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Resilience of Small Beef Packers and the USDA Meat Supply Chain Initiative

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ABSTRACT

We focus on the plant-size resilience relationship among small beef packers during COVID-19. Defining resilience as the ability to maintain or increase slaughter and non-resilience as otherwise, we use survey and secondary data to estimate a logit model where resilience is a function of a plant's capacity and age in addition to labor condition variables, COVID-19 policy, and beef production status of the state in which the plant is located. We find resilience is inversely related to plant size but is highest in states with a mask mandate. Implications for the efficacy of the USDA capacity expansion program are highlighted.

JEL Classification: L10, L50, Q18

1 | Introduction

On the eve of the COVID-19 pandemic, 12 out of the 670 beef packing plants in the United States processed 52% of all cattle, each with an annual capacity of 1 million head or more (USDA NASS 2021). COVID-19 Infections among workers at those plants led to several shutdowns and slowdowns of production lines, disrupting the movement of cattle from feedlots to packers. March 3, 2020, marked the first plant shutdown. By mid-June, 14 plants had ceased or reduced operations for periods as long as 21 days (McCarthy and Danley 2020). In early May, cattle slaughter dropped by 34% below its level during the same period in 2019.

The pandemic disruptions brought plant size and resilience to the forefront of national discussion, with cattle groups and academics weighing in on the issue. For example, in a letter sent to the White House and Congress, R-CALF, a cattle group, asserted that the "high level of physical and geographical concentration of America's vital beef supply chain is intuitively and inherently contrary to America's food security interests, as now unequivocally demonstrated by COVID-19" (R-CALF 2020). Lusk (2020) goes further saying that "in the future, owners of large food-processing and packing facilities may look to more regionally distributed facilities to mitigate supply risks that occur from a total plant shutdown, [sacrificing] some economies of scale to provide insurance against plant shutdowns caused by human-spread illnesses."

In June 2021, the United States Department of Agriculture (USDA), "citing lessons learned from the pandemic and supply chain disruptions", announced a $4 billion investment to strengthen the U.S. food supply system (USDA Press Release 2021). The agency targeted part of the investment toward restructuring the beef packing industry by subsidizing the expansion of the slaughter capacity of smaller beef packing plants. The assumption is that the restructuring would result in a more diffused beef processing and, thus, a more resilient industry.

Two retrospective studies of the relationship between plant concentration and resilience have examined the USDA assumption using alternative metrics. Bina et al. (2022) use publicly available 2020 weekly data from five beef-producing regions to measure resilience by comparing the percentage of 2020 cattle slaughter relative to three alternative benchmark levels (the 2019 slaughter, the average 2015–2019 slaughter, and the average 2017–2018 slaughter). Plant concentration is measured by the respective shares of plants with 2000-4999 capacity and with 5000 plus head daily capacity in a region's weekly total capacity. The higher the volume of cattle slaughter in 2020 relative to the benchmarks, the higher the resilience. The authors find a weak relationship between plant concentration and resilience, concluding that additional smaller plants would not have made the industry more resilient during the pandemic.

Cooper et al. (2023) analyzed daily slaughter data of 33 largest plants from April 6, 2020, through January 18, 2022, representing 74% of federally inspected slaughter in 2021. They regress two resilience measures on plant size, measured by engineering capacity[1] and other controls. The two resilience measures are the difference between production and capacity relative to capacity and between actual and normal production relative to normal production. The smaller the difference, the higher the resilience. The effect of capacity on resilience was estimated during the initial shock period of the pandemic (April–May 2020) and afterward (April 2020–January 2022). The authors find that while additional small packer capacity could have enhanced resilience during the initial pandemic shock, that capacity would have been redundant afterward.

While Cooper et al.'s (2023) plant-level study mitigates aggregation bias in Bina et al.'s regional-level study, neither study considers the smaller plants. Bina et al. (2023) only consider 2000-plus head capacity plants. The 33 plants Cooper et al. (2023) focus on are the largest plants processing three-quarters of all cattle processed in the United States. The omission of small plants is a surprising gap in the literature, given that they are the most likely to fit the profile of the establishments targeted by the USDA capacity expansion policy (USDA Press Release 2021) and research interest in its efficacy.

This study fills the gap by examining the relationship between plant size and resilience among small packers during COVID-19 using data from a survey of smaller packing plants and public sources. The following section highlights the survey method and data. Section 3 posits a resilience model and describes variable construction and sources. Section 4 presents and discusses the model estimates. The final section summarizes and concludes.

2 | Plant Survey

We obtained information on 289 processing plants across the United States about their operations during the peak COVID-19 period of March to June 2020 via a telephone survey. We collected data on plant type (slaughter, processing, both), the dominant livestock processed by the plant (predominantly beef, pork, poultry, and sheep/goat), plant capacity (maximum and typical capacity in slaughter head/day), age of establishment, and, whether the plant ceased, reduced, maintained, or increased beef processing (MIP) during COVID-19[2]. Based on the database of packers maintained by the USDA FSIS (2024), we initially identified 545 small beef packers (mainly those with less than 100,000 slaughter head per year) as potential candidates for conducting the survey. However, only 358 processing plants agreed to participate in the telephone survey conducted from June to August 2022. After removing data from predominantly pork, poultry, and sheep/goat processing plants and data with incomplete information, we ended up with 289 cross-sectional plant-level observations for our final analysis.

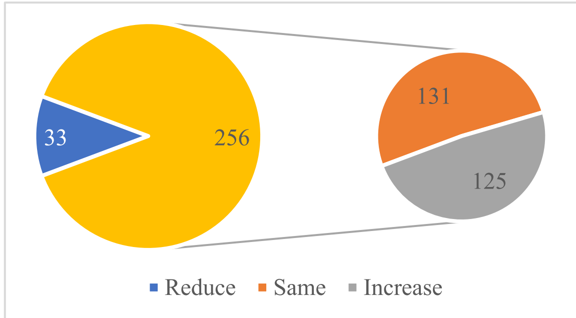


FIGURE 1 | Operation adjustment of processing plants due to COVID ($N = 289$).

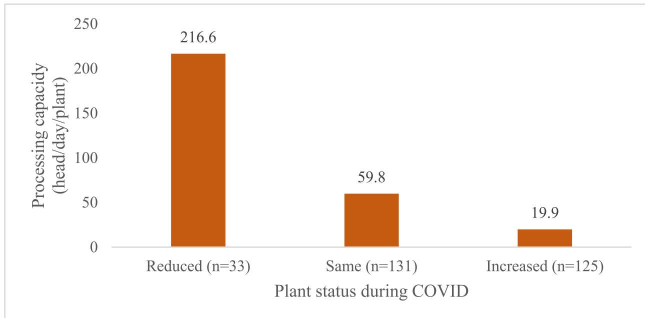


FIGURE 2 | Operation adjustment due to COVID and plant size.

Survey responses related to plant operation during the pandemic outbreak from March through June 2020 are highlighted in Figure 1. Thirty-three out of 289 respondents (about 11%) reported reduced operation in response to COVID-19. None of the plants surveyed ceased operation. Of those 256 plants that did not report reduced operation, 125 (almost 50%) reported increased slaughter, and 131 plants—the other half—reported normal slaughter.

The reported processing capacity ranges from 1 to 5200 head daily. Figure 2 shows how the processing capacity is related to the operation adjustment due to COVID-19. The figure shows that processing plants reported to have reduced operation during COVID-19 have an average capacity of about 217 head/day. In comparison, the capacity of plants that reported normal operation during COVID-19 has an average capacity of 60 heads/day. Finally, those who reported an increase in operation during COVID-19 have an average capacity of 20 heads/day.

These observations suggest a negative relationship between plant capacity and resilience during COVID-19.

3 | Resilience Model and Data

We follow Azzam, Gren and Andersson (2023) and posit that the three main factors related to beef packing resilience are plant size, labor conditions, and public policy toward COVID-19. To assess the importance of those factors statistically for small meat packers, we specify the following logit model:

$$\mathrm{MIP} = \Phi(\beta_1 + \beta_1 \ln \mathrm{Cap} + \beta_2 \ln \mathrm{Age} + \beta_2 \ln \mathrm{Wage} + \beta_3 \mathrm{RTW} + \beta_4 \mathrm{MSK} + \beta_3 \mathrm{MPS}),$$

where $\Phi(.)$ is the logit function. The variable MIP, obtained from the survey, is an indicator variable equal to 1 if the beef processing plant maintained or increased beef processing (MIP) during March–June 2020, indicating resilience, and zero otherwise, indicating nonresilience. The dichotomy draws on the general resilience literature, which defines resilience as the ability to absorb a shock and maintain function (Holling 1973; Azzam, Gren, and Andersson 2023). The β-parameters measure the relationship of the associated variables on the log odds of a plant maintaining function during the March-June 2020 period.

The variables *Cap* and *Age*, also from the survey, are the plant characteristics variables denoting cattle processing capacity and the age of the packing plants. COVID-19 policy by a state, where the plant, is located is captured by that state's adoption of a mask mandate (*MSK*), as reported by the CDC, Center for Disease Control and Prevention (2021). Labor conditions are represented by whether or not the state is a Right-to-Work (*RTW*)[3] state, as summarized by NCSL, National Conference of State Legislatures (2023), and state-level wages (*Wage*) for meatpacking workers, as published by BLS, Bureau of Labor Statistics (2023). *MPS* is an indicator variable if a packing plant is located in a major packing state (Nebraska, Colorado, California, Texas, Iowa, Kansas, Nevada, Pennsylvania, Illinois, and Missouri) and zero otherwise.

75% of the plants in our study are located in states with mask mandates. Figure 3 shows that more than 90% of plants in states with mask mandates during COVID-19 reported normal or increased operation, while around 80% reported increased or normal operation for the states without the mask mandate.

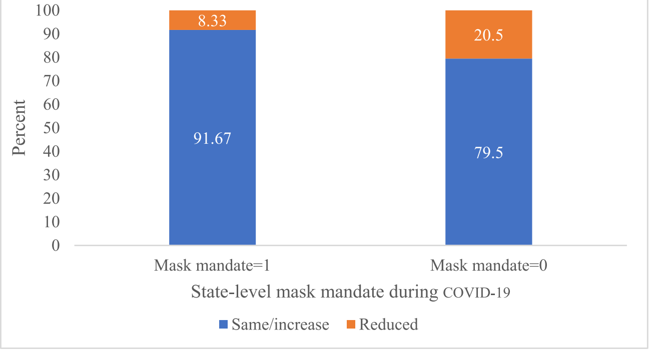
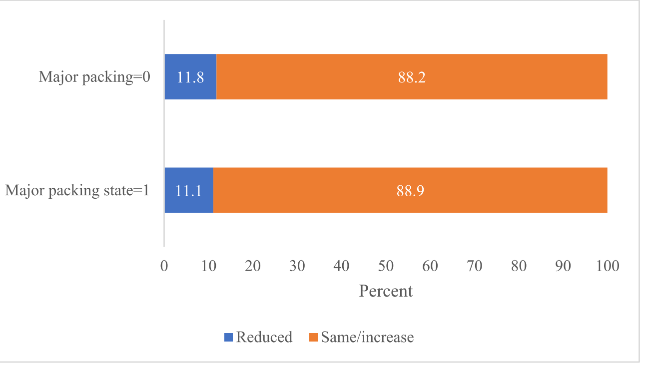


FIGURE 3 | Operation adjustment during COVID by mask mandates.



* Major packing states are NE, CO, CA, TX, IA, KS, NV, PA, IL, and MI.

FIGURE 4 | Operation adjustments during COVID by major packing states (1/0). * Major packing states are NE, CO, CA, TX, IA, KS, NV, PA, IL, and MI.

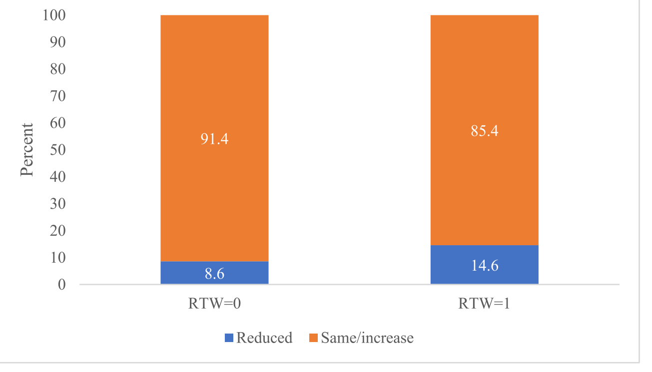


FIGURE 5 | Operation adjustment by packers by states' RTW status.

About 56% of the plants in the survey were located in major packing states. Figure 4 shows that the plants in major meatpacking states did not report having higher or normal operations differently than those in nonmajor packing states.

Figure 5 shows that a larger share (almost 15%) of processing plants located in the states with RTW status reported reduced operation compared to those without RTW (nearly 9%), implying a possible negative relationship between RTW status and plant operations.

4 | Logistic Regression Results

Table 1 reports the logit estimates of the parameters in the model presented in the equation. The variables *Age, Wage, RTW*, and *MPS* do not have a significant relationship with the MIP status of the smaller beef packing plants during COVID-19. The estimates of capacity and mask mandate are negative, positive, and statistically significant, indicating their role in the resilience of smaller beef plants.[4]

TABLE 1 | Relationship between the operational status of smaller plants during COVID-19 and plant capacity.

Variables	MIP status during COVID
Capacity	−0.000608**
	(0.000275)
Age	−0.00245
	(0.00748)
Wage	0.000925
	(0.00160)
Right to Work	−0.302
	(0.406)
Mask	0.902**
	(0.381)
Major packing state	0.0220
	(0.461)
Constant	0.915
	(1.438)
Observations	289

Note: Robust standard errors in parentheses.
*$p < 0$; **$p < 0.05$; ***$p < 0.01$.

The parameter estimate of plant capacity in Table 1 represents only the relationship of capacity with the odds ratio of MIP and non-MIP status during COVID-19. Since the odd ratios are not directly interpreted as probabilities, we use the estimates in Table 1 to compute the predicted probabilities of plant MIP status during COVID-19 as plant size increases. While computing such probabilities, we fixed *Age* and *Wage* values at their sample mean and examined how probabilities change with plant capacity and alternative scenarios of *RTW*, *MSK*, and *MPS* combinations. The predicted probabilities are presented in Table 2.

Reading the Table row-wise, the probability of MIP status during COVID-19 for a 10-head daily capacity plant that is not located in a Right-to-Work ($RTW = 0$), mask mandate ($MSK = 0$) and major beef-producing state ($MPS = 0$) is 83.8%. That probability declines to 79.3% if a plant with the same capacity is a Right-to-Work state ($RTW = 1$), has no mask mandate ($MSK = 0$), and is not located in a major beef-producing state ($MPS = 0$). The rest of the values in Table 2 can be read similarly.

Reading the Table column-wise, we observe the following. A plant's probability of MIP status during the pandemic declines with plant size for all *RTW*, *MSK*, and *MPS* scenarios, supporting the notion that the larger the packing plant, the weaker its relationship with the pandemic resilience. Table 2 values show that the steepest decline in the MIP probability associated with expanding plant capacity from 10 to 1500 head occurs with scenario 1-0-0, where there is a 19 percentage point decline. In contrast, the lowest drop of 9 percentage points is observed in the 0-1-0 and 0-1-1 scenarios. Irrespective of capacity, plants located in states with mask mandates have the highest probability of weathering the pandemic, suggesting the efficacy of face coverings during the pandemic.

TABLE 2 | Relationship between plant resilience (probability of MIP status), plant capacity, and the plants located in RTW-MSK-MPS states.

Capacity	RTW-MSK-MPS values															
	0-0-0		1-1-1		1-0-0		1-1-0		1-0-1		0-1-0		0-0-1		0-1-1	
(Head)	Est.	p-val	Est.	p-val	Est.	p-val	Est.	p-val	Est.	p-val	Est.	p-val	Est.	p-val	Est.	p-val
10	0.838	0.0003	0.906	< 0.0001	0.793	0.0013	0.904	< 0.0001	0.797	0.0003	0.927	< 0.0001	0.841	0.0006	0.929	< 0.0001
100	0.831	0.0005	0.901	< 0.0001	0.784	0.0020	0.899	< 0.0001	0.788	0.0004	0.923	< 0.0001	0.834	0.0009	0.925	< 0.0001
500	0.794	0.0067	0.877	< 0.0001	0.740	0.0189	0.875	< 0.0001	0.744	0.0052	0.904	< 0.0001	0.797	0.0074	0.906	< 0.0001
1000	0.740	0.0879	0.841	0.0007	0.678	0.1795	0.838	0.0043	0.682	0.1149	0.875	0.0006	0.744	0.0796	0.877	0.0003
1500	0.677	0.3333	0.796	0.0359	0.608	0.5333	0.793	0.0659	0.613	0.4703	0.838	0.0257	0.682	0.3094	0.841	0.0185
Change in probability	−0.16		−0.11		-0.19		−0.11		-0.18		−0.09		−0.16		−0.09	

Note: The RTW, MSK, and MPS values indicate whether these variables are equal to 1 or 0. For example, 0-0-0 represents all three variables are fixed at zero values. The values in the row "Change in probability" indicate probability differences when capacity increases from 10 to 1500 head. Abbreviations: Est. = Probability of MIP status; *p*-val = *p*-value of the estimates; MPS = plant located in a major beef-producing state; MSK = plant located in a state with a mask mandate; RTW = plant located in a right-to-work state.

5 | Summary and Policy Implications

In this paper, we contribute to the retrospective literature on the relationship between plant size and resilience in meatpacking during COVID-19. We examine the relationship among small beef packers, a group that has received scant attention in the plant-size resilience literature, though they are the most likely candidates for the USDA small-packer capacity expansion program for enhancing resiliency in the U.S. beef supply chain.

Defining a plant as resilient if it maintained or increased slaughter during COVID-19 and non-resilient if it reduced or ceased slaughter, we specify a logit model where resilience is a function of plant capacity and age, in addition to characteristics of the state in which the plant is located. The characteristics are labor conditions, proxied by meatpacking wages, COVID-19 policy, proxied by the presence/absence of a mask mandate, and whether a state is a major beef producer. Data on the resilience variable and plant capacity was obtained from a survey of 289 packers across the United States. Data on the states was gathered from secondary sources.

We find that the probability of resilience, that is, of maintaining or increasing slaughter during the pandemic, is inversely related to plant size, irrespective of labor conditions, mask mandate policy, and beef production status of the state in which the plant is located[5]. The inverse relationship between resilience and plant size may be due to the fact that smaller plants have a lesser concentration of workers and work in adequately spaced out environments that limit the possibility of infection and operational disruption. As to why plants in states with a mask mandate are the most resilient at each plant capacity level, one plausible explanation is that states with mask mandates further helped minimize COVID infections at plants and consequently helped the plants operate smoothly. Hence, the role of mask mandate in plant resiliency should be understood as an enabling factor rather than the cause of resilience. An implication for the USDA program is that an expansion of the capacity of small packers would not enhance their resilience, particularly if the plants are located in states without a mask mandate. Irrespective of state pandemic policy, the results also suggest that the program may be more efficacious if capacity is expanded by building new and smaller plants rather than existing ones, as expanding smaller plants into larger plants could diminish their resiliency. However, it should be noted that having many smaller plants comes at the cost of reduced efficiency of the beef supply system due to the scale of operation. So, there is a trade-off between resiliency and efficiency. Examining this trade-off and the optimal size of the processing plants in relation to both resiliency and efficiency is an interesting question that future empirical research on this topic can explore. Furthermore, given that the addition of smaller plants could potentially increase industry supply, with price implications that can threaten the survival of less efficient smaller plants, some small packers may need additional support to stay in business during normal times. Hence, while promoting the smaller plants, their ability to survive during normal periods without government subsidy also needs to be considered.

Author Contributions

Sunil P. Dhoubhadel: conceptualization, investigation, funding acquisition, writing–original draft, methodology, validation, visualization, writing–review and editing, software, formal analysis, project administration, supervision, resources, data curation. **Azzeddine Azzam:** funding acquisition, investigation, writing–original draft, methodology, validation, visualization, writing–review and editing, formal analysis, project administration, resources, conceptualization. **Binod Khanal:** writing–original draft, methodology, validation, visualization, writing–review and editing, software, formal analysis, data curation.

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Ethics Statement

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data used in this research are collected from a survey and publicly available database sources. The public data and codes used in this analysis are available on request from the authors.

Endnotes

[1] Engineering capacity refers to the maximal physical output level. This level does not involve optimizing behavior like economic capacity (Squires and Segerson 2022).

[2] Obtaining an actual increase or decrease in slaughter data during COVID-19 would have been better to make it a continuous dependent variable. However, as the respondents were responding based on their memory and not based on actual recorded data, their response in terms of actual numbers would not be accurate. Therefore, we opted for a qualitative measure of MIP during COVID to facilitate response.

[3] The RTW provides employees of the states the freedom to work without taking a labor union membership. However, it can also affect the collective bargaining ability of the workers to demand better labor conditions.

[4] Following a suggestion by a reviewer, we also added average income per state resident as an explanatory variable to consider the hypothesis that higher-income states might have more rapidly implemented COVID-19 mitigation strategies. We found no statistical support for the hypothesis.

[5] We caution the reader that the negative relationship between plant size and resilience during COVID-19 only applies to the plants in our sample, which considers smaller plants with a slaughter capacity of 100,000 head/year or less. Whether the negative relationship holds for larger plants is beyond the scope of this paper and has already been addressed in the literature.

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