TECHNICAL EFFICIENCY ANALYSIS OF CITRUS FARMS IN BRAZIL

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Introduction

- Brazil is the world´s largest producer of fresh orange and orange juice.
  - Orange production in 2013/2014 = 17.549 millions of tons (IEA, 2013)
  - Juice exports in 2013/2014 = 1.895 millions of tons (CITRUS BR, 2013)
- Crisis in the citrus industry
  - Decreasing number of independent citrus farmers: 15,000 in 2001 to 10,100 in 2013
  - Decreasing production area: 609,475 ha in 2000 to 464,447 in 2013
  - Decreasing production: 356 millions of boxes (2000) to 269 million of boxes (2013)
- Some hypotheses to explain the crisis:
  - Low prices
  - Low production efficiency of citrus farms

Problem Statement

What are the factors that explain the technical efficiency differentials between citrus farms Brazil?

- Hypothesis:
  - Personal aspects of farmers and aspects of decision-making process (managerial aspects) have potential to influence the efficiency of farms (Rougoor et al., 1998)

Objectives

- Estimation of a production frontier based on data from Brazilian citrus farms
- Identification of the effect of

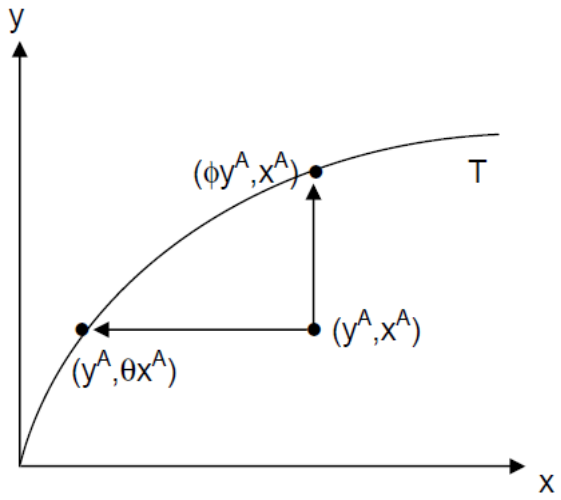
  personal aspects of farmers and

  aspects of the decision-making process

  on the technical efficiency of the farms.

Conceptual Background

- **Production frontier theory (Koopmans, 1951; Debreu, 1951; Farrell, 1957; Coelli and Battese, 1993; Fried et al., 2008)**



- **Effects of management tools on the efficiency of farms (Rougoor et al., 1998; Wilson et al., 1998; 2001)**

Research Methodology

- Personal interviews
- 2013/14 crop season (cross-sectional data)
- Sample: 98 citrus growers
- Stochastic production frontier:
  - Translog functional form
  - Inefficiency effects single stage econometric model (Battese and Coelli, 1995):

$$\ln(y_i) = f(x_i;\ \beta) + \ v_i - u_i \qquad i = 1, 2, \dots, N$$
$$u \sim N^{+}(\mu, \sigma_u^2)\ with\ \mu = \ \delta z$$

y_i = Orange production
x_i = Production factors: land, labor, capital, fertilizers, pesticides
β = Parameters of the production frontier
v_i = Stochastic Error Term
u_i = Inefficiency term
μ = Inefficiency mean parameter
z = vector of explanatory variables (personal aspects and aspects of decision making)
δ = Parameters of explanatory variables

Variable	Description
Production (y)	Number of orange boxes
Area (x_1)	Area with orange trees (hectares).
Labor (x_2)	Hours of labor
Capital (x_3)	Annual service flow of tractors and main agricultural implements (hours).
Fertilizers (x_4)	Amount of NPK fertilizers (in kg).
Pesticides (x_5)	Total expenditure with pesticides (in Brazilian Reais)
Undergraduate (z_1)	Dummy variable: 1 if the farmer has undergraduate education, and 0 if not.
Expectations (z_2)	Dummy variable: 1 to 5 (1 = complete disagreement and 5 = complete agreement) "The environment of commercial disputes and anticompetitive practices of orange juice processing companies has negatively affected my investments in citrus production in recent years and continues to affect my expectation in relation to the future of the activity".
Technical assistance (z_3)	Dummy variable: 1 if the farmer has received; 0 if not.
Adoption of long run contracts (z_4)	Dummy variable: 1 if the farmer adopted; 0 if not. Proxy variable for commercialization planning.
Index of IT management tools (z_5)	Index: 0 to 7 adoption of: (1) electronic spreadsheets of cost control; (2) electronic records of input stock; (3) electronic records of production, productivity and incidence of pests per plot of land; (4) use of integrated managerial software systems; (5) use of internet to access market information; (6) adoption of precision agriculture techniques; (7) quality certifications.

Variable	Parameter	Coefficient	Standard Error	z-value
Constant	β_0	0.2946***	0.0590	4.9961
lnx1 (hectares)	β_1	0.3851***	0.0892	4.3195
lnx2 (labor hours)	β_2	0.1031	0.0676	1.5253
lnx3 (machine hours)	β_3	0.2611***	0.0898	2.9081
lnx4 (kg NPK)	β_4	0.2396***	0.0723	3.3119
lnx5 (pesticides expenditures)	β_5	0.0080	0.0555	0.1440
lnx1 x lnx1	β_{11}	0.3911	0.3807	1.0272
lnx1 x lnx2	β_{12}	-0.1823	0.2010	-0.9070
lnx1 x lnx3	β_{13}	0.2185	0.1969	1.1098
lnx1 x lnx4	β_{14}	-0.1326	0.2565	-0.5171
lnx1 x lnx5	β_{15}	-0.3009*	0.1632	-1.8434
lnx2 x lnx2	β_{22}	0.2810	0.2414	1.1640
lnx2 x lnx3	β_{23}	0.2453	0.1719	1.4271
lnx2 x lnx4	β_{24}	-0.1085	0.1389	-0.7814
lnx2 x lnx5	β_{25}	-0.1482	0.1178	-1.2577
lnx3 x lnx3	β_{33}	-0.6594***	0.2221	-2.9688
lnx3 x lnx4	β_{34}	-0.0574	0.1740	-0.3298
lnx3 x lnx5	β_{35}	0.1472	0.1535	0.9590
lnx4 x lnx4	β_{44}	0.2709	0.2694	1.0057
lnx4 x lnx5	β_{45}	-0.0423	0.1326	-0.3188
lnx5 x lnx5	β_{55}	0.2700	0.1652	1.6344
Inefficiency model				
z1 (under graduation)	δ_1	0.1802	0.1161	1.5516
z2 (expectations)	δ_2	0.1966***	0.0333	5.8921
z3 (technical assistance)	δ_3	-0.0839	0.1370	-0.6125
z4 (long run contracts)	δ_4	-0.2503*	0.1438	-1.7401
z5 (index of management tools)	δ_5	-0.2015***	0.0506	-3.9837
Variance Parameters				
σ_s^2		0.0900***	0.0300	2.9986
γ		0.8053***	0.1150	7.0005
Log-Likelihood		12.198		
Chi-squared		71.973***	-	
Efficiency mean		0.7524		
N = 98				

*** Significant at 1%, ** significant at 5%, * significant at 10%.

Discussion

- Partial elasticities of production at sample mean:
  - Area = 0.3851 (significant at 1% level)
  - Labor = 0.1031
  - Capital = 0.2611 (significant at 1% level)
  - Fertilizers NPK = 0.2396 (significant at 1% level)
  - Pesticides = 0.008
- Elasticity of scale at sample mean = 0.9969 (constant returns of scale)
- Elasticity of scale of 98 farms of the sample
  - 17 operating at optimal scale (constant returns)
  - 24 operating with decreasing returns of scale
  - 57 operating with crescent returns of scale
- Optimal scale = 55,000-85,000 boxes per crop year

Discussion

Efficiency index of farms

Technical efficiency score	Number of farms
<50%	11
50-70%	24
70,01-80%	13
80,01-90%	25
>90,01%	25
Average efficiency	0,7524
Standard deviation	0,1767
Maximum	0,9702
Minimum	0,2831

Discussion

- Three “explanatory management variables” are significant
  - INDEX OF IT MANAGEMENT TOOLS
    - Marginal effect on efficiency = 1.88% at sample mean
  - EXPECTATIONS
    - Marginal effect on efficiency = -1.83% at sample mean
  - ADOPTION OF LONG RUN CONTRACTS
    - Marginal effect on efficiency = 2.33% at sample mean

Conclusions

- Optimal scale = 55,000-85,000 boxes
- Mean technical efficiency = 75.24%
- Farmers can improve the scale and technical efficiency
- Management variables are important to improve efficiency

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