The impact of pasture recovery in the agricultural GPV of Brazil's Cerrado

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Introduction

- Rising global demand for food
- Advances in agricultural production and environmental issues
- Relevance of Brazil in the agricultural production context
    - Cerrado region of Brazil - World's Breadbasket, according to The Economist (2010)
- Increased attention to the environmental impacts of agricultural production in other biomes - Amazon and Atlantic Forest.
- Need to expand food and energy production while maintaining environmental balance (without deforestation and/or CO_2)

- Degraded pastures as a key element in this discussion
    - Conversion of degraded pastures into productive areas
- What is the marginal gain from pasture conversion? What is the potential income from this conversion?
- Paper's Contribution:
    - Quantification of the gains in the agricultural GPV (Gross Production Value) of the municipalities in the Cerrado region generated by the conversion of degraded pastures into productive pastures
    - Obtain a potential gain directly, based on local productivity and the GPV of livestock farming in the municipality.

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Background

- Pasture accounts for 27% of 203.4 million of hectares in the Brazilian Cerrado. → In more than 10% of municipalities, at least, 50% of the pasture is degraded to some degree (ANDRADE et al. 2017, 2019)
- The Cerrado has the highest potential for deforestation among Brazilian biomes (VIEIRA FILHO, 2018)
  - $133.028,64$ km^2 (6.53%) was deforested in the Cerrado between 2006 e 2017

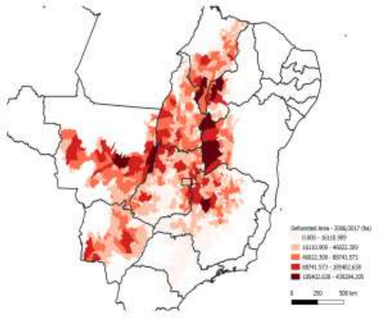

Figure 1: Accumulated Deforestation in Cerrado - 2006 to 2017

- Paris Agreement → Low Carbon Agricultural Program (Programa ABC - Agricultura de Baixo Carbono)
    - Reducing deforestation by 40%
    - Recovering 15 million hectares of degraded pastures → Potential mitigation between 83 and 104 Millions/t of CO_2 *equivalent* until 2030
- Improvement of degraded pastures can be a means of increasing agricultural production while conserving the Cerrado.
    - Environmental Benefits
    - Intensification of Livestock →↑ cattle per hectare
    - The advance in efficiency from profitable technological improvements creates further financial incentives to avoid deforestation
- Land Dynamics: Displacement Deforestation

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Theoretical Model

- Multi-output and Multi-input Model: Distance Function
- **Output distance function**: Determine the maximum amount by which outputs could be expanded given available inputs
- Duality Theory: Shadow Price $\rightarrow$ Marginal Cost for output Shadow Revenue (FULGINITI, 2010)

$$D_o^t(x_t, y_t, A_t) = \ inf_\theta\{\theta : \left(x; \frac{y_t}{\theta}\right) \in \tau, \theta \in \mathbb{R}^*\}$$

Marginal Cost for Output

$$\frac{\partial D_o^t(x_t, y_t, A_t)}{\partial y_m} = \psi_m$$

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Empirical Model and Data

Table 1: Descriptive Statistics for agricultural inputs and output in Brazilian Cerrado - 2006 and 2017

2006	N	Mean	SD	Min	Max
Livestock GVP (R$/millions)	1390	24.95	59.06	0	1667
Agriculture GVP (R$/millions)	1390	61.02	12.81	0	1502
Other GVP (R$/millions)	1390	0.422	1.99	0	48
Capital (number of tractors)	1390	208.37	269.90	0	2424
Labor (number of workers)	1390	3500	3733	59	33284
Crop Land (ha)	1390	17690.92	37216.15	17	500981
Natural Pasture (ha)	1390	17058.68	86362.01	0	2957015
Good Planted Pasture (ha)	1390	37306.19	73340.25	0	1030769
Degraded Pasture (ha)	1390	3869.31	7397.72	0	103006
Other Areas (ha)	1390	36491.83	69536.48	0	1301687
Schooling (%)	1390	0.0734	0.0763	0	0.6190
Technical Assistance Land (%)	1390	0.5155	0.2661	0	1
Social Capital Land (%)	1390	0.3927	0.2396	0	0.9987
Suitability Index Mean	1390	469.09	76.24	206.87	703.55
2017					
Livestock GVP (in millions)	1390	44.89	73.10	39	993
Agriculture GVP (in millions)	1390	107.38	24.88	0	2993
Other GVP (in millions)	1390	5.13	24.36	0	538
Capital	1390	301.97	384.19	0	3777
Labor	1390	2372	2372	0	21812
Crop Land	1390	22772.99	50704.63	0	579271
Natural Pasture	1390	13842.45	72273.57	0	2359794
Good Planted Pasture	1390	37463.58	71605.95	0	923658
Degraded Pasture (ha)	1390	4414.58	9348.23	0	98092
Other Areas	1390	39945.52	77770.78	13	1606384
Schooling (%)	1390	0.1313	0.0957	0	0.500
Technical Assistance Land (%)	1390	0.5292	0.2676	0	0.9984
Social Capital Land (%)	1390	0.1389	0.1667	0	0.7987
Suitability Index Mean	1390	469.09	76.24	206.87	703.55

$$D_o(x, y) = f(A_{Crops}, A_{NP}, A_{GP}, A_{DP}, A_{Others}, K, L, Y_{Agri}, Y_{LS}, Y_{Others})$$

The productive agricultural areas are divided into four parts: crops land (A_{Crops}), good planted pasture (A_{GP}), degraded pasture (A_{DP}) and Natural pasture (A_{NP}) K is Capital; L is Labor; The information about production is represented by a local agricultural GPV per activity: livestock (Y_{LS}), agriculture (Y_{Agri}), and other activities (Y_{Others}), which is basically timber.

The distance function including the technology change variable (FULGINITI; PERRIN, 1993) can be demonstrated as:

$$D_o = A_{Crops}^{\alpha_1}.A_{Past}^{\zeta}.K^{\alpha_3}.L^{\alpha_4}.Y_{Agri}^{\beta_1}.Y_{LS}^{\beta_2}.Y_{Others}^{\beta_3} \quad (1)$$

where

$$\zeta = \alpha_{20} + \alpha_{21}.\%A_{GP} + \alpha_{22}.\%A_{DP}$$

Knowing that $A_{DP} = A_{Past} - A_{GP} - A_{NP}$ [1], an increase in the amount of good pasture (A_{GP}) is from degraded pasture (A_{DP}) [2] would affect the level of livestock production.

The idea of using the Technological Change Variable is related to the quality of natural and human resource as well as to technical change (FULGINITI; PERRIN, 1993)

- Homogeneity of degree 1:

$$\begin{aligned}\frac{D_o}{Y_{Others}} &= \Lambda.\frac{Y_{Agri}^{\beta_1}.Y_{LS}^{\beta_2}}{Y_{Others}^{\beta_1+\beta_2}}\\ &= \Lambda.\left(\widetilde{Y_{Agri}}\right)^{\beta_1}.\left(\widetilde{Y_{LS}}\right)^{\beta_2}\end{aligned}$$

- Cobb-Douglas Distance Function:

$$\begin{aligned}-\ln Y_{Others_t i} =& \beta_{0_t i} + \beta_1.\ln\widetilde{Y_{Agri}} + \beta_2.\ln\widetilde{Y_{LS}} + \alpha_1.\ln A_{Crops} +\\ & \alpha_{20}.\ln A_{Past} + \alpha_{21}.\%A_{GP}.\ln A_{Past} + \alpha_{22}.\%A_{DP}.\ln A_{Past} +\\ & \alpha_5.\ln K + \alpha_6.\ln L + \alpha_7.SIM + \delta t_i + \sum_{h=1}^{9}\psi_i\ FS_i + v - D_{o_t i}\end{aligned}$$

Impact of Transformation from Degraded Pasture to Productive Pasture

- Applying the Implicit Function Theorem, as in Rada (2011, 2012, 2013) $\rightarrow$ Analyze the transformation of the region degraded pasture area into good planted pastures with the same yields average from the region
- The impact of the marginal transformation of a hectare of degraded pasture into a hectare of good planted pasture: $\frac{dD_o}{dA_{GP}}$:

$$\begin{aligned} \frac{\partial Y_{LS}}{\partial A_{GP}} =& Y_{LS} . \frac{1}{\beta_2} . \left[\frac{\alpha_4 A_{GP} - \alpha_2 A_{DP}}{A_{PD} . A_{GP}} \right] \\ =& \ Y_{LS} . \gamma_{GPLS} \end{aligned} \tag{2}$$

where γ_{GPLS} is a semi-elasticity for good planted pastures to livestock production, that means, a hectare of good pasture affecting livestock production γ_{GPLS}%

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Results

Table 2: Estimated Models - ODF

	COLS	MLE	MLE
Crop Land	-0.1815***	-0.2197***	-0.1739***
	(0.0140)	(0.01441)	(0.0137)
Share of Degraded Pasture	0.1008***	0.1028***	0.0799***
	(0.0137)	(0.0137)	(0.0129)
Share of Good Pasture	-0.0482***	-0.0402***	-0.0430***
	(0.0057)	(0.0057)	(0.0056)
Pasture Land	-0.2759***	-0.2212***	-0.2671***
	(0.0154)	(0.0162)	(0.0151)
Capital	-0.2801***	-0.2881***	-0.2438***
	(0.0179)	(0.0172)	(0.0178)
Labor	-0.2721***	-0.2727***	-0.2921***
	(0.0188)	(0.0187)	(0.0189)
Agriculture GPV	0.2515***	0.3002***	0.2470***
	(0.0091)	(0.0108)	(0.0094)
Livestock GPV	0.6745***	0.6271***	0.6847***
	(0.0095)	(0.0109)	(0.0097)
t	-0.7025***	-0.6832***	-0.6997***
	(0.0331)	(0.0322)	(0.0364)
Suitability Index	-0.0013***	-0.0012***	-0.0011****
	(0.0002)	(0.0002)	(0.0002)
Constant	-0.6397***	-0.6387***	-1.1907***
	(0.2176)	(0.5671)	(0.2139)
States	Yes	Yes	Yes
Inefficiency Control	-	No	Yes
Log-Likelihood	-	-2473.91	-2393.51
Wald Test	-	68112.75	63627.67
Prob ¿ χ^2	0.0000	0.0000	0.0000
Observations	2718	2718	2718

Source: Search Results
Standard errors in parentheses
*** p¡0.01, ** p¡0.05, * p¡0.1
Source: Research Results

Table 3: Technical Efficiency Exogenous Control

Social Capital	4.0677***
	(0.7583)
Aridity Index	0.0613***
	(0.0136)
Schooling	23.4483***
	(4.4839)
Constant	-1.5581***
	(0.3595)

Source: Research Results

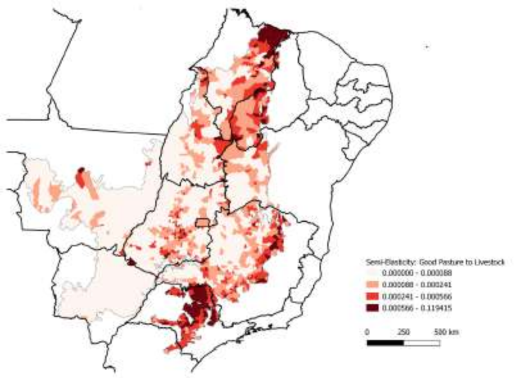

Figure 2: Semi-Elasticity of Livestock GPV from Good Pastures (γ_{GPLS})

$$\gamma_{GPLS} = \frac{1}{\beta_2} . \left[\frac{\alpha_4 A_{GP} - \alpha_2 A_{DP}}{A_{PD} . A_{GP}} \right]$$

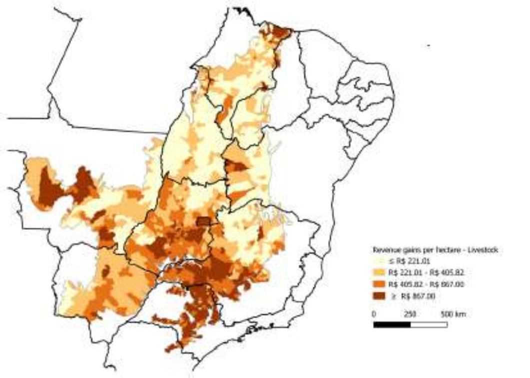

Figure 3: GPV of Livestock from Good Pastures

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Conclusion

- Recovery of degraded pasture is a potential solution to the lack of agricultural land
- Having two technical parameters of costs of recovery of a degraded pasture - Costa (2010) and Zimmer et al. (2012) - 34% of municipalities of Cerrado show positive net earnings.
- The estimation of marginal gains to recovery pasture can support the development of actions, such as adjustments in rural credit line focused on restoration,

Thanks

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