Location and Capacity of Biofuel Mills in Brazil

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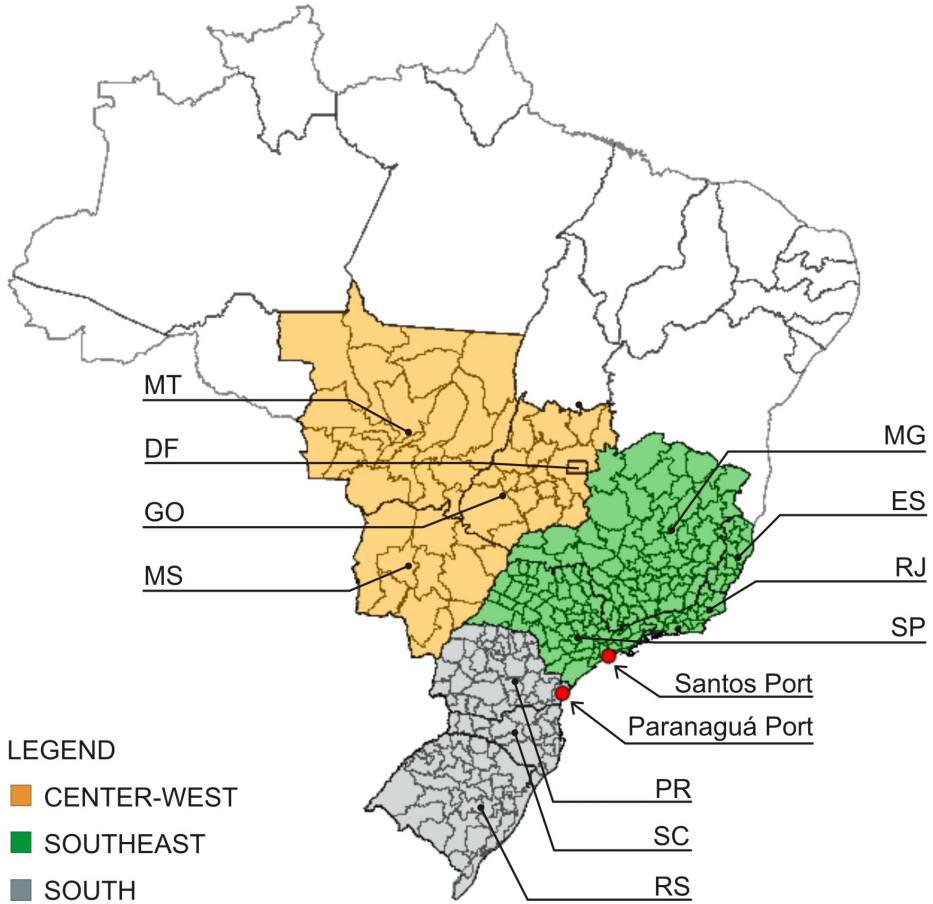
Objectives

- Investigate empirically location and capacity decision drivers for biofuel mills in Brazil using regional variables.
  1. Where biofuel mills locate? Why?
  2. How is their installed capacity decided?
- Build an understanding about the economic forces at work in the formation of these bioenergy producing regions, drawing upon the Brazilian experience with ethanol and biodiesel.

The Sample

Consists of 306 micro-regions in the Brazilian Center-West, Southeast and South regions. Similar to NUTS 3 in Europe or Counties in the US.



Dependent Variables

- Location $\rightarrow$ Binary variable $\rightarrow$ Probit Regression.
  - Existing biofuel mills in 2011.

$$BM_{i,b} = \begin{cases} 1 & \text{if} \quad \text{Micro-region } i \text{ hosts at least one biofuel } b \text{ mill.} \\ 0 & \text{if} \quad \text{Micro-region } i \text{ does not host a biofuel } b \text{ mill.} \end{cases}$$

- Capacity $\rightarrow$ Censored variable $\rightarrow$ Tobit Regression.
  - Ethanol $\rightarrow$ Number of workers in each micro-region in Dec/2010.
  - Biodiesel $\rightarrow m^3/year$ in each micro-region.

$$C_{i,b} = \begin{cases} C^*_{i,b} & \text{if} \quad C^*_{i,b} > 0 \\ 0 & \text{if} \quad C^*_{i,b} \leq 0 \end{cases}$$

Explanatory Variables and Expected Contributions

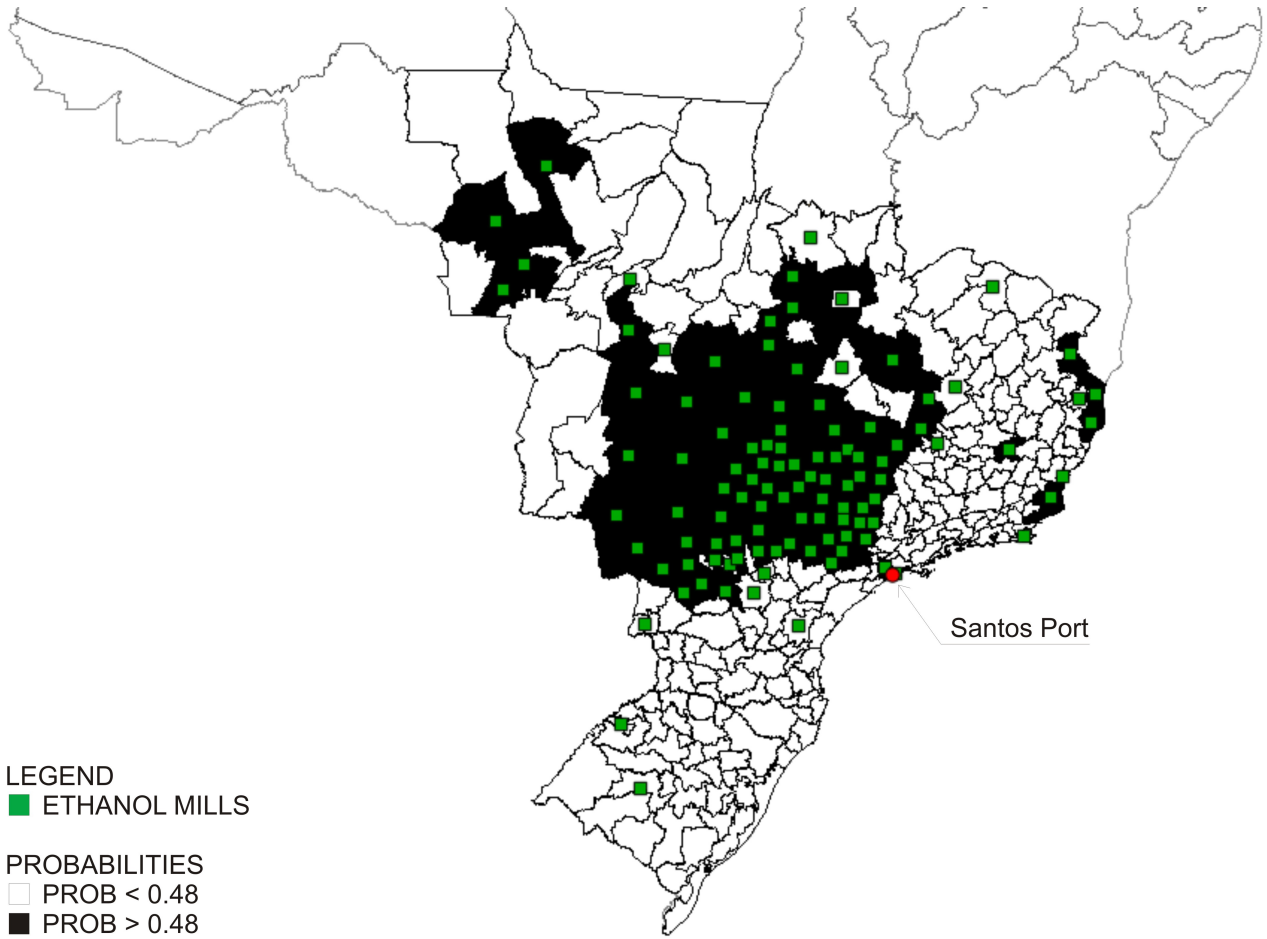
It is assumed that variables that contribute positively to locational decisions should exert the same influence on installed capacity.

Variable	Group	Ethanol	Biodiesel
Distance to Santos Port	S	-	+
Feedstock Quantity	S	+	+
Feedstock Price	S	-	-
Area	S	+	+
Distance to Soy Crushing Mill	S	n/a	-
Raw Vegetable Oil Employment	S	n/a	+
Highway Density	I	+	+
Railway Density	I	+	+
Power Transmission Grid Density	I	+	n/a
River Density	I	+	n/a
State Fossil Fuel Substitutes Price	D_1	+	+
Automobiles	D_1	+	n/a
Trucks plus Buses	D_1	n/a	+
Distance to Ethanol Storage Terminal	D_1	-	n/a
Distance to Fuel Terminal	D_1	-	-
Cattle	D_2	+	+
Poultry	D_2	n/a	+
Hogs	D_2	n/a	+

Note: n/a stands for not applied.

Ethanol Probit - Predicted Probabilities vs. Existing Mills

Model accuracy of 92.16 % $\rightarrow$ misclassifies 24 micro-regions.



Summary for Ethanol Regressions

- Location → Probit.
  - Away from Santos Port (not expected, but with non-linearities).
  - **Abundant sugarcane supply.**
  - **Low sugarcane price.**
  - Small Areas → correlation of 0.68 with distance from Port.
  - **Low transmission grid density** (not expected, untapped potential for bioelectricity).
  - High River Density.
  - High Number of Automobiles.
  - **Near Ethanol Storage Terminals.**
  - Variables (S), (I) and (D), (D_1) are jointly significant.
- Capacity → Tobit.
  - **Cattle** → indication of land availability to increase sugarcane production → Part of dLUC.
  - Variables (S) and (D), (D_1) and "(D_2)" are jointly significant.

Biodiesel Program Design

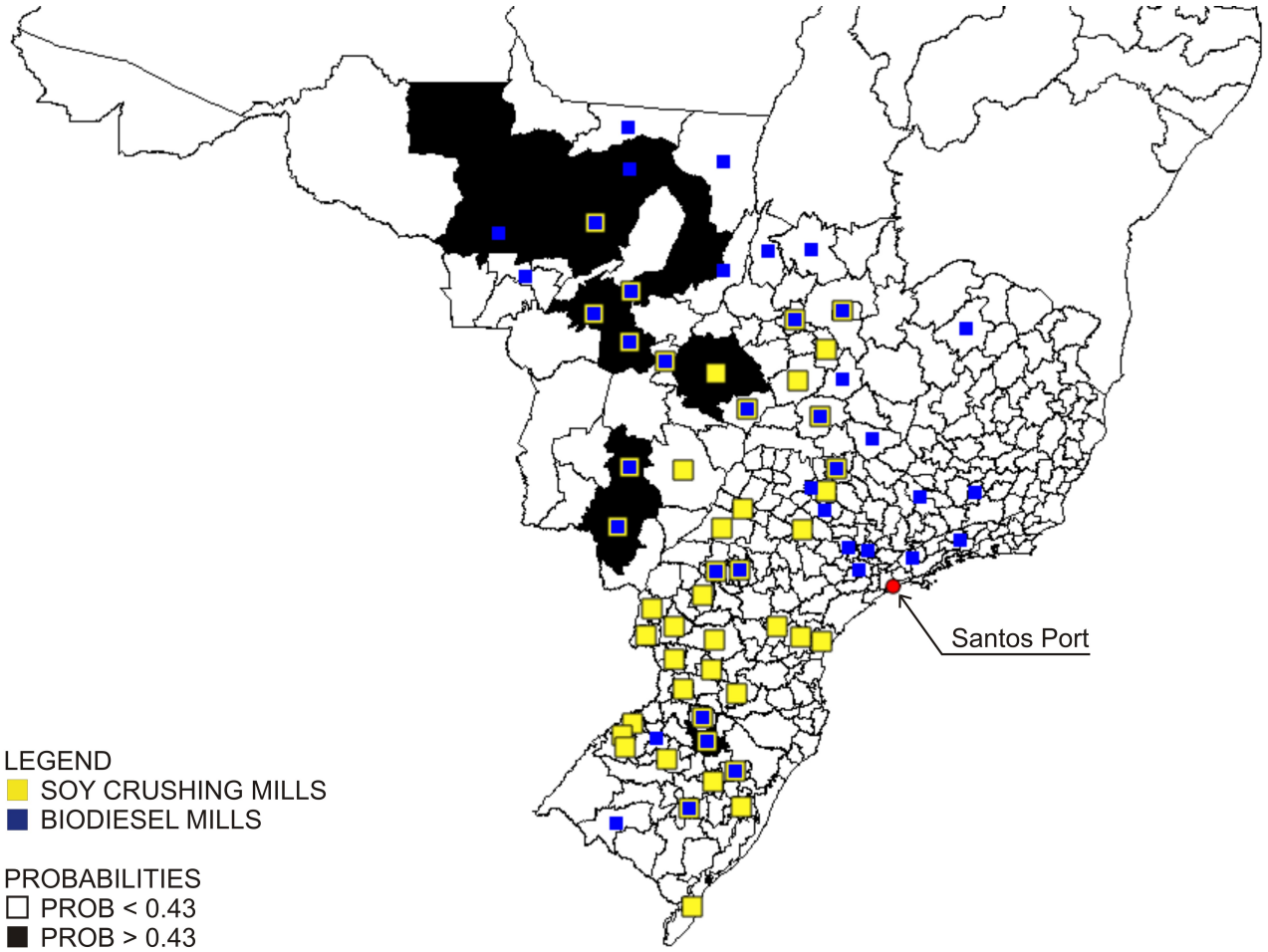
Locational incentives through two federal tax exemptions.

- For castor beans and oil palm produced in the North and Northeast regions, from any producer, tax exemption of 30.5 %.
- Social Fuel Stamp $\rightarrow$ Minimum purchase requirements from small farmers that vary in each region.
  - Full tax exemption if feedstocks are castor beans or oil palm in the North and Northeast regions.
  - Exemption of 67.9 % for any feedstock, in any region.

Huge excess capacity for biodiesel caused by over-entry. Installed capacity (5.8 billion liters/year) is more than twice of that required to meet the current 5% blending mandate (2.4 billions liters) in 2010.

Biodiesel Probit - Predicted Probabilities vs. Existing Mills

Model accuracy of 89.22 % $\rightarrow$ misclassifies 35 micro-regions.



Initial Movers Disadvantage

Rare case of excess capacity with continued entry → Mislocation.

- 18 micro-regions host both a biodiesel mill and a soy crushing mill.
- 22 micro-regions host biodiesel mills not coupled with a soy crushing mill.
- 27 micro-regions with unattended soy crushing mills which could potentially host biodiesel mills.

What caused mislocation?

- Infant industry with many uncertainties.
  1. Economic attractiveness of feedstocks.
  2. Technological route, methanol vs. ethanol → non-renewable vs. renewable.
- Federal locational incentives through tax exemptions to attract investments to poor regions of the country and use castor beans or palm oil as feedstocks from small farmers.

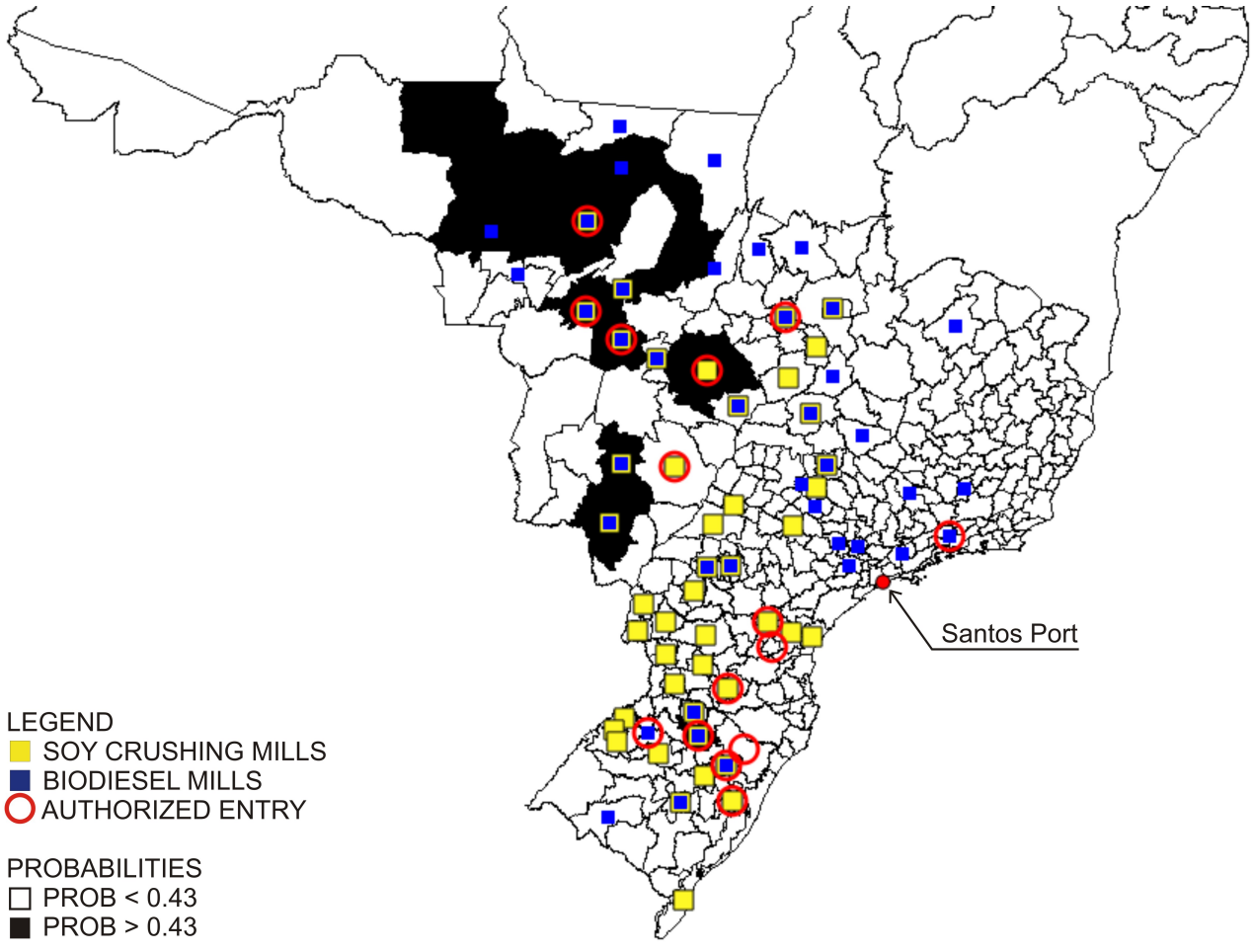
Technological Route Choice

- Biodiesel mills that opted for the ethylic route are expected to be close to ethanol supply.
- Evidence that, proportionately, biodiesel mills located in the Southeast region have opted more for the ethanolysis or hybrid route than in other regions.

	Methanolosys	Ethanolosys	Flexible
Center-West	78%	0%	22%
Southeast	43%	21%	36%
South	78%	11%	11%

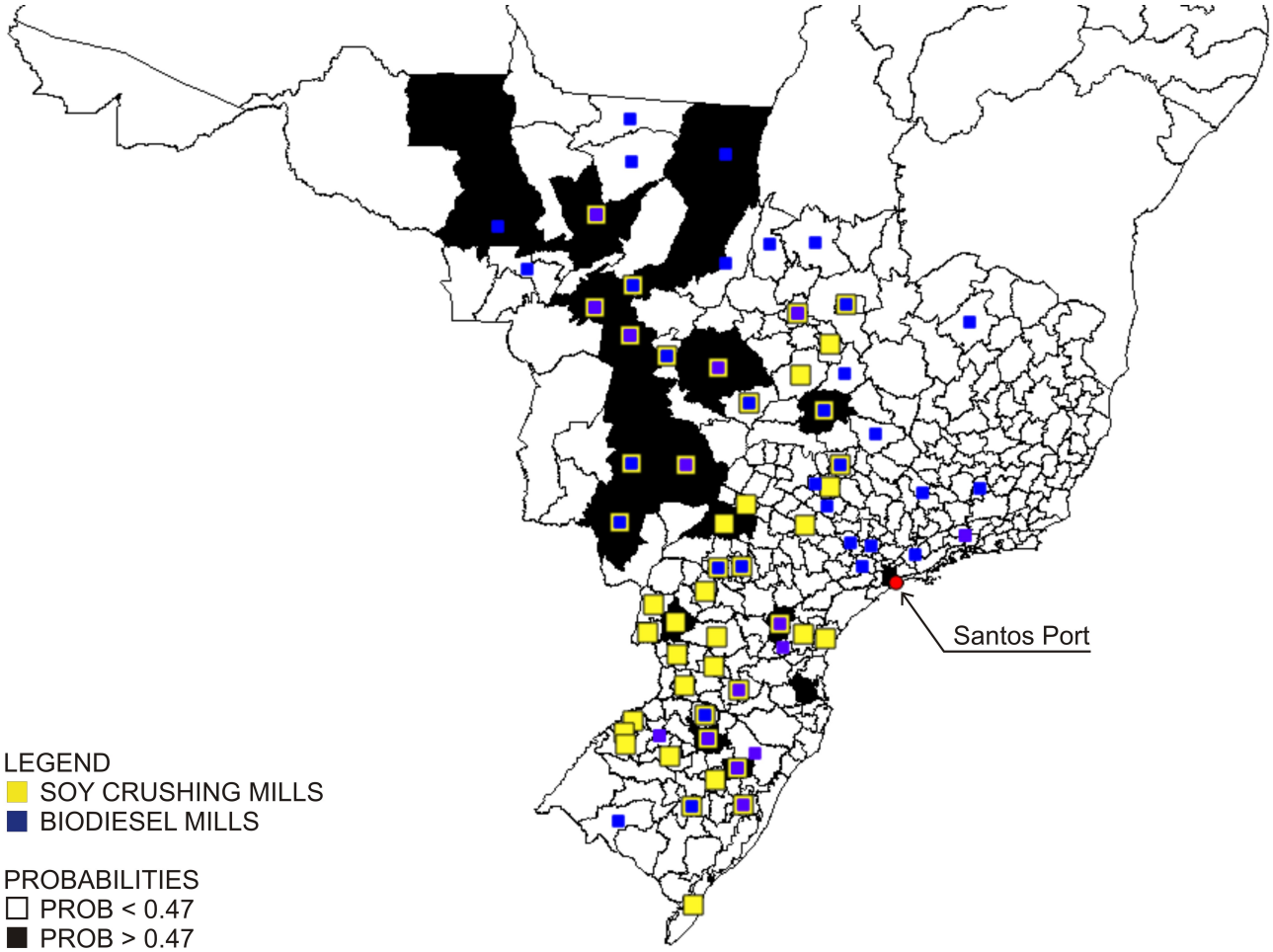
- As the ethylic route can be adapted to the methylic route, the only cause of mislocation becomes again a problem of feedstock procurement cost.

Authorized Expansion and Entry in Biodiesel



Biodiesel Probit - Predicted Probabilities vs. All Mills

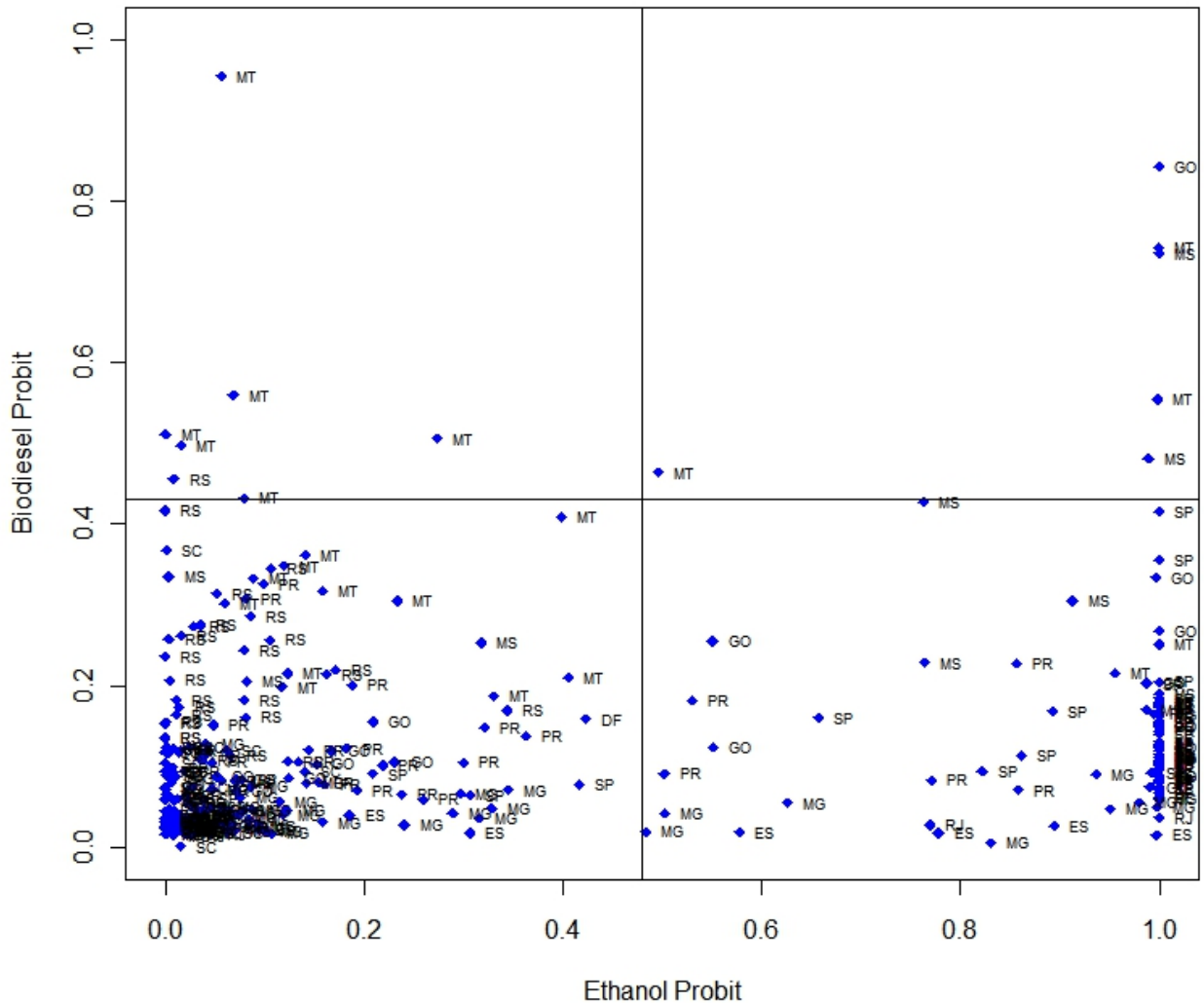
Model accuracy of 86.93 % $\rightarrow$ misclassifies 40 micro-regions.



Summary for Biodiesel Regressions

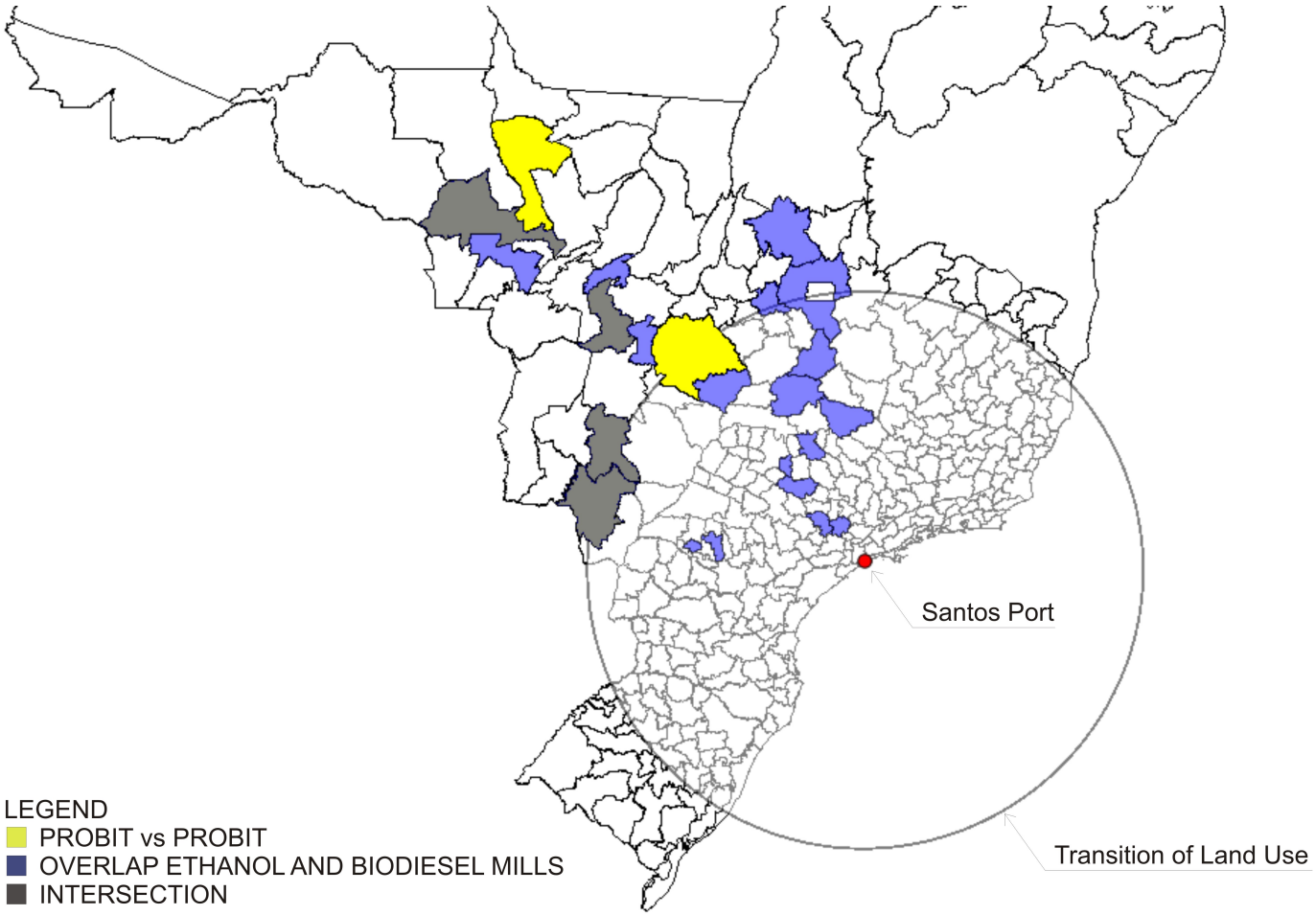
- Location → Probit.
  - **Abundant soybean supply.**
  - **Near soybean crushing mills.**
  - **High number of workers in raw vegetable oil production.**
    - Proxy for the capacity of soybean crushing mills.
  - High railway density.
  - Only supply (S) variables are jointly significant.
- Capacity → Tobit.
  - Excess capacity → unlikely that in the short and medium term, other oil crop will be employed as feedstock in large scale.
  - Only supply (S) variables are jointly significant.

Bio-Refineries - Probit vs. Probit



Bio-Refineries II

- 21 micro-regions already host both types of biofuel mills.



Conclusions

- Almost the same set of statistically significant variables drives location and capacity decisions $\rightarrow$ their shocks are transmitted through two channels.
- Categories of jointly statistically significant variables reflect the way competition with fossil fuels occur.
  - Ethanol $\rightarrow$ Supply and Demand $\rightarrow$ Endogenous market size.
  - Biodiesel $\rightarrow$ Supply $\rightarrow$ Exogenous market size.
- Supply variables are always jointly significant, raw materials in particular $\rightarrow$ Access to agricultural feedstock in large scales.
- Biofuel production is linked to the structure, dynamics and bottlenecks of the agricultural sector which provides its feedstock.
  - This link is forged by technological factors and cost structure derived from bioenergy production function.

Policy Implications

- Improve efficiency, competitiveness, profitability and resilience in the agricultural sector (e.g. international trade negotiations, improving infrastructure, R&D).
- Ethanol
  - Ethanol Storage Terminals $\rightarrow$ affect several micro-regions.
  - Untapped potential for bio-electricity due to past and current regulatory framework in the power sector.
- Biodiesel
  - Inefficient transport mix mainly based on road transportation, which is diesel intensive.
  - Do nothing $\rightarrow$ continued entry and exit.
  - Increase blending mandate up to 10%.
    - B7 in 2013 and B10 in 2014.
    - Involve different mandates by state or region to account for regional idle capacity.
  - Export $\rightarrow$ Unlikely as it costs more than petroleum diesel.

Speculating on Further Implications

- The most economically viable way to produce biofuels, or that has minimum subsidies requirements, is to start as a spin-off of an already existing, mature, at the technological frontier, competitive in international markets agro-industry.
- Examples
  - Ethanol from corn in the US and from sugarcane in Brazil.
  - Biodiesel from soybean in the US, Brazil and Argentina, from palm oil in Indonesia and Malaysia and from rapeseed in EU.
- This provides an explanation of how bioenergy can actually contribute to energy security.
- Existing agro-industrial complexes are also more likely and more experienced in influencing policies to their benefit.

Questions & Answers

Muito Obrigado!
Thank You!

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