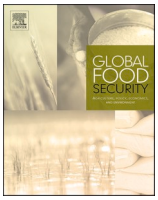
Global Food Security 26 (2020) 100409

Contents lists available at ScienceDirect

Global Food Security

journal homepage: www.elsevier.com/locate/gfs



Rising concerns over agricultural production as COVID-19 spreads: Lessons from China

Mingzhe Pu, Yu Zhong *

Institute of Agricultural Economics and Development, Chinese Academy of Agricultural Sciences, 100081, Beijing, China

ARTICLE INFO

Keywords:
COVID-19
Agricultural production
Food security
Food supply chain
China

ABSTRACT

There are rising concerns over the impact of COVID-19 on the agricultural production, which may become a nonnegligible threat to the long-term food supply and food security. This paper discusses the impact of COVID-19 on agricultural production in China, followed by government responses to alleviate the negative effects. The results show that unreasonable restrictions would block the outflow channels of agricultural products, hinder necessary production inputs, destroy production cycles, and finally undermine production capacity. It is expected that China's experiences could give warnings and suggestions to other countries that are experiencing serious outbreak to protect domestic agricultural production, especially developing countries.

1. Introduction

Different from previous foodborne zoonotic diseases, COVID-19 has raised global concerns about food security (WFP, 2020a; FAO, 2020a; Torero, 2020a). Since the outbreak of the pandemic, panic buying of food has occurred in many countries. What's worse, some countries have begun or are considering export restrictions (IFPRI, 2020). The World Food Programme (WFP), Food and Agriculture Organization (FAO), International Food Policy Research Institute (IFPRI), and other international organizations have issued calls to keep the global food trade open. The Extraordinary G20 Agriculture Ministers' Meeting in April also confirmed the need for collective action to ensure that markets function well. After March, COVID-19 has spread across the globe more rapidly. By July 9th, over 12 million confirmed cases and 500 thousand deaths were reported in at least 200 countries, territories or areas (CSSE-JHU, 2020). Influenced by the Great Lockdown against the COVID-19 and the steep recession (Torero, 2020b), the food systems are under risk as never before, pushing increasing number of people under poverty, hunger and malnutrition (WFP, 2020b).

Although challenges in the global food supply chains have captured public attention, little is known about the effects of COVID-19 on agricultural production; most existing studies focus on logistics and distribution (FAO, 2020b; Reardon and Swinnen, 2020; Reardon et al., 2020; Gray, 2020). In fact, lessons from China have shown that some countermeasures against COVID-19 disrupted production. This represents a nonnegligible threat to the long-term food supply (FAO, 2020c). Such production-undermining cases are not observed only in China, but also in other developing and developed countries. As a retrospective analysis of the pandemic period in China, this paper identified the impacts of COVID-19 on China's food production and corresponding policy responses. We hope that these practices could remind other countries that are experiencing serious outbreak to protect domestic agricultural production, and for China itself, to find way forward to consolidate production foundation in the food supply chain and build a more sustainable food system.

2. Previous experiences and current thinking

Foodborne zoonotic pathogens (FZP) are increasing in frequency (Bett et al., 2020). Outbreaks of FZPs, such as HIV-AIDS (1970s-), SARS (2003), H5N1 (2005–2010), H1N1 (2009), MERS (2008-present), and Ebola (2015), have posed continuous threats to public health. When it comes to food security, their impacts vary due to the differences in transmissibility and the animal hosts of the pathogens.

Ebola, MERS, and SARS, with short incubation periods and high lethality rates, mainly shocked the food systems in certain areas where they spread (Vos et al., 2020). They devastated agricultural production by damaging agricultural labor forces (Lopez et al., 2006) and hindering other input factors (Gong et al., 2020). Decreasing production pushed the rural and the poor into food insecurity. After the outbreak of Ebola in 2014, more than 40% of the arable land in affected areas was not cultivated (Fan, 2020), and Guinea's rice production dropped by 20%

* Corresponding author. New Main Building, 12th Zhongguancun South Street, Haidian District, Beijing, China.
E-mail addresses: pumingzhe@caas.cn (M. Pu), zhongyu@caas.cn (Y. Zhong).

https://doi.org/10.1016/j.gfs.2020.100409
Received 18 May 2020; Received in revised form 9 July 2020; Accepted 13 July 2020
Available online 20 July 2020

(WB, 2015). These diseases even slowed down the economic development (WB, 2015), and reduced the government's purchasing power in the international food market.

H5N1 and H1N1, with relatively low lethality and strong infectivity, ultimately resulted in global pandemics. But their impacts on food system were mainly on production sector rather than the whole supply chain. A large number of livestock and poultry were killed by the virus, or were disposed to stop the virus spreading. Besides, the demand for animal products decreased massively. During the H1N1 epidemic in 2009, 64% of the consumers in China stopped buying pork (USMEF, 2009), bringing $270 million losses to the American Pork Association in the second quarter of 2009 (Gong et al., 2020).

COVID-19 cannot be classified into either of the above two categories, neither of which raised concerns over global food security. At the beginning of the pandemic, some people believed that it would have little impact on the food supply (Vos et al., 2020). The epidemic is believed to be more severe in densely populated cities than in rural areas (Reardon et al., 2020). Bulk commodities can be loaded and shipped by machines with minimum human-to-human interactions (Vos et al., 2020). Besides, global food production is improving and stocks higher than the alert level (FAO, 2020d). However, panic with respect to food is spreading globally (FAO, 2020a; WFP, 2020a, 2020c).

COVID-19 is destroying the agricultural production sector, which is the root of food system. Although the direct impacts will overwhelmingly be felt post-farm (Reardon et al., 2020), an increasing number of on-farm problems have been witnessed in various countries (UN, 2020). For example, in northwest India, wheat and pulse harvesting was disrupted because of non-availability of migrant labor (Dev, 2020). In Ethiopia, vegetable farmers suffered not only from income loss due to overstocked products but also from a shortage of important inputs. This served to lower farmer income and reduce production intentions (Tamru et al., 2020). Even in the developed countries such as United States and Canada, overstocked milk, vegetables, livestocks, and poultry were dumped or destroyed (Weersink et al., 2020; Bellany and Corkery, 2020). If these on-farm problems remain unsolved, the food supply chain would be more fragile and lose sustainability. More people who live on agricultural production would trap in poverty.

3. Agricultural responses in COVID-19 epidemic: Evidences from China

China is the first country that has controlled the COVID-19. Along with an unprecedented scale of protection and control measures across the country, the national emergency food supply system (NEFSS) started to gather, transport and distribute food. This system consists of the stockpiles of refined grain products in large and middle-size cities, emergency processing enterprises, emergency supply outlets, emergency distribution centers, and emergency storage and transportation enterprises. In addition, the "Cereal Bag" Provincial Governor Responsibility Mechanism (CBPGRM) and the "Food Basket" Mayor Responsibility Mechanism (FBMRM) also played important roles. The CBPGRM, which was officially issued in 2014, defines the responsibilities of provincial governments in ensuring food security in terms of production, circulation and consumption within their provinces. The FBMRM, which was introduced as "Food Basket" Program since 1988, requires the mayors to be responsible for the production and stable supply of meat, eggs, milk, fish, vegetables and fruit in their cities. Thanks to the quick reaction of NEFSS and the solid food supply basis guarded by CBPGRM and FBMRM, the food prices remain stable and food supply can meet the need (FAO, 2020e; Chen et al., 2020a).

3.1. Agricultural production disrupted by prevention and control measures

As the epidemic continues, the Chinese government finds that some prevention and control measures are undermining agricultural production. It is also believed that the current stable food supply would not last long if these problems remain. The production in the next season may drop dramatically, threating national food security. With the sheer size of China's population (Huang and Yang, 2017), this would have profound impact on the global food system.

3.1.1. Block product outflow channels

The traditional offline sales channels were cut off or inefficient during the epidemic. On one hand, the demand of agricultural products plummeted in the short term due to the quarantine measures. "Closed management of communities/villages" and "family outdoor restrictions" policies decreased purchasing frequency and outdoor consumption significantly. The closure of conventional urban sales outlets resulted in purchasers failing to make purchases as planned. On the other hand, the distribution channels were fractured due to logistics restriction. At first, all the inter-region and intra-region logistics gave way to medical teams and supplies. Live poultry and swine distribution was forbidden in some areas with the thinking that they might be potential epidemic transmission channels. Then logistics restriction was loosen a bit, but both the drivers and the trunks on the road required strict certifications for safety. Consequently, the marketing quantity of the agricultural products dropped dramatically (see Fig. 1).

The obstacles in outflow channels pushed sales pressure back to the production sectors, resulting in large amounts of unmarketable agricultural products. Most pig pens, chicken coops, fish ponds and farm lands were overstocked, especially for seasonal perishable products. China's major winter fruit-producing provinces (e.g., Guangxi, Hainan) and winter vegetable-producing provinces (e.g., Yunnan, Sichuan) sent out distress signals. The China Agricultural Product Marketing Association (CAPMA) collected 3482 pieces of overstocked agricultural product information across the nation from February 20th to March 31st, approximately 85 pieces per day. The information included 53% fruit, 18% animal products, 16% vegetables, 7% grain and edible oil, and 3% aquatic products (see Fig. 2). This indicated that the epidemic has had a greater impact on perishable agricultural products than other products. The total overstocked weight recorded by CAPMA was over 2.76 million tones, including 21.64 million chickens, 11.08 million ducks, and 246.6 thousand pigs. These numbers only reflect a fraction of the total overstocked products.

3.1.2. Hinder agricultural production inputs

The effect of the epidemic on labor inputs mainly lay on restricting labor movement. Farmers were not allowed to go out or gather under any circumstances except for shopping for necessities. This led to a shortage of labor and decreased production efficiency. Some grain-producing areas in the southeastern coastal provinces could not plant crops on time, due to the lack of migrant skilled grain growers from Hubei, Hunan, and Sichuan provinces. Most farm service providers stopped working due to the fear of the epidemic or the traffic restrictions (Wei and Lu, 2020). Some providers could plant 6 ha per day before the epidemic; however, after the epidemic broke out, they could only cover 3 ha per day because of the difficulty in hiring tractor drivers.

Crop planting were delayed to some extent. Chinese farmers usually complete their planting preparations around the Spring Festival. However, in this year most production inputs were not ready due to the lockdown policies. The online survey data collected from 1501 rural households by the Chinese Academy of Agricultural Sciences (CAAS) showed that 51.19% of respondents had difficulty buying fertilizers, pesticides, and other inputs, and 20.39% had no access to purchasing these necessities (Zhong et al., 2020). On the national level, data from the Ministry of Agriculture and Rural Affairs (MARA) showed that the seed markets' opening time was delayed by 10–15 days, and seed sales decreased by 10%–30% by March 10th compared with the previous year (NDSP, 2020a). Only 36% of rural households had direct access to fertilizers by March 4th (NDSP, 2020b).

The breeding industry faced a serious feed shortage. Like other

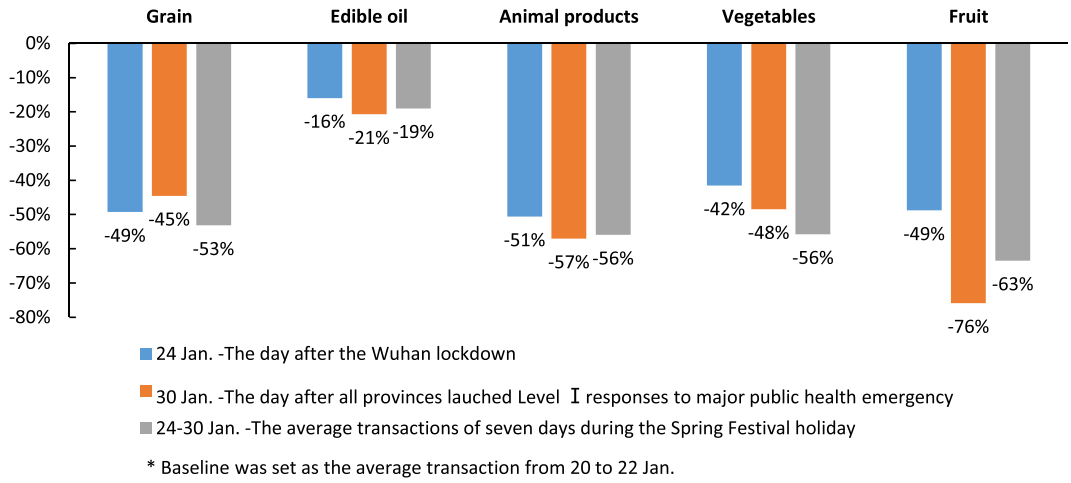


Fig. 1. Reduction in marketing quantity of grain, edible oil, animal products, vegetables and fruit during the COVID-19 epidemic in China.
Notes: 1. Transaction changes were calculted in unit of weight (tonnes). 2. January 23rd is the day when Wuhan was placed under lockdown policy. 3. January 29th is the day when all provinces in China lauched Level I responses to major public health emergency. 4. Numbers are calculted based on a big-data information platform called National Data Service Platform of Agricultural and Rural Response to COVID-19 set by MARA, http://snsj.agri.cn/market-operation.

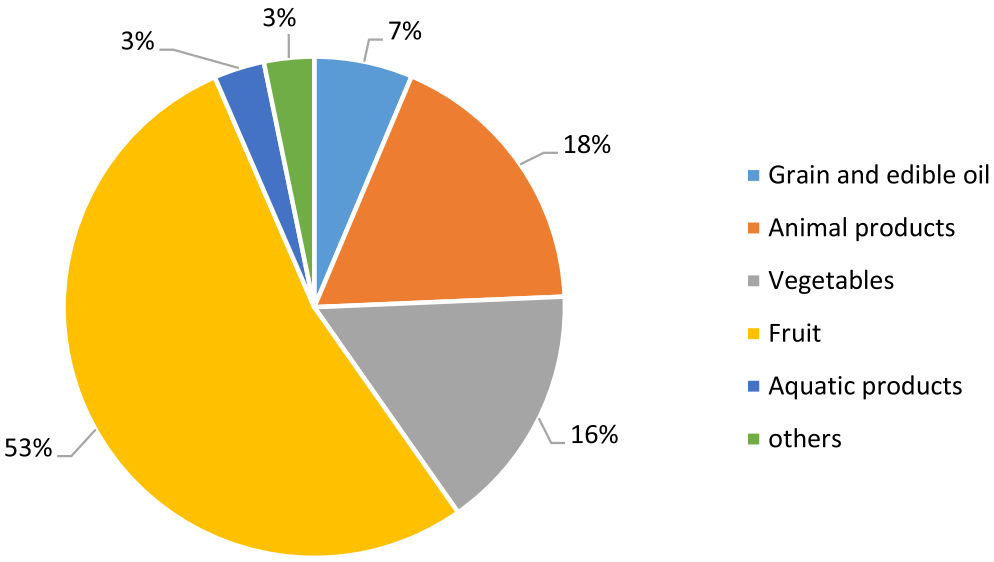


Fig. 2. The breakdown of overstocked agricultural products information from CAPMA. Note: Distribution of the 3 482 pieces of overstocked information into clusters focused on different agricultural products. The figure refers to the number of reports regarding overstock agricultural products. The information was collected across the nation by CAPMA through an online platform from February 20th to March 31st. http://www.ceninfo.net/index/dataInfo.htm?t=1.

factories, feed mills were closed during the epidemic. Distribution of feed and veterinary drugs were cut off to stop the virus from spreading. As a result, many breeding farmers were short of feed stocks or even ran out of feed. Some poultry farms had no choice but to bury their baby chicks and ducks. According to the research from CAAS, over 60% of baby chicks were humanely disposed during the epidemic (Xin et al., 2020). What's worse, the COVID-19 epidemic period overlapped with African swine fever (ASF) in China, which had reduced the pork supply sharply last year. The obstruction in veterinary drug transportation further crushed pig-breeding industry, bringing more difficulty in maintaining pork supply and driving price higher.

3.1.3. *Destroy agricultural production cycles*

The prevention and control measures broke the nature growth cycle of agricultural products, which would further disrupt the normal cycles of food supply and increase market volatility in the medium term. Agricultural production combines natural growth and economic activities. This feature determines that the planting and breeding should follow a set time frame (Luo, 2020). The failure to plant or breed at the right time may result in production reduction.

In terms of staple grain, the pandemic shocked the early rice most in China. February and March, the worst time of the pandemic, are the sowing period of early rice, and the overwintering period of winter wheat. Some lockdown policies have delayed seeding and transplanting of early rice in South China for about 10 days, and farmland plowing in Central China. The impact on the winter wheat is much smaller because the time-critical works during the overwintering period are less and simpler. The middle rice, late rice and maize, whose sowing stages range from April to July across the whole country, were not affected directly. Considering the fact that the proportion of early rice in total grain production is only 5%, the impact of the COVID-19 on the staple grain is small. However, the risk of production reduction still raise concerns among the government and the public. On one hand, China has a huge population and the demand for staple grain are extremely inelastic. Reduction in supply may lead to soaring prices. On the other hand, this pandemic may accelerate the shift of the rice cropping system from the "double seasons" to "single season", which is believed to be a threat on the total production in the long term (Chen et al., 2020b).

The production of livestocks and poultry was severely disrupted in February. Animals need to eat every day, which requires intensive care

from farmers (Zhang, 2020). The supply chains of perished food often operate on a "just in time" basis (Bruno et al., 2020). Therefore the timing of inputs and selling is often inflexible (Stephens et al., 2020). Social distancing and mandatory lockdown caused producers to miss some production windows, resulting in significant short-term disruptions. The reduction in the chicken production was estimated to be 1.46 million tons in the first quarter, which may reduce the total supply by 1.14 million tones in this year (Zhou et al., 2020). If quick actions could be taken to cope with this challenge, the short-term disruption would not evolve to be a long-term shock in the entire year. Because poultry has a short production cycle, and the reduction could be made up soon by the following season. China's pig industry, which is already shocked by the ASF at the end of 2019 (WB, 2020), is hit again by the COVID-19. The production is estimated to decrease by 10.5% and price increased by 25% in 2020 (Zhu et al., 2020). Restoring the capacity of pig production has become one of the key tasks of China's agricultural development this year. In addition, we should realize that the recovering of all agricultural products is highly constrained by the financial conditions of producers (Weersink et al., 2020).

3.1.4. Undermine production capacity and sustainability

If the above short-term impacts are not controlled, they will directly affect the sustainable production capacity of agricultural products. First, the supply chain is difficult to recover once it is broken, because new natural production cycles need a long time to cultivate and restore. The growth cycle for poultry is about six weeks, that of pigs is about three months and that of crops is longer. But food demands are always there. The experts from CAAS believe that the poultry meat supply will continue to decrease in the first half of 2020 under the impact of the epidemic, and it is likely to take at least four months to fully recover (Zhou et al., 2020). During the recovering period, the poor would be hurt by the high prices and food shortage (Si et al., 2020).

Second, the loss in harvest would decrease production investment for the following season. On one hand, the overstocked products brought a huge loss to farmers. Taking chicken as an example, the pandemic have led to a loss of over 12.5 billion yuan (about 1.78 billion dollars) in the first quarter (Xin et al., 2020). On the other hand, the production costs kept increasing during the epidemic. In our survey with 22 representative grain producers, farmers in Jilin province (produces maize, in North China) and Hunan province (produces rice, in South China) claimed that the price of pesticides and fertilizers increased by 200 yuan per ton, 20% higher than the prices before the pandemic. Similarly, cooperatives in Fujian province also claimed that the price of pesticides and fertilizers increased by 20%, and the price of seeds increased by 10%. Without enough money, farmers have no incentives and capacity to continue farming (FAO, 2020c,e; Stephens et al., 2020).

Third, the decrease in off-farm income affects farmers' livelihoods, as well as their intentions for production. Our survey found that many small farmers planned to seek off-farm jobs after the epidemic to maintain their livelihood. If so, the amount of abandoned farmland may increase, which would directly affect the production capacity. However, their plans may not be realized; because the off-farm working, which accounts for over 40% of rural households' income in China (Cheng and Zhu, 2020), is also squeezed sharply by the pandemic. The unemployment and underemployment of rural migrants is one of the biggest problems during the pandemic (Ye et al., 2020). By March 7th, only 60% of the rural migrants had returned to work. As a result, the disposable income per capita of rural residents declined by 4.7%, and the monthly income per capita of rural migrants decreased by 7.9% in the first quarter (Wei and Lu, 2020). If these difficulties remain unsolved, more population may step back into poverty and hunger, impacting on the national goal of eliminating poverty by 2020. Constrained by limited cash flow and financial liquidity of farmers, these problems could also affect the agricultural production.

3.2. Government responses

Fortunately, the government is targeting these problems. From the end of January to late March, the Chinese government issued 16 urgent notices to ensure an ample supply of food, effective logistics for delivering agricultural inputs and support agricultural production (see Fig. 3). These notices can be divided into three categories. The first involves unblocking the logistics. The Ministry of Transport has enacted a notice clearly stating that basic living necessities, including agricultural products, are covered in the scope of emergency transportation. Transportation departments at all levels are required to open "green channels" for important agricultural products and give priority to related transportation. The second is to match supply with demand. In addition to CAPMA, MARA also organized other associations and e-commerce enterprises to achieve direct matching and transactions. Farmers and local governments cooperate with e-commerce platforms and arrange live-streaming events to boost online sales. The third is to ensure production of important agricultural products. The measures includes differentiating labor movement control measures in accordance with local risk levels, resuming the agricultural inputs production and logistics, speeding up breeding industry and agricultural production, and direct financial supports (FAO, 2020e).

Since the government took these measures, the problems in agricultural production have been effectively alleviated. By April 24th, CAPMA had organized major agricultural product markets to actively connect with 12 key production and marketing regions. More than 2.24 million tons of overstocked products found buyers. Other e-commerce enterprises sold 88.2 thousand tons, reaching 19.8 million online transactions.

Agricultural inputs are kept flowing. About 78 percent of township-level roads in more than 1500 agricultural counties of 25 provinces was kept open by the end of February (WB, 2020). This proportion increased to 92% by March 22nd (JPCM-SC, 2020a). By the middle of April, 98% of agricultural material enterprises have resumed normal operation and reached 90% of normal production, both percentages higher than those of the same period last year. The "green channels" promoted by the government has worked. 96% of agricultural material branch shops have opened, and 80% of rural households have direct access to inputs buying (JPCM-SC, 2020b). Public services supporting crop production turned to online mode. By April 28th, the China Agricultural Technology Extension Information platform has organized 40 thousand agricultural technicians and 7 thousand experts to answer over 6 million online questions regarding spring planting (JPCM-SC, 2020c).

Consequently, the production and supply of agricultural products is recovering fast from the COVID-19 outbreak. Stimulated by the strong supports by the government, farmers plant 313 thousand more hectares of early rice than the last year (MARA, 2020). Compared to February, the amount of live hog in stock increased by 3.6% in March. The poultry industry turned to making profits in March in spite of the huge loss in February. The total acreage of vegetables is over 4.47 million hectares in March, an increase of 1.33 million hectares than that in February (JPCM-SC, 2020d). The supply of livestock sector and vegetables has resumed normal by April.

As a result, the consumer price index (CPI) fell gradually. On the basis of February, the consumer price index (CPI) fell 2.87% in May. Food prices dropped 9.95%. The price of grain was stable, and the price of edible oil dropped 0.50%. The marketing quantity of vegetables increased, and the price of fresh vegetables dropped 29.32%. The price of pork was reduced by 20.94%. The price of eggs, aquatic products, and fresh fruit dropped 9.97%, 2.34%, and 3.18%, respectively.

4. Concluding remarks

The experiences in China indicate that difficulties in agricultural production should be attached importance to as COVID-19 spreads. The impacts of the epidemic on food supply chain started immediately from

19 Jan.	**MARA** Urgent notice on ensuring vegetable production and supply during COVID-19 epidemic	➢ Strengthen production guidance ➢ Help match supply with demand ➢ Smooth transport channels
1 Feb.	**MC** Notice on further ensuring supply of life necessities (including grain and edible oil, meat, vegetables et al.)	➢ Take quick actions to unblock transport channels from distribution centers to retail terminal ➢ Check the number of the necessities inventories and distribution methods ➢ Stabilize the social expectations and increase public confidence
4 Feb.	**MARA** Urgent notice on maintaining livestock and poultry industry in operation and ensuring supply of meat, egg and milk	➢ Do not block transport vehicles for livestock and poultry products ➢ Do not close slaughterhouses ➢ Support enterprises to resume work
6 Feb.	**MC** Notice on ensuring delivery and distribution life necessities during COVID-19 epidemic	➢ Help enterprises to increase efficiency in transportation of life necessities ➢ Help enterprises to solve difficulties and problems in circulation
11 Feb.	**MC** Notice on further ensuring supply of life necessities in major cities	➢ Increase inventory of life necessities ➢ Establish and improve the emergency distribution system ➢ Maintain market orders
	MARA Notice of ensuring agricultural products sales in poor-stricken regions during COVID-19 epidemic	➢ Coordinate with e-commerce enterprises to open special online sales channels ➢ Give credit priority, Subsidize loan interests ➢ Quick sampling inspection on the quality safety of the agricultural products
13 Feb.	**MARA** Announcement on simplifying certification and approval process during COVID-19 epidemic (for pesticide, fertilizer, feed and feed additive, veterinary drug, seed and seedling, etc.)	➢ Extend the valid period of relevant registration certificates ➢ Simplify approval process ➢ Optimize the approval process and make timely approval decisions based on electronic materials
14 Feb.	**MC** Notice on further strengthening linkages between agricultural demand and supply during COVID-19 epidemic	➢ Increase commercial inventory by providing subsidies and interest discounts ➢ Reducing fees, setting up special sales zones, and providing convenience certificates for sellers
	MC, MF Urgent notice on enhancing collaboration and coordination between agricultural and commercial sectors to improve the food supply chain during COVID-19 epidemic	➢ Arrange a certain percentage of funds to maintain supply ➢ Allow flexible use of the funds ➢ Simplify the procedures of fund appropriation
	MF, MARA Notice on ensuring stable production and adequate supply of agricultural products during COVID-19 epidemic	➢ Reduce or waive the guarantee fees of the agricultural credits ➢ Distribute agricultural production disaster relief funds as soon as possible ➢ Increase subsidies for cold storage and preservation facilities
16 Feb.	**MARA, NDRC, MT** Urgent notice on alleviating the current practical difficulties and speeding up the resumption of the breeding industry	➢ Release more public corn storage ➢ Open green channels for feed products ➢ Enhancing collaboration between the enterprises and the banks
21 Feb.	**MC** Notice on overall planning and management of the life necessities supply	➢ Coordinate well with the key enterprises which undertaking the emergency supply tasks ➢ Provide innovative supply modes, such as "centralized purchase + distribute by the community ", "online order + contactless delivery" ➢ Simplify the approval process of resuming work
25 Feb.	**MC** Notice on popularizing the best practices of ensuring life necessities supply during the COVID-19 epidemic	➢ Centralized purchasing and distribution for the closed communities ➢ Contactless delivery ➢ Developed electronic maps to provide accurate sales information for the residents ➢ Provide various standardized food combos
2 Mar.	**LGCC COVID-19** Guidelines for agricultural production in spring planting season	➢ Maintain the planting areas of the grain crops ➢ Differentiated resuming spring planting measures in accordance with local risk levels ➢ Ensure smooth transportation and sufficient supply of agricultural materials ➢ Provide online services of agricultural guidance
13 Mar.	**MARA** Notice on further simplifying certification and approval process to speeding up the resumption of agricultural enterprises	➢ Simplify examination and approval procedures ➢ Temporarily exempt from on-site inspection process ➢ Compress the approval time by over one third ➢ Expand the scope of online approval
19 Mar.	**MARA, MF, CBIRC** Notice on further strengthening supports to ensuring stable production and supply of pork	➢ Lower the threshold for loan interest subsidy: from 5000 pigs to 500 pigs ➢ Extend the valid date of policy-based agricultural credit loan to December 31, 2020 ➢ Relax the standard of non-performing loan ratio for hog breeding

Fig. 3. Timeline of Chinese government responses to alleviate difficulties in agricultural sector as COVID-19 spreads.
Abbreviations: Ministry of Agriculture and Rural Affairs (MARA), Ministry of Commerce (MC), Ministry of Finance (MF), National Development and Reform Commission (NDRC), Ministry of Transport (MT), China Banking and Insurance Regulatory Commission (CBIRC), Leading Group of the Central Committee on the Response to COVID-19 (LGCC COVID-19).

the “midstream” or “downstream” part, then will extend upward to the “upstream” production part. The former has drawn wide attention, while the latter has not. With more production-undermining cases observed around the world, we need to take urgent actions to prevent or mitigate the negative effects. Especially for developing countries, protecting agricultural production is the key to ensure food security and people’s livelihood. China’s experiences could offer some suggestion to cope up with those challenges.

Ensure effective logistics for agricultural products. Prevention and control measures should not interfere the transportation channels for agricultural products. It is necessary to ensure the smooth connection of supply-and-demand information. Regarding the sale of agricultural products, priority must be determined according to the storage characteristics of each product. The availability of cereal products must be ensured at all times. Also, perishable products, such as vegetables and milk, can be transported to suburbs to ease the sales pressure. In addition, e-commerce and delivery companies can help promote the connection between production and sales.

Ensure effective supply of critical inputs. It is important to open a "green channel" for agricultural production inputs and to ban unauthorized roadblocks. For rural areas where the epidemic is mild, village governors can organize farmers to go to their fields separately at different times. In areas where conditions permit, mechanized service and intelligent equipments should be promoted to reduce labor density. For the livestocks and poultry industry, the feed and veterinary medicine supply must be maintained. Fertilizer, pesticides and feed production should keep in operation above the basic demand line. The government, industrial associations and agricultural cooperatives should help promote the purchase and delivery of critical agricultural inputs.

Provide various supports to agricultural production and farmers. Anti-epidemic training and necessary epidemic prevention materials must be provided to production and logistics sectors. Also, compensation measures should be introduced to support production. For farmers or farms with difficulties in production, targeted subsidies or low-interest loans should be provided. Rural poverty-stricken households should be given income subsidies to ensure their livelihood. By implementing these measures, farmers’ motivations for agricultural production can be strengthened and the capital, technology, and labor inputs for the next crop season can be guaranteed.

Make use of innovative methods to promote sales. Food demand during the epidemic is only suppressed by prevention and control measures temporarily. The key is to find a new bridge to match supply to demand as the traditional offline channels are cut off. The e-commerce has shown enormous potential. The online platforms of the government, industrial associations and enterprises can help share market information and find new sales channels. The livestreaming events and online

promotion could revive sales of overstocked agricultural products. The delivery companies also play important roles to ensure the well-functioning of food supply chain. Some new services, such as contact-less delivery and shared pick-up points, could be provided to minimize human-to-human interactions.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements:

This work was supported by the National Natural Science Foundation of China (71903187); the Agricultural Science and Technology Collaborative Innovation Key Program of Chinese Academy of Agricultural Sciences (CAAS-ZDRW202012), the Agricultural Science and Technology Innovation Program of Chinese Academy of Agricultural Sciences (ASTIP-IAED-2020-01), the Agricultural Science and Technology Innovation Program for Special Talent of Chinese Academy of Agricultural Sciences (ASTIP-IAED-2018RC-01), the Special Fund for Basic Scientific Research (161005202001-1-3, 161005202001-1-4) of Chinese Academy of Agricultural Sciences.

References

Bellany, D.Y., Corkery, M., 2020. Dumped Milk, Smashed Eggs, Plowed Vegetables: Food Waste of the Pandemic. New York Times. 11 April 2020. https://www.nytimes.com/2020/04/11/business/coronavirus-destroying-food.html (accessed 7 July 2020).

Bett, B., Randolph, D., McDermott, J., 2020. Africa's Growing Risk of Diseases that Spread from Animals to People. IFPRI Research Post, 7 April 2020. https://www.ifpri.org/blog/africas-growing-risk-diseases-spread-animals-people (accessed 22 April 2020).

Bruno, E.M., Richard, J.S., Summer, D.A., 2020. The Coronavirus and the Food Supply Chain. ARE Update, vol. 23. University of California Giannini Foundation of Agricultural Economics, pp. 1–4, 4.

CSSE-JHU, 2020. Coronavirus COVID-19 Global Cases by the Center for Systems Science and Engineering (CSSE) at. Johns Hopkins University, 9 July 2020. https://gisanddata.maps.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6 (accessed 9 July 2020).

Chen, Z., Zhan, Y., Zhang, Y., Fan, S., 2020a. The impacts of COVID-19 on global food security and the coping strategy. Chin. Rural Econ. 425, 2–12 (in Chinese).

Chen, C., Groenigen, K.J., Yang, H., Hungate, B.A., Yang, B., Tian, Y., Chen, J., Dong, W., Huang, S., Deng, A., Jiang, Y., Zhang, W., 2020b. Global warming and shifts in cropping systems together reduce China's rice production. Glob. Food Secur. 24, 1–7. https://doi.org/10.1016/j.gfs.2020.100359.

Cheng, G., Zhu, M., 2020. Increasing farmers' income in 2020: impacts of and recommendations under the COVID-19 pandemic. Issues Agric. Econ. 484, 4–12 (in Chinese).

Dev, S.M., 2020. Addressing COVID-19 Impacts on Agriculture, Food Security, and Livelihoods in India. 8 April 2020. IFPRI Research Post. https://www.ifpri.org/blog/addressing-covid-19-impacts-agriculture-food-security-and-livelihoods-india (accessed 23 April 2020).

Fan, S., 2020. Preventing Global Food Security Crisis under COVID-19 Emergency. 6 March 2020. IFPRI Research Post. https://www.ifpri.org/blog/preventing-global-food-security-crisis-under-covid-19-emergency (accessed 22 April 2020).

FAO, 2020a. Impact of the Covid-19 Pandemic on Food Security and Food Systems. FAO Council. CL 164/10, 6-10 July 2020. http://www.fao.org/3/nd059en/ND059EN.pdf (accessed 7 July 2020).

FAO, 2020b. COVID-19 and the Risk to Food Supply Chains: How to Respond? Rome. https://doi.org/10.4060/ca8388en (accessed 7 July 2020).

FAO, 2020c. Sustainable Crop Production and COVID-19. https://doi.org/10.4060/ca8807en. Rome, (accessed 7 July 2020).

FAO, 2020d. The FAO food price index. World Food Situation. Released date: 2 April 2020. http://www.fao.org/worldfoodsituation/foodpricesindex/en/ (accessed 25 April 2020).

FAO, 2020e. Local Food Systems and COVID-19: A Look into China's Responses. Rome, 8 April 2020. http://www.fao.org/in-action/food-for-cities-programme/news/detail/en/c/1270350/ (accessed 2 May 2020).

Gong, B., Zhang, S., Yuan, L., Chen, K.Z., 2020. A balance act: minimizing economic loss while controlling novel coronavirus pneumonia. J. Chin. Gov. 1–20. https://doi.org/10.1080/23812346.2020.1741940.

Gray, R.S., 2020. Agriculture, transportation, and the COVID-19 crisis. Can. J. Agric. Econ. 1–5. https://doi.org/10.1111/cjag.12235. Special issue.

Huang, J., Yang, G., 2017. Understanding recent challenges and new food policy in China. Glob. Food Secur. 12, 119–126. https://doi.org/10.1016/j.gfs.2016.10.002.

IFPRI, 2020. COVID-19 Food Trade Policy Tracker. https://www.ifpri.org/project/covid-19-food-trade-policy-tracker (accessed 6 July 2020).

Joint Prevention and Control Mechanism of the State Council, 2020a. Press Conference of the Joint Prevention and Control Mechanism of the State Council, 22 March 2020. http://www.gov.cn/xinwen/gwylflkjz65/index.htm (in Chinese).

Joint Prevention and Control Mechanism of the State Council, 2020b. Press Conference of the Joint Prevention and Control Mechanism of the State Council, 4 April 2020. http://www.gov.cn/xinwen/gwylflkjz81/index.htm (in Chinese).

Joint Prevention and Control Mechanism of the State Council, 2020c. Press Conference of the Joint Prevention and Control Mechanism of the State Council, 28 April 2020. http://www.gov.cn/xinwen/gwylflkjz106/index.htm (in Chinese).

Joint Prevention and Control Mechanism of the State Council, 2020d. Press Conference of the Joint Prevention and Control Mechanism of the State Council, 19 April 2020. http://www.gov.cn/xinwen/gwylflkjz97/index.htm (in Chinese).

Lopez, A.D., Colin, D.M., Majid, E., Dean, T.J., Murray, C.J., 2006. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. Lancet 367, 1747–1757. https://doi.org/10.1016/S0140-6736(06)68770-9.

Luo, B., 2020. Agricultural development during the high incidence period of epidemics: new challenge and new thinking. J. Huazhong Agric. Univ. (Soc. Sci. Edn.) 237, 1–6. https://doi.org/10.13300/j.cnki.hnwkxb.2020.03.001 (in Chinese).

MARA, 2020. The Agricultural and Rural Economy Continues Recovering in May, 12 June 2020. http://www.moa.gov.cn/xw/zwdt/202006/t20200612_6346447.htm (accessed 5 July 2020).

National Data Service Platform of Agricultural and Rural Responses to COVID-19, 2020a. The National Agricultural Technology Center Has Released the Operation Situation of Crop Seeds Planted in Spring and Summer. National Data Service Platform of Agricultural and Rural Responses to COVID-19. Ministry of Agriculture and Rural Affairs of the People's Republic of China, 10 March 2020. http://snsj.agri.cn/article-detail?id=0cdadbf4-626d-11ea-a3c9-0242ac120002&route=agricultural-manage (in Chinese).

National Data Service Platform of Agricultural and Rural Responses to COVID-19, 2020b. Are the Agricultural Inputs Enough for the Spring Planting? Please See the Big Data. National Data Service Platform of Agricultural and Rural Responses to COVID-19. Ministry of Agriculture and Rural Affairs of the People's Republic of China, 4 March 2020. http://snsj.agri.cn/article-detail?id=2c99dbe2-5dd2-11ea-a392-0242ac120002&route=agricultural-manage (in Chinese).

Reardon, T., Bellemare, M.F., Zilberman, D., 2020. How COVID-19 May Disrupt Food Supply Chains in Developing Countries. IFPRI Research Post, 2 April 2020. https://www.ifpri.org/blog/how-covid-19-may-disrupt-food-supply-chains-developing-countries (accessed 23 April 2020).

Reardon, T., Swinnen, J., 2020. COVID-19 and Resilience Innovations in Food Supply Chains, 6 July 2020. https://www.ifpri.org/blog/covid-19-and-resilience-innovations-food-supply-chains (accessed 7 July 2020).

Si, W., Zhang, Y., Fan, S., 2020. How to ensure food and nutrition security under the COVID-19 epidemic: a global perspective. Issues Agric. Econ. 483, 11–16 (in Chinese).

Stephens, E.C., Martin, G., Wijk, M., Timsina, J., Snow, V., 2020. Editorial: impacts of COVID-19 on agricultural and food systems worldwide and on progress to the sustainable development goals. Agric. Syst. 183, 102873. https://doi.org/10.1016/j.agsy.2020.102873.

Tamru, S., Hirvonen, K., Minten, B., 2020. Impacts of the COVID-19 Crisis on Vegetable Value Chains in Ethiopia. IFPRI Research Post, p. 13. April 2020. https://www.ifpri.org/blog/impacts-covid-19-crisis-vegetable-value-chains-ethiopia (accessed 22 April 2020).

Torero, M., 2020a. Without food, there can be no exit from the pandemic. Countries must join forces to avert a global food crisis from COVID-19. Nature 580, 588–589. https://doi.org/10.1038/d41586-020-01181-3.

Torero, M., 2020b. Prepare Food Systems for a Long-Haul Fight against COVID-19. IFPRI Blog, 2 July 2020. https://www.ifpri.org/blog/prepare-food-systems-long-haul-fight-against-covid-19 (accessed 7 July 2020).

UN, 2020. Policy Brief: the Impact of COVID-19 on Food Security and Nutrition. June 2020. https://www.un.org/sites/un2.un.org/files/sg_policy_brief_on_covid_impact_on_food_security.pdf (accessed 7 July 2020).

US Meat Export Federation, 2009. USMEF: Reaction of Chinese Consumers to H1N1, 4 September 2009. https://thepigsite.com/news/2009/09/usmef-reaction-of-chinese-consumers-to-h1n1-1 (accessed 8 July 2020).

Vos, R., Martin, W., Laborde, D., 2020. As COVID-19 Spreads, No Major Concern for Global Food Security yet. IFPRI Research Post. March 10 2020. https://www.ifpri.org/blog/covid-19-spreads-no-major-concern-global-food-security-yet (accessed 22 April 2020).

Weersink, A., von Massow, M., McDougall, B., 2020. Economic thoughts on the potential implications of COVID-19 on the Canadian dairy and poultry sectors. Can. J. Agr. Econ. 1–6. https://doi.org/10.1111/cjag.12240. Special issue.

Wei, H., Lu, Q., 2020. Impact of COVID-19 on "agriculture, rural areas, and rural people" and countermeasures. Econ. Rev. J. 425, 36–45. https://doi.org/10.16528/j.cnki.22-1054/f.202005036 (in Chinese).

WFP, 2020a. 2020 - Global Report on Food Crises. https://docs.wfp.org/api/documents/WFP-0000114546/download/?_ga=2.110830339.728196019.1594181106-199106846.1593758578 (accessed 6 July 2020).

WFP, 2020b. World Food Programme to Assist Largest Number of Hungry People Ever, as Coronavirus Devastates Poor Nations. https://www.wfp.org/news/world-food-programme-assist-largest-number-hungry-people-ever-coronavirus-devastates-poor (accessed 7 July 2020).

WFP, 2020c. Food Insecurity Projections. https://docs.wfp.org/api/documents/WFP-0000116529/download/ (accessed 6 July 2020).

Word Bank, 2020. Responding to COVID-19 in China : Ensuring Food Security (English). World Bank Group, Washington, D.C. Disclosure date: 1 July 2020. http://documents.worldbank.org/curated/en/210231593658823735/Responding-to-COVID-19-in-China-Ensuring-Food-Security (Accessed 3 July 2020).

World Bank, 2015. The Economic Impact of Ebola on Sub-saharan Africa: Updated Estimates for 2015. World Bank Group, Washington, DC. Report Number 93721. https://openknowledge.worldbank.org/handle/10986/21303 (accessed 30 April 2020).

Xin, X., Zheng, M., Zhao, G., Wen, J., Wang, J., 2020. Impact of the COVID-19 on China's poultry breeding industry. National poultry industry technology system. Chin. Acad. Agric. Sci. 2020. February 20, (in Chinese).

Ye, X., Cheng, Y., Zhou, Q., Yin, H., 2020. Impacts of COVID-19 on rural and agricultural development in 2020 and its countermeasures. Issues Agric. Econ. 483, 4–10 (in Chinese).

Zhang, X., 2020. Chinese Livestock Farms Struggle under COVID-19 Restrictions. IFPRI Research Post, 26 March 2020. https://www.ifpri.org/blog/chinese-livestock-farms-struggle-under-covid-19-restrictions (accessed 22 April 2020).

Zhong, Y., Pu, M., Liu, M., Zhang, L., 2020. The impact of COVID-19 on China's food security and suggestions for ensuring stable grain production issues in agricultural economy. Issues Agric. Econ. 4, 13–22 (in Chinese).

Zhou, L., Sun, J., Chang, S., Yang, N., Li, A., 2020. Measurement and Countermeasures of on the Gap between Supply and Demand of Livestock and Poultry Meat during the COVID-19 Pandemic. Consulting Report for Fight against the COVID-19. Chinese Academy of Agricultural Sciences, 3 March 2020. http://wz.snsj.agri.cn/nczy/zjfx/202003/t20200304_346924.html (in Chinese).

Zhu, Z., Pu, H., Yang, C., 2020. Impacts of COVID-19 epidemic on China's pig industry and corresponding countermeasures. Issues Agric. Econ. 483, 24–30 (in Chinese).