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Introduction

The United States experienced catastrophic failure in its beef and pork value chains in April – June of 2020 because of plant closures due to COVID-19. At one point, 40% of beef and pork processing capacity was down, meat was rationed, and some hogs were euthanized.¹ The European Union experienced several plant shutdowns but did not experience scarcity of meat or euthanize any animals during this period. More recently, the United States experienced a scarcity of baby formula because of a shutdown of a large plant in Michigan compounded by other supply chain problems.²

This report summarizes expert opinions collected during a trip to Ireland, the Netherlands, and Germany. The purpose of the trip was to find out why the European Union was apparently able to deal with COVID-19 more successfully than in the United States. We visited plants in all three countries and also spoke with industry experts. We were then able to compare the EU experiences as described to us against work we had already done that documented the US experience.³

We begin with some demographic data and then provide a bulleted list of possible reasons for the differential impact of the pandemic. The circumstances were highly complex and we cannot assign weights to these possible reasons. Next, we provide the results of a numerical simulation model that shows that the probability of catastrophic failure increases as the size of the plants

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increases relative to the size of the industry. This suggests that the presence of proportionally larger US plants may help explain why the US experience was so catastrophic.

**Demographic Data**

Figures 1 and 2 below show historic data on cattle and hog slaughter for the United States and European Union. As can be seen, hog slaughter in the European Union is far greater than in the United States. Note also that US slaughter was trending up and that EU slaughter was trending down. Cattle slaughter in the United States is greater than in the European Union; and, again, US slaughter numbers were growing as the EU numbers were falling.

**Figure 1. Hog slaughter in the United States and European Union 2010:2023 (000 Head).**

Source: USDAS PS&D.
Figure 2. Cattle slaughter in the United States and European Union 2010:2023 (000 Head).

Source: USDAS PS&D.

Figures 3, 4, 5, and 6 below show the location of US and EU hog and cattle herds. The cattle industries in both areas are well dispersed as is the pork industry in the European Union. US pork production is concentrated in Iowa and surrounding states and in North Carolina.
Figure 3. European Union pig farm density.

Source: https://vividmaps.com/density-pig-farms-europe-union/.
Distribution of the main livestock types in the EU-27. Animal density is expressed in livestock units (LU) per ha utilised agriculture area, in which the relative weight of a mature dairy cow is set at 1 and that of a mature beef animal at 0.5 (source: Lesschen et al., 2011).

Figure 4. EU-27 dairy cow (left) and beef cattle (right) density.

Figure 5. US cattle and calf inventory, 2012.

General Points

Below we provide a summary of what we learned from European Union industry experts about their understanding of the differential impact. This is not a scientific analysis and many of the points relay on anecdotal information.

- As can be inferred in the slaughter charts shown above, at the time of the outbreak, the US pork and beef industries were close to slaughter capacity. The US pork industry was in growth phase and the US beef industry was suffering from the closure of a large beef plant in Holcomb, Kansas. US plants are typically double-shifted and they use the third shift for cleaning and maintenance. This makes it hard to increase the length of a shift.
The European Union had some surplus capacity in beef and pork processing sectors and was able to add to shift lengths to single-shift plants when needed. Farms also had “surplus” capacity in order to meet country-specific and/or EU space requirements. US slaughter animal weights are typically larger than in the European Union, which made it easier for EU plants to move to heavier weights.

- The US pork industry is concentrated in states where it makes most economic sense. Beef and pork production in the European Union are spread out across countries in part because countries could and did impose barriers to protect domestic production prior to EU accession. Therefore, pork production in the European Union is more spatially diversified. Pork plants in Iowa are so concentrated that it is possible for workers in different plants to reside in the same location.

- COVID-19 outbreaks closed US plants as early as late March continuing onto the start of May. COVID-19 outbreaks in the European Union were at a peak in late summer/early fall. It is not clear why the European Union experienced a delay. When the outbreaks occurred in the United States, testing was not yet easily available. By the time outbreaks occurred in the European Union, plants were able to test workers as they arrived and send home those who tested positive.

- Large hog plants in the United States typically kill more than 100,000 pigs per week. Large hog plants in the European Union are about half this level. Large beef plants in the European Union kill about 2,000 per week. Large beef US plants are at 30,000 per week. The owners of smaller plants in the European Union are not interested in moving to a larger plant size. The experts we spoke with made the point that US plants all use the same cutting specifications because they sell into a large domestic market. The red meat sector and cutting specifications in the European Union evolved to meet national and even sub national tastes in EU countries. Plants that sell into other EU countries must be able to change cutting specifications to meet tastes in other countries. This flexibility and nimbleness is best accomplished in smaller plants. We were also told that the owners of
smaller EU plants are wary about consolidating their kill from smaller plants into a large US-style plant. Livestock farmers in the European Union are responsible for transport of animals and typically like to sell them to plants closer to home. The implications of much larger US plants are discussed in the last section of this report.

- Large US plants typically require as many as 2,000 workers. EU beef plants require about 400 workers and EU pork plants about 1,000 workers. The larger the number of workers the more likely it is that they will need custom-built housing or dormitories. One EU plant owned by Tonnies did have a dormitory and had to close. It seems possible that worker-to-worker transmission occurred in worker housing as well as at plants. Denser housing would have speeded this transmission.

- EU line speeds are about one half of US line speeds. Faster line speeds require that workers are closer together as each worker has a more limited task. Plants where workers are closer together are likely to have more in-plant COVID-19 transmission and greater difficulty implementing separation between workers.

- When plants in the European Union did have to slow or halt production they were able to send the surplus animals to facilities owned by their competitors. The industry experts in the European Union called this response a “network approach” or “network development.” This level of coordination might run afoul of US antitrust laws.

- Many of the plants in the European Union are cooperatives. The farmer owners of the plants were willing to keep animals on feed when plants had to slow or halt production. The plant managers were willing to kill larger hogs when this was needed. The cooperative model reduces tension between livestock producers and livestock processors.
Impact of Plant Size on the Resiliency of a Supply Chain

There is an intuitive link between plant size and the probability of catastrophic failure. If a country has only one plant and this plant is forced to close, then this is a catastrophic failure. But if a country has 1,000 plants then it is highly unlikely that so many of them would fail at the same time in a way that would lead to catastrophic failure. This section of the report calibrates this concept using data on the size of US and EU pork plants.

The largest pork plants in the United States each kill about 20,000 animals a day, which is approximately 4% of national production. Large pork plants in the European Union each kill about 10,000 per day, accounting for 1% of EU slaughter.

Suppose that each plant has a 10% chance of failure at any one time and that the failure of one plant is independent of plants. Suppose also that the loss of 20% of production is catastrophic. Then we can calculate the probability of catastrophic failure for a range of plant sizes. This relationship is shown in the figure 7 below. Figures 8–11 perform the same analysis for a range of probability of closures and definitions of catastrophic failures.

In figure 7, which we consider the most likely scenario, plants have a 10% probability of failure and catastrophe is defined as losing 20% or more of capacity. The probability of catastrophic failure increases at first because there is a higher probability of losing 20% or more of production if there are two or three equally sized plants than there is for one plant. But as the number of firms exceeds five, the probability of catastrophic failure begins to fall. At 25 plants (the US case), this probability is a little under 10%, while at 100 plants (the EU case) it is close to zero.

The general shape of this relationship is robust with respect to the probability of a plant closure or the definition of catastrophic failure as shown by figures 8–11.4

Policy Implications

US plant sizes presumably grew in order to take advantage of economies of scale. It was in the private interests of the plant owners to take advantage of these scale economies. Owners of plants impacted by the closure did experience financial harm when they closed, but others along

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4 A similar result can be inferred from NBER Working Paper Ma, M., and J.L. Lusk. 2021. “Concentration and Resilience in the U.S. Meat Supply Chains.” This is true even though they have a completely different model. We were not aware of this Ma and Lusk paper when we performed these simulations.
the supply chain also experienced harm. Large plants can have a negative externality if they increase the probability of catastrophic failure as is shown in the figures below. Negative externalities can, in some cases, be used to justify government intervention, and this appears to be what is motivating USDA to provide grant funding for medium-sized pork and beef plants.

Figure 7. Chance of catastrophic failure assuming plants have an independent 10% chance of failure and catastrophic failure is 20% or more down at one time.
Figure 8. Chance of catastrophic failure assuming plants have an independent 10% chance of failure and catastrophic failure is 30% or more down at one time.
Figure 9. Chance of catastrophic failure assuming plants have an independent 15% chance of failure and catastrophic failure is 30% or more down at one time.
Figure 10. Chance of catastrophic failure assuming plants have an independent 5% chance of failure and catastrophic failure is 20% or more down at one time.
Figure 11. Chance of catastrophic failure assuming plants have an independent 5% chance of failure and catastrophic failure is 40% or more down at one time.