Meat production, climate change and world trade: China as a global player between trade war and epizootics

A longer version of this article has been prepared as a contribution to the ‘Sino-German Cooperation in Agricultural Sciences and Climate Change’, a sub-project of the Sino-German Agricultural Centre. The DCZ is coordinated by the IAK Agrar Consulting in a consortium with the IAMO and financed by the Federal Ministry of Food and Agriculture (BMEL) as part of its bilateral cooperation program.

Global pork production has increased steadily in recent decades. China currently consumes almost half of the 120 million tons (Mt) of global production (OECD 2019). As a result of the growing pork production, consumption of soybean-based proteins for feeding pigs, especially with the expansion of industrial production systems, has increased tremendously. China imported 96 Mt of soybeans in 2017, and 53% of these imports were sourced from Brazil (FAO 2019). In the following, I assess the greenhouse gas emissions (GHG) associated with pork production in China with a focus on emissions associated with trade. I will examine the impacts of the rise in soybean consumption in China and the associated emissions due to land-use change caused by the expanding soybean cultivation in the exporting countries. I will focus mainly on the soybeans sourced from Latin America, where the expansion of soybeans has caused widespread deforestation. Land-use change in response to soy expansion occurs directly through expansion of soybeans on previously forested land. However, soy expansion also incurs indirect land-use changes (iLUC) by converting areas previously used as cattle pastures into soybean fields, which in turn can lead to further deforestation since new grazing land is gained at the expense of the forest to replace the lost grazing land. Moreover, rising demand for soybeans contribute to land speculations in Brazil, with the prospects of higher future profits, which may stimulate further deforestation. I will examine the changes in emissions embodied in the trad-
ed soybean because of the potential effects of the recent disruptions of trade volumes in response to the trade war between China and the US as well as the trade effects of the decline in China’s pig stocks due to the African Swine Fever (ASF) epidemic.

— **Greenhouse gas emissions in pork production** —

Emissions of pork production will likely increase substantially because demand for pork is bound to rise by one third between 2005 and 2030 (MACLEOD et al. 2014). In the Netherlands, France, and Germany, the emissions intensity (the emissions in carbon dioxide equivalents (CO₂ eq) per kilogram of product) range from 3 to 5 CO₂ eq per kg of pork. The direct greenhouse gas emissions associated with imported feed, i.e. the emissions in the production process without accounting for land-use change, make up between 25 and 40% of the emissions intensity (VAN GRINSVEN et al. 2019). In China, emissions intensity was 2.9 kg CO₂ eq/kg pork in 2009 (JIANYI et al. 2015), but without accounting for emissions embodied in trade. Emissions intensity in China was substantially higher in small-scale pig production systems of the past with 10.8 CO₂ eq/kg pork in 1979, but improved rapidly after the systemic change in Chinese agriculture (JIANYI et al. 2015). In other words, the shift from traditional to industrial pig production systems greatly enhanced emissions efficiency and hence reduced greenhouse gas emissions per production unit or per kilogramme pork. However, these emissions estimates account merely for domestically produced feed but fail to account for the emissions found in land-use changes elsewhere, including deforestation, which are included in feed imports. However, China only began importing soybean feed after 1990 and up to the beginning of the 2000s the import amounts were negligible. Figure 1 — **Soybean trade** —

Soybean is a legume with high protein and oil content. Almost 90% of the global soybean production is processed into soybean oil and soybean meal (or soybean cakes). The meal or cakes have about 50% protein content and are almost exclusively used as animal feed. Of the 120 million hectares (Mha) of global soybean area, about 50 Mha are destined for export; this is the largest area and the highest share of all crops that are destined for international trade (LEVERS & MÜLLER 2019). Soy is therefore the most profitable of the ‘Export-Cash-Crop’in global comparison. China imported almost 96 Mt of soybeans in 2017, equivalent to 64% of the globally traded volume of soybean (FAO 2019). 94% of the soybean imports of China (92 Mt) were imported from just three countries: the US, Brazil, and Argentina. Figure 1 — **Soybean imports of China** rose steadily since the trade liberalizations after China’s accession to the WTO in 2001. The US was the most important supplier in much of the 2000s, but China increasingly sourced soybeans from Brazil after 2001. Since 2013 the largest share of the soybean imports of China come from Brazil; in 2017, imports from Brazil amounted to 53% (52 Mt). Figure 1 — **Emissions of soybean imports** —

Soybean expansion in South America has been a major culprit of the high deforestation rates in the region, particularly during the 2000s. More recently, soy expansion
occurred mainly on cattle pastures, but there is strong evidence that soy expansion has also displaced cattle pastures further north, where pasture expansion contributes to deforestation. Hence, soybean expansion is held responsible for direct and indirect deforestation. — Multiplying the soybean imports of China with average soybean yields in the respective exporting countries reveals that Chinese soybean imports in 2017 required about 15 Mha of soybean cultivation in Brazil, 2 Mha in Argentina, and 10 Mha in the US. **However, from the perspective of emissions, the origin of the soy imports matters and if these imports have led to deforestation in the export countries.** Since recently, tracing the imports back to their place of origin is possible with data that link imports to source regions (e.g. districts) through tracking supply chains of commodities (GODAR et al. 2016). Such data are available from [https://trase.earth](https://trase.earth) (Transport Supply Chains for Sustainable Economies) and at the time of writing included soybean value chains for Brazil with data on regional deforestation rates since 2006 and their associated CO\textsubscript{2} emissions. — Emissions from deforestation associated with soybean exports from Brazil have dropped to below 20 Mt CO\textsubscript{2} eq per year since 2013. **Figure 2** Emissions associated with soybean exports to China stabilized in recent years, despite the strong increase in soybean exports to China. This suggests that less soy has been associated with direct deforestation after the implementation of the soy moratorium, a voluntary commitment not to purchase soy on land that was deforested after 2006 and signed by the major soybean traders. Yet, the deforestation rates and emissions in the Trase data are conservative because they only account for deforestation caused directly by soybean expansion within the last five years. However, the greatest part of deforested land was converted to pastures first (about 80\% between 2000 and 2014, (ZALLES et al. 2019)). Only in a second step, did conversion to soybean cultivation take place on former forest land. The expansion of soybean areas is therefore a longer-term process consisting of multiple stages. Moreover, indirect land-use changes and land speculations of rainforest into soybean cultivation from the intermediate stage of pastures is not accounted for by the Trase data, despite its significant scope.
— Trade and production shocks —

Trade war between China and the US

In mid-2018, the US administration imposed tariffs on Chinese goods worth 250 billion US$. The Chinese government retaliated with 25% tariffs on many US goods, including soybean. In turn, US soybean exports to China diminished by 50% already in 2018 (FUCHS et al. 2019). In the following, I outline the consequences of the trade war, as well as of the African Swine Fever below, for China with data extracted from news reports because the official statistical sources known to me only contained data until 2017 when I wrote this article.

As a result of the trade war, China is directing more attention to South American producers of soybeans, at the expense of soy imports from the US, which almost halved from the 33 Mt in 2017 to 16.6 Mt in 2018 (XU & PATTON 2019). Combined with the outbreak of the African Swine Fever in mid-2018 (see info box on p. 34), this led to a reduction of Chinese soy imports from 97 Mt in 2017 to 85 Mt in 2019. A large part of today's soybean imports are used to produce additional poultry, the main alternative to pork (ANAND 2019). As an alternative to the reduced US imports, China ramped up its imports from Brazil from 52 Mt in 2017 to 66 Mt in 2018, equivalent to 75% of all Chinese soybean imports in 2018 (SU 2019).

The increase of 14 Mt is equivalent to an additional area demand of 4.5 Mha, assuming average Brazilian soybean yields between 2015 and 2017 of 3.1 tons per hectare. Among others, China has also signed a deal with Argentina, the world's largest exporter of soybean meal. Under this deal, Argentina can produce soybean meal in its own facilities for export to China.

Increases of soybean imports have been a major driver of land-use expansion in Brazil, including direct replacement of rainforests by soybean cultivation and indirect deforestation through the replacement of pastures, which leads to additional pastures gained at the expense of the rainforest. To approximate the emissions footprint of the additional demand of Brazilian soybeans by China, I calculate the average emissions per ton of soy imported by China in 2017 for the Cerrado (0.31 tons of CO₂ eq per ton of imported soy), assuming the soy moratorium effectively prevents deforestation in the Amazon. I then multiply the emissions factor with the 4.5 Mha of additional area demand. This results in an increase of
The ASF is a virus, which causes haemorrhagic fever with high mortality rates to pigs. China reported the outbreak of ASF in August 2018. One year after the outbreak, pig stocks have contracted by at least 39% or about 170 million pigs (the numbers vary and the actual decrease may well be a lot larger) but the low point seems to have been reached in autumn 2019 (Siu 2019). As a result of the epidemic, prices for pork reached record highs in China (up to 50 CNY or around €6.41) per kg carcass weight in October 2019; this is roughly three times the price in Germany or the US. Domestic demand for pork contracted due to the rising prices, and consumers partly substituted pork with alternative animal proteins, such as from poultry and beef. — The ASF has two key effects on global trade flows:

The lower number of pigs in China decrease domestic demand for soy-based feed and hence the soybean imports of China. Second, ASF causes rising imports of pork and pig offals from other countries, most notably from the EU. Rising meat imports can be associated with higher emissions in the producing countries if the producers expand stocks. — The rising demand for pork from China offers novel opportunities for Brazilian agribusiness and China has, for example, already approved 25 plants of pork production for export in Brazil (FORTUNE 2019). Higher pork production in Brazil could facilitate a new wave of deforestation because the soybean-maize rotations now become more profitable because both outputs can now be turned into cash: the soybean as protein source for the pigs and the maize to supply the pigs with energy. The higher profitability of the soybean-maize system make deforestation more likely and will arguably spur land speculation in the Amazon and the Cerrado. In short, the emissions embodied in pork consumption may substantially rise through direct and indirect land-use changes.
land-use related emissions from 6.7 to 8.1 Mt CO$_2$ eq, an increase of 18%. This is likely a conservative estimate because no indirect land-use change is considered and because the recent surge of deforestation, arguably partly due to soy expansion, has not been taken into consideration. In addition, data on the dramatic increase of deforestation most likely in part due to the expansion of soybean cultivation caused by targeted slash and burn clearance under the new Bolsonaro government cannot be collected. It should be noted again, that these emissions account only for direct deforestation induced by soybean up to five years after deforestation and fail to account for indirect land-use change and speculation. Subsequent, more comprehensive indirect land-use changes, including those speculative effects cannot be taken into account with the current state of data, so that the actual export-related CO$_2$ emissions are most likely significantly higher.

--- Discussion ---

The industrial pork production in China relies on imported protein feed from a few key producers, notably the USA, Brazil, and Argentina. The globalization of soy trade, however, renders the pig industry vulnerable to disruptions in trade relations. Besides, the large industrial production complexes make the pig industry prone to outbreaks of contagious diseases, as witnessed by the ASF epidemic. In recent years, China experienced both a trade as well as a disease shock, and both shocks have fundamentally altered trade flows, production relations, and associated greenhouse gas emissions.
The trade war with the US shifted soy imports of China away from the US, mainly towards Brazil. The expectations of increasing demand for soy from China has improved profit expectations of the Brazilian agribusiness, further bolstered by the agribusiness-friendly policies of the Bolsonaro government. This combination has already been made responsible for the spikes in forest fires in Brazil in 2018 across much of the Amazon and the Cerrado. Further, ASF has contributed to substantial increases of pork imports of China from the US, EU, and Brazil; the latter is now ramping up domestic pork production, which contributes to the added pressure for remaining forest resources. In summary, changes in trade flows can fundamentally affect global greenhouse gas emissions as well as the distribution of emissions among countries. A large share of emissions emerges at the site of production where emissions are also accounted for. However, emissions embodied in traded products remain unaccounted for in the places of consumption, and, as I have shown for the example of Brazil, the emissions embodied in trade are substantial. A move from production-based to consumption-based recording of CO₂ emissions in pork production may help to raise awareness of the full emissions embodied in a product by quantifying its emissions footprint. Only recently, such emissions calculation became possible due to value chain data that traces imports to the location of production. These data open up opportunities to better steer demand, such as by labelling products with their carbon footprint or by levying emissions taxes to internalize parts of the external environmental costs. Internalizing environmental costs can also support border adjustment taxes, which are under consideration by the EU to avoid that production with higher environmental costs is outsourced to non-EU countries.

Acknowledgements

I am grateful to Florian Schierhorn and Thiago Reis for many useful comments that helped to improve this article and to Thomas Kastner for providing the bilateral trade flow data. All remaining errors are mine. This work has been supported by the Sino-German Agricultural Centre (DCZ).
— Bibliography


— Sources and credits

p. 30 Photo Soybean harvest in Mato Grosso, 2008 © AlfRibeiro - stock.adobe.com
Figure 2 CO2 emissions caused by Brazilian soybean exports associated with deforestation © Own presentation. Data: trase.earth
p. 34 Photo in info box: EM recording of ASF virions © Friedrich-Loeffler-Institut. Background photo conceptually edited: based on Photo Drone aerial view of deforestation in soy agriculture farm and forest trees in the Amazon rainforest, Brazil ©Imago Photo - stock.adobe.com