Research Note
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Market Power and Carbon Emissions in the Amazon

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Market power can be beneficial to the environment – by distorting production to lower levels, emissions also decrease. But what happens when the regions affected by market power are the most productive, lowest emitters?

Introduction

The cattle supply chain is the leading driver of deforestation worldwide (WRI 2022) and a major source of carbon emissions. In the Amazon, the region I focus on, 90% of deforestation (2015-19) turns into pasture for cattle. Cattle in the Brazilian Amazon alone is responsible for 1.7% of global greenhouse gas emissions. These emissions vary geographically and are highest along the expanding agricultural frontier, where deforestation creates the bulk of industry emissions.

Like many other polluting industries, the cattle supply chain is not perfectly competitive. Ranchers sell their cattle to slaughterhouses, the intermediaries that process the animals into beef products. Because of high transportation costs, they can only sell to a few slaughterhouses in their surrounding regions. This creates a situation where slaughterhouses exert monopsony (buyer) power over the ranchers they buy from. Thus market power acts in a way similar to environmental policies. By reducing cattle prices in equilibrium, it disincentivises cattle production and thus reduces emissions (Buchanan 1969). But unlike such policies, it does not necessarily target the regions that emit the most.

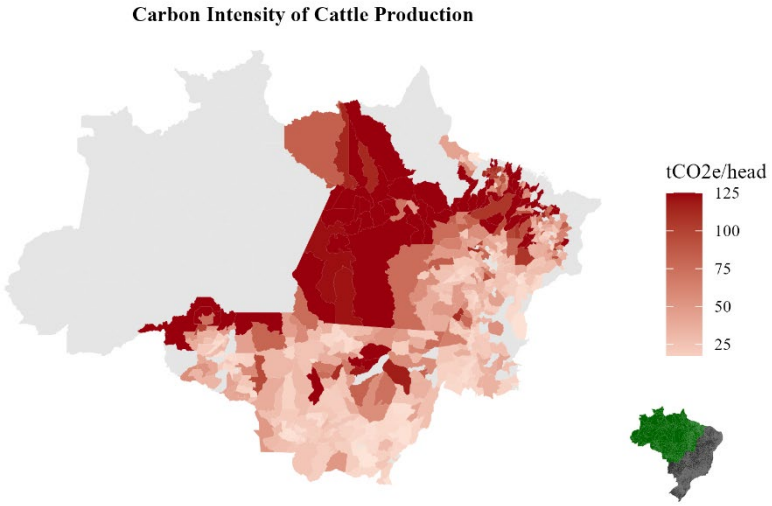
This study finds that market power affects the "wrong" places. While slaughterhouse monopsony power plays a major role in distorting rancher incentives, it mostly affects regions in the south of the Amazon, its agricultural core. The Amazon frontier, where the bulk of emissions originates, sells to many small competitive slaughterhouses. I use a rich dataset of millions of cattle transactions and a structural model to quantify this spatial pattern. While slaughterhouse monopsony power reduces aggregate emissions, it affects primarily core regions that emit relatively little. Furthermore, there are spatial spillovers – the reduced output in the core is compensated by increases in the frontier. In aggregate, the effects on emissions are small. Market power burdens the most productive regions and is not effective in reducing emissions.

But this pattern of market power also creates avenues for policies that reduce emissions without sacrificing food production. Through my model, I conduct a policy exercise that shows that providing incentives for expanded production in the core, coupled with taxing production in the frontier, can keep production constant while reducing emissions by a third.

Methodology

Throughout the project, I use a "core vs. frontier" distinction to highlight the key patterns I find. In Figure 1 I use rich land use data[1] and emissions accounting methods[2] to map the carbon footprint of a head of cattle across different municipalities (counties). This carbon footprint figure is particularly high on the northwest corner of the map ("the frontier") due to the high levels of deforestation I observe there.

Figure 1: Average emissions embedded in the production of one head of cattle



Note: The carbon intensity is calculated by summing all the emissions in 2017, then dividing by the output that year. Emissions include deforestation (accounting for different carbon stocks across regions), methane emissions from the animals, and other agricultural sources (e.g. fertiliser use).

From an environmental perspective, if one were to choose the ideal place to "introduce" monopsony power, this would be the frontier. Reduced production would offset some of the emissions in the places emitting the most gases per head. The reality is the opposite – monopsony power reduces production in the "cleanest" regions.

Showing this pattern requires data on the supply chain across different regions. Such data are challenging to come across, especially in developing country contexts, but health regulations in this setting provide a unique opportunity to study emissions in the Amazon frontier. Beef consumption poses major risks to human health if cattle carry diseases through their lifecycle. Because of this, Brazilian health authorities require ranchers to issue a public record whenever moving a herd between properties or from a ranch to a slaughterhouse. This record tracks information on the herd's origin and destination, as well as the animals' vaccination status. I use over 10 million of these cattle movement records to trace the relationships between farmers and slaughterhouses across different regions. This allows me to observe how market concentration varies across space. In the core, there are large, highly productive slaughterhouses. They are closer to major urban centers

[1] https://brasil.mapbiomas.org/
[2] https://plataforma.seeg.eco.br/total_emission

and often have export authorisations. These large slaughterhouses concentrate much of the sourcing in their surrounding regions. Frontier regions, on the other hand, sell to many small buyers in a more informal, competitive market.

To quantify how market concentration translates into market power, I use structural modelling tools from international economics and industrial organisation. The model describes the behaviour of ranchers, slaughterhouses, and consumers. The key feature of the model is that slaughterhouses strategically choose the amount of cattle they buy from each region to maximise their profits. As a result, there are markdowns on cattle prices, which are lower than they would be in a perfectly competitive world. Farmers respond to these lower prices by devoting less land to pasture.

Main Findings

The estimated model allows me to quantify market power across space. I show this through estimates of "farmer shares": the share of the beef sales revenue that accrues to farmers. In the decile of regions emitting the least GHGs (per head), farmer shares are on average 68%, with slaughterhouses carrying the remainder as profits. In the top decile of carbon emissions intensity (the frontier), farmer shares are 91% on average.

In the frontier there are unregulated emissions, whereas in the core there are low emissions but distorted production. Policy can greatly reduce emissions by reallocating output from the frontier to the core. I show this by simulating counterfactual policies in my model. In one exercise, I introduce a mix of subsidies (to ameliorate market power distortions) and a carbon tax to target emissions. With this policy mix, emissions can fall by 34% while keeping beef output fixed at the original levels.

Policy Implications

These results have implications for policy debates around the environmental impact of cattle production. Proposals have varied in their design but have one thing in common – a focus on the largest slaughterhouses, whether it be through taxes or environmental standards. This study shows that the regions that sell to the largest slaughterhouses are the ones emitting the least per head of cattle. Policies targeting those places further distort markets that already face monopsony, and they miss the key source of emissions – the frontier. Alternatives that target the frontier, such as increasing protections for national forests and indigenous reservations, can more effectively address the key sources of emissions.

References

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