China caused a significant loss in pig production, and with the burden of the disease falling disproportionately on household farmers, the Chinese pork industry might take years to fully recover. As well, the supply side shock is driving up prices of pork and related commodities for consumers, as well as contributing to increases in poverty, vulnerability, and food insecurity (You et al., 2021).

Other challenges, such as sow reproductive diseases, unstable pork prices, the increasing demand for chilled pork, the low productivity of pig farms, poor management of the pork supply chain, poverty in rural areas, and greenhouse gas emissions related to pork production, continue to present threats to the development of pork production in China. Consequently, a pork value chain analysis in China is conducted here to assess the major constraints to better performance in this chain and to suggest some strategic improvements.

Mapping the Value Chain

Actors in the pork value chain (see Figure 6)

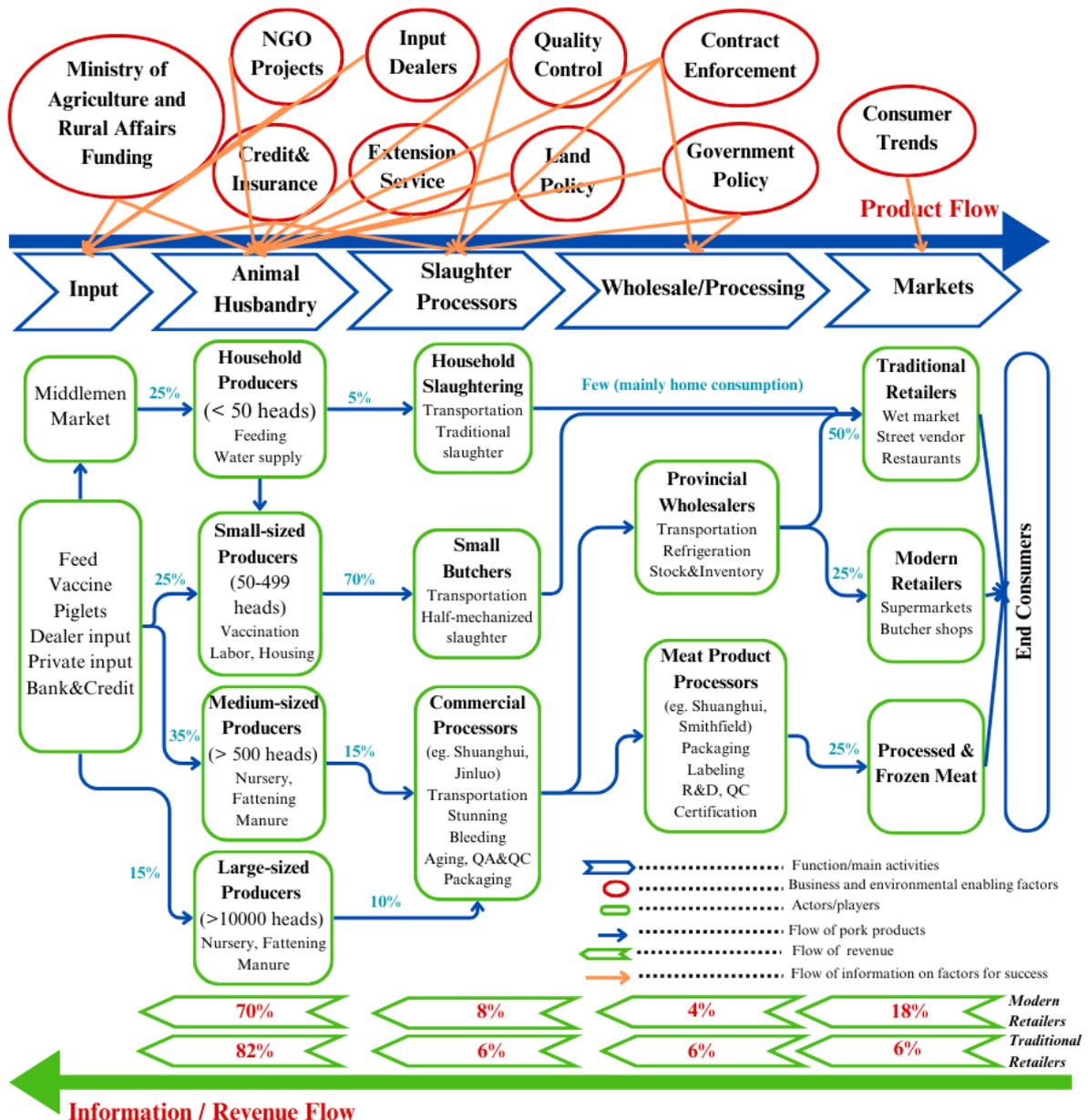
The actors in the value chain are grouped as follows.

Input suppliers: In addition to genetic firms, most inputs including feed production, vaccination and piglets are supported by NGO projects and the Ministry of Agriculture and Rural Affairs in China, while individual household producers rely on the 'middleman' market for feeding and breeding support.

Producers: Producers can be categorised into four types: 25 per cent of household producers fatten pigs by feeding household food waste and sell them to small-sized producers through the middlemen market; a further 25 per cent are small-sized producers with poorly-equipped pig farms; another 35 per cent are medium-sized producers; and the final 15 per cent are large-sized producers who fatten pigs to industrial standards (Figure 4).

Processors: There are three types of slaughterhouses: household slaughtering; small butchers; and commercial processors. Households mainly feed and slaughter pigs for home consumption, but also sell 5 per cent of hand-slaughtered pigs to the wet market. Meanwhile, 70 per cent of fattened pigs are slaughtered at small butchers through a semi-mechanised method, and commercial processors, such as Shuanghui, slaughter 25 per cent of pigs with stunning, ageing and packaging processes. (Reardon, 2015; Liu et al., 2016).

Figure 6. Value chain for pork production in China



Sources: Ministry of Agriculture of the Peoples Republic of China; China Animal Agriculture Association; China Animal Husbandry Yearbook of 2018; China Agricultural Information Network; Food and Agriculture Organization of the United Nations

Wholesalers/processors: Pigs slaughtered at commercial processors are transported to provincial wholesalers and meat product processors, but pigs slaughtered at small butchers are directly sold to traditional retailers including wet markets, street vendors, and the hospitality industry.

Traditional retailers: Traditional retailers, including wet markets, street vendors and restaurants, account for 50 per cent of the total pork market share and sell freshly slaughtered pigs. Farmers may gain 82 per cent profit per head by selling to small butchers rather than traditional retailers (Enting et al., 2009) This indicates that industrialised farms and processors could face challenges in replacing backyard farms and small butchers, because farmers gain relatively high net margins in the traditional retailer model.

Modern retailers: Modern retailers consist of supermarkets and butcher shops that sell chilled pork products, which require an ageing process and packaging for preservation. Modern retailers could obtain 18 per cent of the total value by selling 25 per cent of pork supplied from wholesalers, but farmers may only gain 70 per cent benefit per head in the modern retailer model in contrast to the higher profit percentage made from selling to small butchers (Enting et al., 2009). However, this retailer model is growing rapidly, nevertheless, due to the increased demand for chilled pork.

Processed meat: The addition of significant value occurs in this stage as 25 per cent of pork is processed into meat products by commercial processors such as Shuanghui. The successful improvement in Shuanghui's product is a result of China's income growth and the fast-increasing demand for quality pork, especially among the expanding market share of middle-income urban residents (Pan & Kinsey, 2002). However, a limitation to processed products is that only pigs produced by medium-to-large-sized farms are acceptable as sources of the raw materials, as well as their limited export ability due to international food safety standards such as The Codex Alimentarius Commission. Although the Chinese Eleventh Five-year Plan encourages the adoption of international standards in the agriculture sector, the number of Chinese standards based on international measures is low when compared to other countries. Also, low levels of enforcement of regulations by food safety officials and the absence of inspectors supervising the increasing number of commercial processors further lowers the quality of pork products (Ping et al., 2010).

Mapping the pork value chain by costs and value

Due to the limitations of reliable data and the multiple regions of livestock production in China, in this study the cost and value of the pork value chain was assessed through two case studies in Beijing and Shanghai. In Table 1 is illustrated the costs and net profits in various stages of the pork value chain, with the most significant cost coming from feed supply during the pig farming stage, which costs 697.1 Yuan per head, and a relatively low net profit during transportation. Also, supermarkets gain a three-fold net profit when compared to wet markets in terms of the retail stages. In addition, the majority of pork value results from the slaughtering processes of pigs, which means there is little additional value after the slaughtering stages (Table 2).

Mapping pork value chain by GHG

A perceptual map has been developed relating to greenhouse gas (GHG) emissions resulting from pork production in China, with each activity's potential value generated compared to its environmental impact in terms of GHG emissions produced (Figure 7). Because the management of diet and animal

Table 1. Costs and value in various stages of pork value chain in Beijing and Shanghai

Pig Production Stage									
Piglet cost	Feed cost	Electricity	Vaccine	Labor cost	Fixed asset	Land lease	Total cost	Total income	Net
450	697.1	6.25	40	106.15	20	12.5	1332.1	1700	367.9
Pig Procurement and Transportation									
Procurement (Yuan per kilo)	Quarantine	Express way	Vehicle rent	Introduction	Total cost	Total income	Net		
17	2	0.8125	6.75	4	1713.56	1720.64	7.08		
Pig Slaughtering & Processing to Wet Market									
Procurement (Yuan per kilo)	Processing cost	Management cost	Total cost	Total income	Net				
17.35	25	10	1743.98	1760.95	16.97				
Pig Slaughtering & Processing to Supermarket									
Procurement (Yuan per kilo)	Processing cost	Management cost	Sales cost	Financial cost	Shop entrance fee	Total cost	Total income	Net	
17.35	25	10	64	8	2	1817.98	1860.24	42.26	
<ul style="list-style-type: none"> Yuan/head unless otherwise noted. Usually, the slaughterhouse is not willing to cooperate with individual pig producers. Therefore, the middlemen receive an introduction fee by telling the pig collection agents the sources of pig supply. The total carcass weight accounts as 100 kilos here and is usually 72% of the live pig weight. The other parts of the hog are head, feet, offal etc. 									

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Table 2. Cost and return of the retailers in Beijing and Shanghai

	Weight (kg/pig)	Share (%)	Price (\$/kg)	Value (\$/pig)	Share (%)
Cost					
Material					
Pork	61.30	81.34	1.21	74.06	71.32
Others	14.06	18.66	0.97	13.59	13.09
Sales expense				10.76	10.36
Labor				4.83	4.65
Overhead				0.60	0.58
Total	75.36	100.00		103.85	100.00
	Weight (kg/pig)	Share (%)	Price (\$/kg)	Value (\$/pig)	Share (%)
Cost					
Pork	67.05	82.76	1.43	95.99	80.66
Others	12.65	17.24	0.55	6.98	5.87
Sales expense				7.59	6.38
Labor				4.83	4.06
Overhead				3.62	3.04
Total	79.70	100.00		119.01	100.00

Source: (Animal Sciences Group of Wageningen UR Nanjing Agricultural University, 2009)

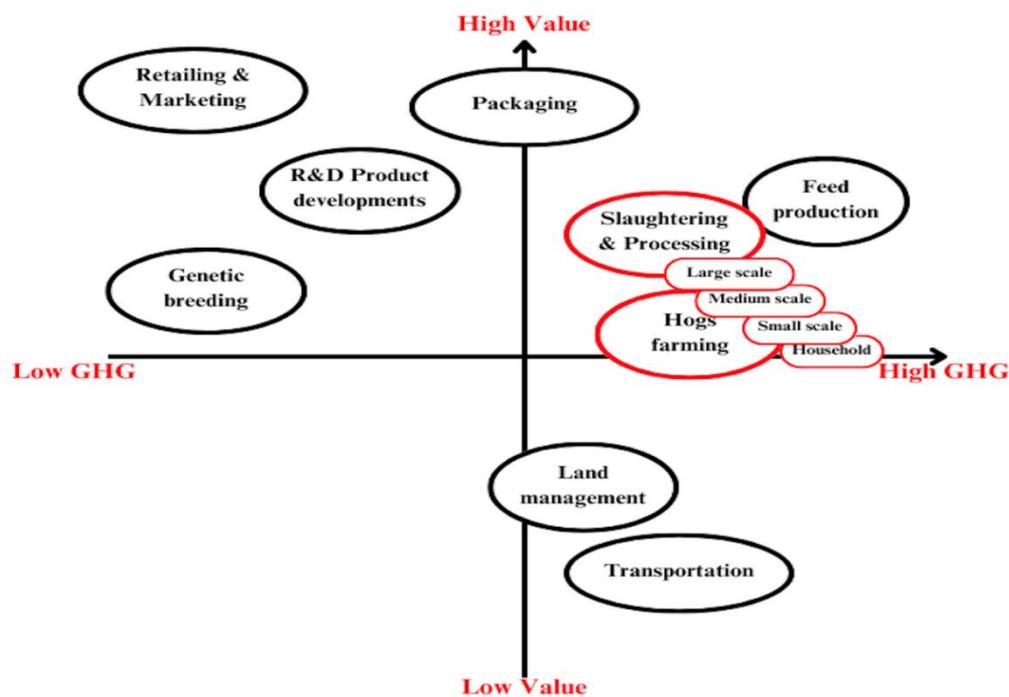
stress impacts the perceived quality of pork products, feed production, pig farming and slaughtering processes could create value for the final product, while these activities, including enteric fermentation and manure management, also contribute the most GHG in total pork production. Moreover, household farming and slaughtering produces relatively high GHG but creates less value for the final product, while industrialised farming and slaughtering perform a better management of GHG and higher value added. It is also true that a potential surplus or deficit of pork in different provinces results in a higher GHG production caused by inter-provincial transportation.

Analysis

Performance assessment

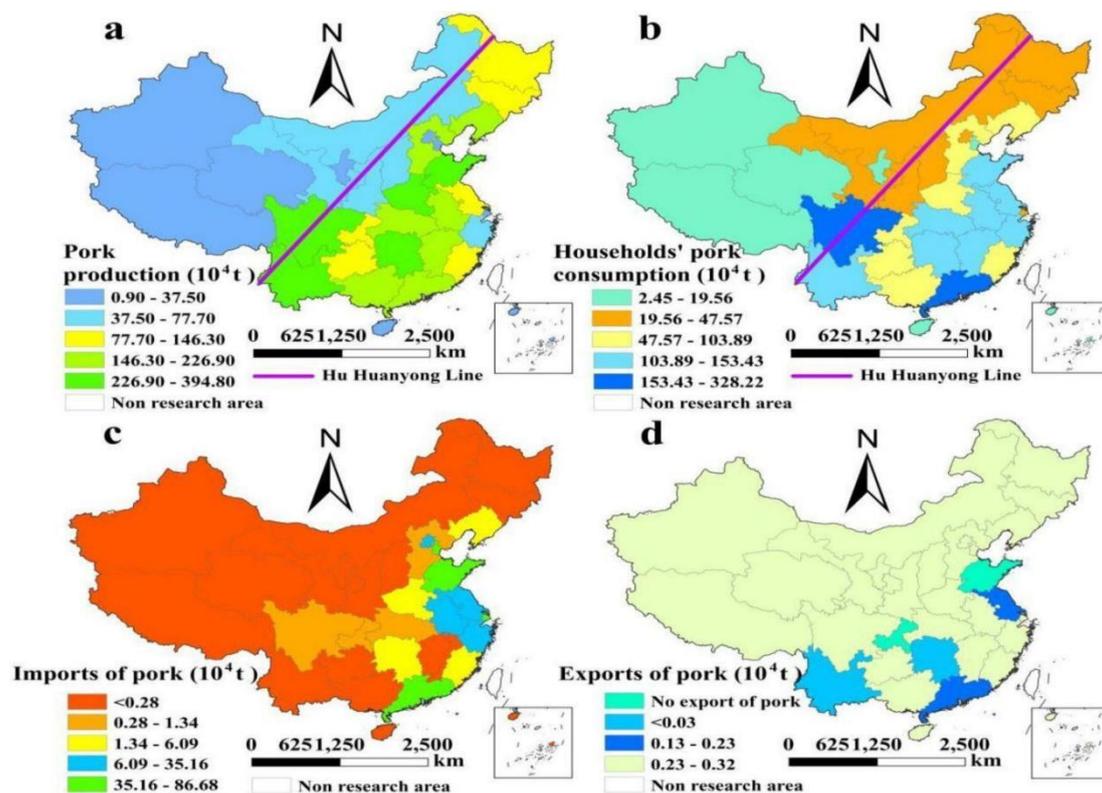
Potential surpluses or deficits of pork manifest variously at the provincial level, which can be observed through the spatial patterns of pork production, households' pork consumption, imports of pork, and exports of pork (Figure 8). Overall, the "Hu Huanyong Line" serves as the boundary distinguishing pork production and households' pork consumption in China, with a relatively low parameter in the west and high one in the east. Furthermore, most regions such as Sichuan, Hunan, and Yunnan have a potential pork surplus due to significant pig production, with the total potential pork surplus being approximately 19.66 MT. However, only five provinces have a potential pork deficit, accounting for 1.27 MT. As a consequence, the management of potential surpluses or deficits of pork should be considered, as well as the avoidance of GHG produced by trans-regional transportation of pork.

Figure 7. Greenhouse gas (GHG) emissions Vs value additions of pork production



Source: (National Development and Reform Commission of People’s Republic of China, 2002)

Figure 8. The spatial patterns of pork production, households’ pork consumption, imports of pork, and exports of pork in China in 2020



Source: (Chen et al., 2021)

Constraints and challenges

Productivity

Based on Chopra & Meindl's theory, farming and processing units can be defined as key facilities at which pigs could be transformed into value added products, and the metric capacity of facilities is the maximum number of pigs that can be fattened and slaughtered at a unit (Chopra & Meindl, 2013). The productivity of pig farming and slaughtering both remain low due to a large number of backyard and small-sized producers, and some households in rural areas are still left behind, since these poorly educated, unequipped producers and processors provide relatively low value pork in limited amounts per year. Despite previous governmental policies, neither the target of increasing the scale of pig farms, nor that of having 52 per cent of pigs raised by operations with more than 500 head, has been achieved (Table 3).

Table 3. China's hog production policies adapted to changing circumstances

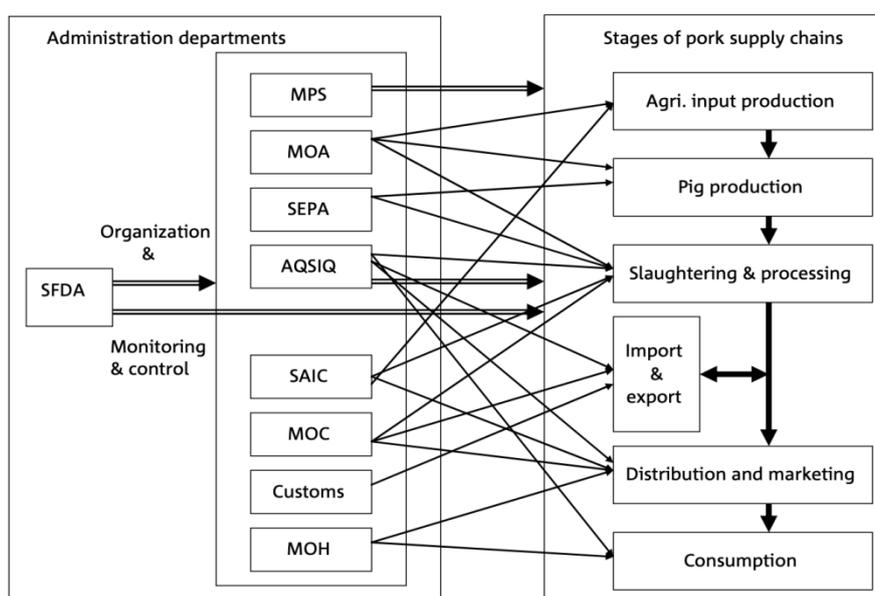
Year	Events
1950s	Mao Zedong urged communal farms to raise pigs as a source of organic fertilizer for grain crops.
1960s-70s	With tight food supplies, authorities prioritized production of food grains over meat.
1980	Livestock was included in market-oriented liberalizations of the centrally planned agricultural sector announced by the Communist Party leadership.
1983	Central and local governments launched a set of "lean hog" production bases, setting up breeding farms, feed mills, and disease prevention systems.
1985	Hu Yaobang—head of China's Communist Party—urged increased production of pigs to add more protein to the Chinese diet and to supply organic fertilizer for crops.
1989	Pork production was a prominent part of a "vegetable basket" initiative to supply cities with vegetables, meat, and fish.
1994	China liberalized imports of soybean meal and other high-protein feed ingredients.
1999	China liberalized soybean imports, shifting imports from soybean meal to soybeans.
2001	Accession to the World Trade Organization reduced import tariffs for pork.
2006	A livestock modernization program was launched as part of the 11th 5-year plan.
2007	Subsidies for hog producers were introduced: subsidies for artificial insemination, a sow subsidy, subsidized insurance for sows, free vaccinations, a subsidy for construction or refurbishment of large-scale farms, and transfer payments to major pork-supply counties.
2007	An epidemic of porcine reproductive and respiratory syndrome constrained supplies of hogs, causing pork prices to soar, which attracted new attention to pork industry policies and investment.
2009	A program was launched to stabilize hog prices by buying and selling reserves of frozen pork.
2011	A virus caused high mortality among China's piglets, contributing to another surge in pork prices that prompted an expansion of production capacity.
2011	News media revealed widespread use of banned feed additives by hog farmers, prompting tighter regulation and pledges by companies to increase vertical integration of pork production.
2013	Thousands of dead pigs were discovered floating in Shanghai's Huangpu River, contributing to stricter enforcement of regulations limiting where hog farms may be operated.
2013	China's WH Group purchased the U.S. pork company Smithfield Foods.
2014	China's State Council introduced regulations limiting waste emissions by livestock farms.
2015	China's Minister of Agriculture led a national conference on livestock modernization that encouraged fostering new types of livestock businesses, improved breeds, and strict oversight of feed, slaughter, and veterinary drugs. A target of 52 percent of hogs raised by operations of 500 head or more was set for 2020.
2016	The Ministry of Agriculture's 5-year plan set objectives of increasing scale of hog farms, utilizing hog waste, shifting hogs away from cities and southern watersheds, improving cold chain, establishing traceability, and increasing vertical coordination.

Source: Compiled by ERS from Chinese government reports and news media.

Information

The addition of value is driven by information collected through a traceable system, and the traceable system within the entire supply chain both ensures food safety and addresses food quality (Carndall et al., 2013). On the one hand, retail markets consist of a large number of wet markets, where pork safety is a major concern because of the increased risks of cross-contamination. Meanwhile, food standards applied to pork slaughtering, such as HACCP and ISO 9000, are still limited in application: a recent survey indicated only 30 per cent of companies in China had applied the HACCP system, while 40 per cent had done so with the ISO system (Trienekens et al., 2009). Although there are many legal systems established by the Government and related institutions (Figure 9), more than half of pork produced by households and small-sized producers is not traceable. Also, overlapping functions between the administrative departments in managing pork safety may pose a risk to the flow of the supply chain. On the other hand, a series of pork certification programs is lacking in China. Despite the Chinese Government's investment in improving the standard of agricultural products, such as 'green food' and pollution-free food, none of these standards is related to pork products. There is little value added after slaughtering because of the absence of a proper standard for determining the eating quality of meat.

Figure 9. Departments monitoring pork safety in China



Source: (Trienekens et al., 2009)

Market segments

The total value of pork sold in wet markets is much lower than chilled pork sold in supermarkets, and Chinese markets face challenges in shifting wet markets towards modern retailing due to consumer preferences. Although scientific research has shown higher quality in chilled pork, including for color, tenderness, and so on, many studies indicated that Chinese consumers prefer recently-slaughtered

pork rather than chilled pork, because they believe pork preserved over a long period is not fresh (Wang et al., 2018). Also, the weak market linkage at the provincial level, and increased demand for chilled pork due to urbanisation, may cause a potential surplus or deficit of pork.

Feed production

Feed inputs account for more than 50 per cent of total pork production costs, and the increasing demand of consumers for quality and safe pork and the upgrading of the industry could lead to higher feed costs in the future. In addition, because most household farmers are sensitive to the price of feed supply, pigs may be fattened with low nutrient feed produced by feed manufacturers, which further impacts the quality of pork.

Animal health

In addition to African swine fever (ASF) in 2019, China's pork market was also impacted by multiple strains of PRRS in previous years. However, government programs and regulations in preventing animal disease are not implemented, and recent studies indicated poor management of record immunisations and animal quarantine certificates in China's pork industry, as well as veterinary professionals to carry out vaccinations being in short supply (Sun et al., 2016).

Price variability

The Chinese pig industry has experienced unusual price fluctuation in recent years because of the spread of African swine fever (ASF) and COVID-19. Recently, the Chinese government introduced a market intervention program for stabilising the market, named 'hog price alert' (Table 4), and this program aims to stabilise pork prices by buying and selling pork for government reserves.

Table 4. China's hog price alert

China's pork market intervention guidelines		
Hog-grain price ratio ¹	Color code	Government action
Over 9:1		Sell frozen pork reserves into the market; issue subsidies to low-income consumers.
6:1 to 9:1	Green ("normal")	Monitor markets and price fluctuations; issue information. Pork reserves mainly used for emergencies and disasters.
5.5:1 to 6:1	Blue	Add to central and local pork reserves when ratio is in this range for 4 consecutive weeks.
5:1 to 5.5:1	Yellow	Subsidize interest on loans to large meat processing companies to encourage them to add to commercial reserves and increase pork processing.
Under 5:1	Red	Increase central reserves and require large and medium cities to increase local reserves of frozen pork when the ratio is in this range for 4 consecutive weeks. The number of live hogs kept in reserve may be increased. If the ratio is still in this range after reserve purchases, a temporary subsidy of 100 yuan per sow may be given to farms in main hog-producing counties when sow inventory is down 5 percent year-on-year. Appropriately limit pork imports to reduce the market supply; "improve" the food safety system to encourage pork exports.

¹Some provinces set a higher threshold for the hog-grain price ratio.

Source: USDA, Economic Research Service using National Development and Reform Commission, *Regulatory plan for controlling excessive hog price declines*, Bulletin No. 1, January 9, 2009, and provincial guidelines for implementation.

However, this policy has a limited impact on the market, because frozen pork only occupies a small

amount of market share. Also, it is hard to discern the pork price through a hog price alert, since it lacks information about the amount, timing, and location of pork reserve purchases and sales.

Sustainability

The environmental impact of pork production in China mainly results from backyard and small-sized farms and processors, including slaughter-related energy emissions and on-farm practices, with another major contributor being unnecessary transportation caused by poor management of surplus or deficit pork at the provincial level.

Poor strategic fit

The pork value chain in China involves a high level of implied demand and supply uncertainty across provinces and retail markets, so the strategic fit of a responsive value chain should be more suitable. Because the value results from consumer willingness to pay for a product with multiple attributes, a responsive value chain can better meet consumer needs by building up its capabilities to increase responsiveness (Chopra and Meindl, 2013). Thus, the strategy for the pork value chain in China is to increase the efficiency of farming and slaughtering through the industrialisation of pig production, reduce risks of pork quality and safety by regulating food standards, and respond to consumer demands for attributes through a series of quality guarantee programs such as farming and processing certifications. Also, due to the perceived value being the overall assessment of benefits and price in the context of buying goods, a low-price chain through the reduction of feed costs can be considered (Zeithaml, 1988). Moreover, all value creation and addition processes should reduce environmental impacts, particularly in provincial transportation and processing, to meet the Sustainable Development Goals 2030 adopted by the United Nations.

Some Suggested Interventions and improvements

Industrialisation of pig farming and slaughtering

Although the number of household producers has decreased, and small-sized producers has increased, in recent years, these small-sized producers still rely on backyard farming and semi-mechanised slaughtering. Industrialisation should predominantly focus on eliminating small-sized producers and increasing the number of large-sized producers. However, this requires intervention from local and central government authorities. One possible solution could be a shareholding company to provide technical support to farmers to increase their skills, which would also benefit the image of the company and, in the long run, increase its market share. Furthermore, investments are needed to develop large standardised production farms and slaughtering zones with input from local authorities, as well as insurance and finance institutions. This may further promote pig production and stabilise market supply (Schneider, 2017).

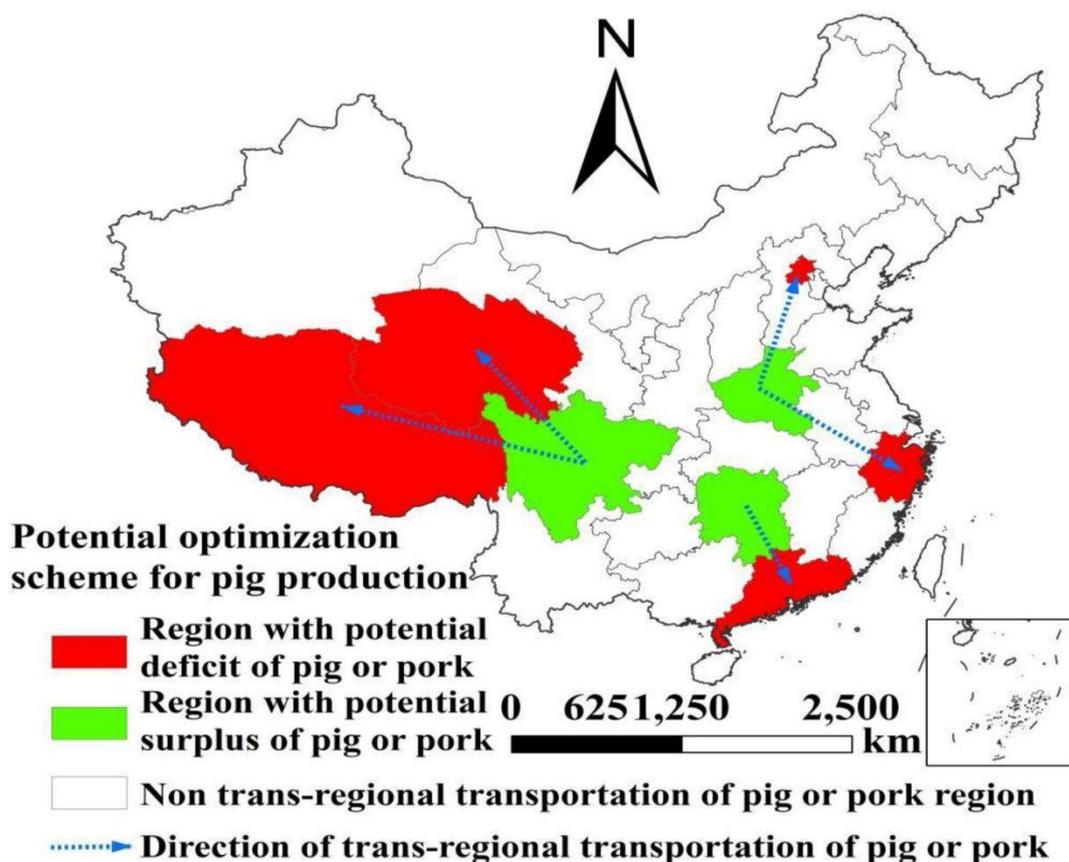
In addition, based on the potential pork surplus or deficit at the provincial level, the spatial distance needs to be evaluated when selecting the location of large standardised production, and a potential

optimisation scheme for pig production is shown in Figure 10 below. It is possible to plan a market link between the source regions of the trans-regional transportation of pork (Sichuan, Hunan) and the target regions (Beijing, Zhejiang), to avoid potential pork surpluses or deficits and minimise the GHG produced by inter-provincial transportation.

Quality and safety management

The improvement of information technology and traceability is the key to quality management, and real-time synchronicity, completeness and accuracy need to be guaranteed when exchanging information. Thus, Radio Frequency Identification technology (RFID) can be applied to trace products within the whole pork chain, and modernised logistic management including e-commerce may be beneficial for monitoring pork quality. Also, investments in training staff on farms, in slaughterhouses and in processing firms, as well as increasing professionals in R&D, could reduce the threat to pork chain innovation and safety problems. In addition, administrative departments monitoring pork safety need to be reorganised in order to provide efficient and accurate support to provinces or local municipalities. Lastly, the government should increase its intervention programs, such as free vaccines to avoid hog diseases, supported feed manufacturing to produce low-cost and higher-quality feeds, and modern equipment for slaughtering.

Figure 10. Potential optimization scheme for pig production



Source: (Chen et al., 2021).

Inventory management

The reduction of cyclical fluctuations in pork production plays an important role in improving self-independence and sufficiency, as well as reducing the importation of pork. The increase in pork prices prompts farmers to expand production, and the corresponding increase in pork supply may take more than a year to enter the market. To stabilise the market, government interventions are required, including market interventions and tax breaks. In particular, the government should predominantly assist farmers with brokering deals with investors or final customers, and with access to land and bank loans. Furthermore, a better solution would be to prepare for the risk of the market rather than uncertainty. Because the outbreaks of animal diseases are known-unknowns, these could be prevented by efficient vaccinations. The improvement of vaccinations and disease resistance may further reduce the risk of cyclical fluctuations in pork production.

Packaging and certifications

Packaging sells what it protects and protects what it sells, and it plays an important role in value addition. With the increase in demand for chilled pork, a large number of wet markets need to be transformed into modern retailing units with packaged meat. This requires investments in high-quality cold chain technology and packaging development. Although Chinese consumers prefer freshly-slaughtered pigs, which may be antithetical to shifting the market segment from wet markets to supermarkets, the education of consumers in science-based assessments of meat quality might be a solution. While the diffusion of meat knowledge may take generations, a forced-selection perspective of diffusion driven by government authorities can speed up the diffusion. According to Abrahamson's theory of the diffusion of innovations, the diffusion within a group can be determined by an organisation outside this group, and innovations will tend to diffuse among groups of organisations when these innovations receive the backing of powerful organisations outside these groups (Abrahamson, 1991).

Furthermore, the market segment of processed pork products in China is small, and it lacks a competitive strategy for adding value to these products. There are opportunities for forming industry-oriented clubs to generate a series of certification programs, for example certificated infrastructure to measure and monitor meat quality traits, geographical indications to protect locally processed pork products, and assessments of meat quality post-slaughtering, as well as an arrangement of Fair Trade to ensure sustainable and equitable trade. All of these grading systems not only increase the purchase intent in the domestic market, but also improve the acceptability for the export market.

Conclusions

In summary, the pork value chain in China needs to be improved to secure the supply for the increasing demand for the quantity and quality of pork. Value-added pork production is an important strategy for both producers and end-consumers, and the proposed improvement emphasises value addition through the industrialisation of producers, the completion of safety controls, the transformation of market segments, and grading systems. Also, the improvement of vaccinations and disease resistance may further reduce the risk of cyclical fluctuations in pork production. By completing these strategies,

China could become self-sufficient in pork supply and competitive in the export market in the future. However, the study of the pork value chain in China still lacks sufficient investigation from a domestic overview, so further research in gathering primary data should be conducted.

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