AGRICULTURE IN AN INTERCONNECTED WORLD

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A Meta-Frontier Approach to Measuring Technical Efficiency and Technology Gaps in Beef Cattle Production in Argentina

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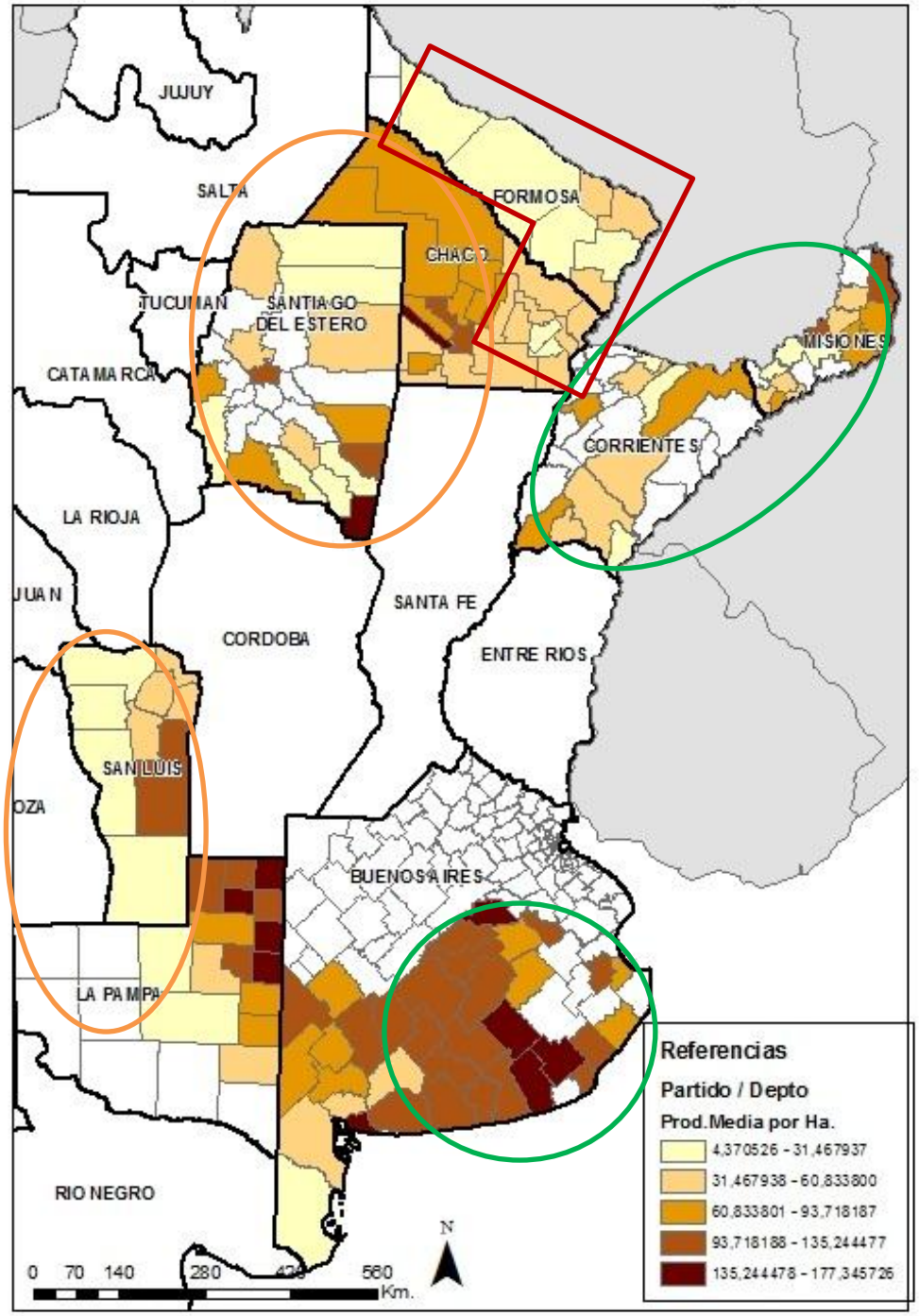
Introduction

In Argentina, there are several regions with cattle production.

Regions have differences in:

- ✓ **Resource endowments:** quality of soils, climate.
- ✓ **Economic infrastructure:** access to market,
- ✓ **Physical and human capital:** handling facilities, quality of the labour force.



Heterogeneity in Average Production at regional levels (Survey data)

Region	Average production (kg/ha/year)
1. Buenos Aires	109.48
2. NE La Pampa & SE Bs. As.	98.07
3. S. del Estero & W Chaco	67.21
4. Corrientes & Misiones	54.97
5. San Luis & NW La Pampa	37.22
6. Formosa & E Chaco	35.68

Data: Technological survey 2009/10, INTA (N=1.289)

Víctor BRESCIA

Objectives

What about efficiency and technology levels in cattle production?

1. Estimate technical efficiency (TE): relative performance within region.

2. Estimate technology gaps: technology comparison across regions.

Data

Technological survey 2009/2010, INTA.

1289 cattle farms from 6 regions. Cross-sectional data.

Cow-calf, stocker, fattening and complete cattle systems.

Some regional differences

Numerical Variables	(1) Buenos Aires	(2) NE LP & SW Bs As	(3) SE & W Chaco	(4) Corr & Misiones	(5) SL & NW LP	(6) F & E Chaco
Number of cattle farms	253	350	173	128	107	278
Annual Sales (kilograms)	163,414	103,821	76,328	72,363	91,403	54,378
Cattle stock (heads)	1,467	830	954	1,332	1,026	1,014
Area (hectares)	1,549	1,786	1,512	1,825	4,601	2,094
Labour (number of workers)	5.62	5.16	5.59	5.64	4.61	5.14
Dummy Variables						
Livestock scale	40%	48%	42%	46%	47%	42%
Electric Fencing	89%	91%	64%	37%	64%	63%
Grains feed	49%	71%	51%	53%	64%	45%
Art. Insemination	19%	27%	28%	34%	23%	31%
Permanent Tech Adv.	47%	37%	19%	18%	31%	18%
Cow-calf operations	18%	12%	34%	30%	38%	41%

Methodology

1. Stochastic Production Frontiers by region (6).

2. Using the estimated parameters we obtain -following O`Donnell *et al* (2008)- a Metafrontier Production Function.

1. Translog (TL) Stochastic Frontiers

$$Y_i = \alpha_0 + \sum_{k=1}^{3} \beta_k^j x_{ki} + \frac{1}{2} \sum_{k=1}^{3} \sum_{l=1}^{3} \beta_{kl}^j x_{ki} \times x_{li} + \sum_{d=1}^{5} \beta_d^j Z_d + v_i^j - u_i^j$$

Y_i : Annual sales (kilograms)

A_i : Area (hectares)

L_i : Labour (number of workers)

K_i : Cattle stock (capital)

Dummy variables:

Z_1 grains feed,

Z_2 electric fencing and livestock scale,

Z_3 permanent technical advisor,

Z_4 artificial insemination,

Z_5 Cow-calf operations.

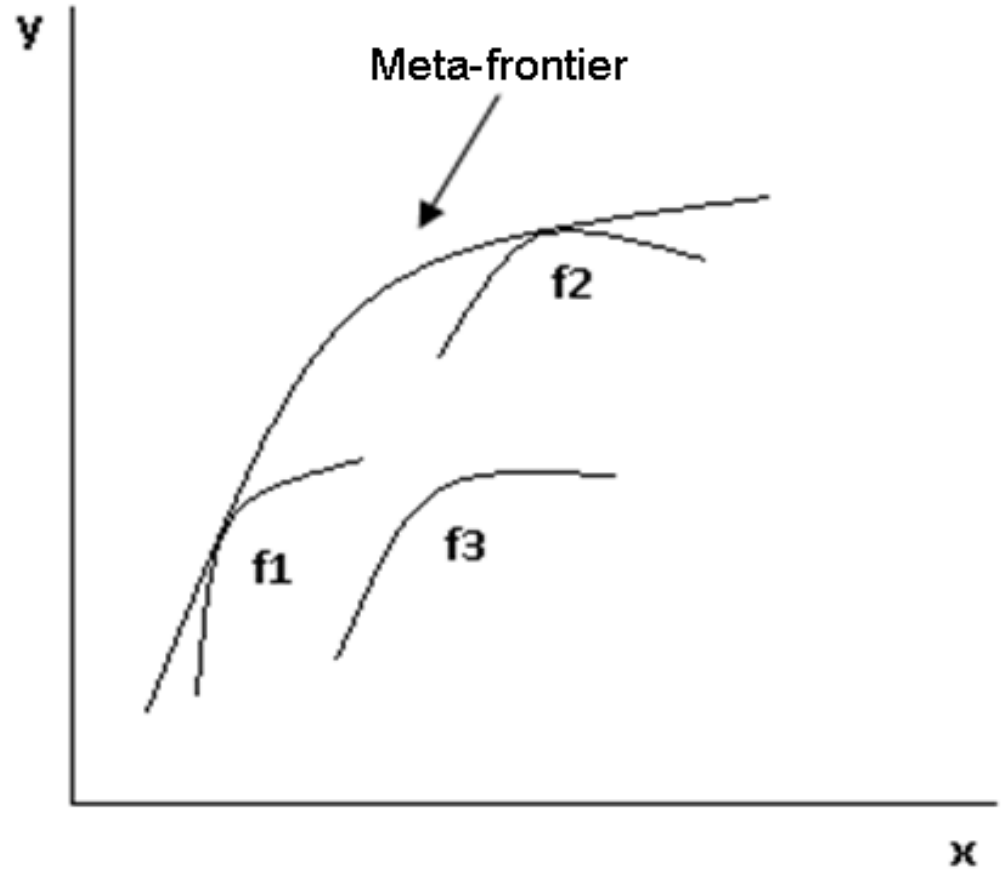
1. TL Frontiers

Dependient variable: Annual sales

	(1) Buenos Aires		(2) NE LP & SW Bs As		(3) SE & W Chaco		(4) Corr & Misiones		(5) SL & NW LP		(6) F & E Chaco	
Constant	0.616***	(0.078)	0.728***	(0.103)	-0.055	(0.623)	0.857***	(0.189)	-0.192	(0.756)	-0.131	(1.505)
Area	0.134	(0.091)	0.274***	(0.062)	0.077	(0.078)	0.470***	(0.111)	0.214***	(0.082)	0.111*	(0.066)
Labour	0.083	(0.074)	0.132	(0.084)	-0.0001	(0.099)	0.0889	(0.126)	0.0898	(0.158)	0.0726	(0.089)
Cattle stock	**0.832*** **	(0.096)	**0.598*** **	(0.070)	**0.765*** **	(0.089)	**0.445*** **	(0.121)	**0.580*** **	(0.108)	**0.717*** **	(0.076)
area2	-0.261**	(0.128)	-0.026	(0.030)	0.0002	(0.071)	0.0625	(0.078)	0.124	(0.078)	0.0669	(0.068)
lab2	-0.112	(0.075)	-0.098*	(0.059)	0.097	(0.106)	0.0583	(0.118)	-0.458*	(0.237)	-0.039	(0.085)
stock2	-0.042	(0.138)	0.0501	(0.043)	0.027	(0.080)	0.160***	(0.052)	0.0253	(0.088)	-0.005	(0.084)
area_lab	0.289	(0.178)	0.105	(0.086)	0.205	(0.134)	0.222	(0.152)	0.1	(0.207)	-0.0793	(0.120)
area_stock	0.289	(0.243)	-0.046	(0.063)	-0.010	(0.129)	-0.289**	(0.113)	-0.213	(0.155)	-0.0825	(0.131)
lab_stock	-0.224	(0.167)	-0.155	(0.110)	-0.231	(0.156)	-0.257	(0.169)	0.303	(0.286)	0.0957	(0.142)
Grains feed	0.250***	(0.069)	0.070	(0.078)	0.199**	(0.096)	-0.132	(0.129)	0.104	(0.133)	0.375***	(0.088)
Electric Fencing & Scale	0.001	(0.078)	0.047	(0.073)	0.026	(0.121)	0.123	(0.166)	0.191	(0.142)	0.0781	(0.100)
Perm tech adv	-0.052	(0.07)	0.196***	(0.074)	0.12	(0.126)	-0.0031	(0.187)	0.0908	(0.151)	0.0234	(0.122)
Art. Insemination	0.023	(0.087)	0.107	(0.081)	0.146	(0.113)	0.165	(0.172)	0.305**	(0.153)	0.0852	(0.108)
Cow-calf operations	0.162	(0.112)	-0.400***	(0.113)	-0.425***	(0.101)	-0.444***	(0.148)	-0.118	(0.152)	-0.0494	(0.085)
Scale $(\beta_1+\beta_2+\beta_3)$	1.04		1		0.84		1		0.88		0.9	
Wald Test χ^2 $(\beta_1+\beta_2+\beta_3=1)$	0.56		0.01		3.47*		0.01		0.81		1.46	
Economy of Scale	Constant		Constant		Diseconomy		Constant		Constant		Constant	
LLF	-208.19		-365.22		-155.14		-132.99		-97.42		-283.34	

2. Meta-frontier Analysis

Definition: the envelope function of the production frontiers. Hayami (1969) - Hayami & Ruttan (1970, 1971).



2. Meta-frontier Analysis

Objective function:

$$\min_{\beta^*} \sum_{i=1}^{N} \sum_{t=1}^{T} \left[lnf(x_{1it}, x_{2it}, \dots, x_{Kit}; \beta^*) - lnf(x_{1it}, x_{2it}, \dots, x_{Kit}; \hat{\beta}^j) \right]$$

s. t. $$lnf(x_{1it}, x_{2it}, \dots, x_{Kit}; \beta^*) \geq lnf(x_{1it}, x_{2it}, \dots, x_{Kit}; \hat{\beta}^j)$$

Minimization of the sum of the absolute deviations of the distance between the MF and the j-th group frontier evaluated at the observed input vector for a firm in the j-th group.

3. Pooled (TL) and Meta-frontier (MF) Models

	Pooled TL		Meta-frontier (MF)
Constant	4.968***	(0.0657)	5.719
Area	0.674***	(0.0323)	0.853
Labour	-0.274	(0.0419)	0.416
Cattle stock	0.430***	(0.0382)	-0.079
area2	0.0214	(0.0214)	0.012
lab2	-0.0859**	(0.0363)	-0.052
stock2	0.126***	(0.0255)	0.189
area_lab	0.139***	(0.0501)	0.246
area_stock	-0.169***	(0.041)	-0.178
lab_stock	-0.0646	(0.0575)	-0.295
Grains feed	0.192***	(0.0416)	0.159
Electric fencing & Livestock scale	0.0820*	(0.0452)	0.018
Perm tech adv	0.242***	(0.0452)	0.184
Art. Insemination	0.0202	(0.0477)	0.109
Cow-calf operations	-0.329***	(0.0476)	0.069
Scale			
$(\beta_1+\beta_2+\beta_3)$	0.9		
Wald Test χ^2			
$(\beta_1+\beta_2+\beta_3=1)$	8.08***		
Economy of Scale	Diseconomy		
LLF	-1441.181		

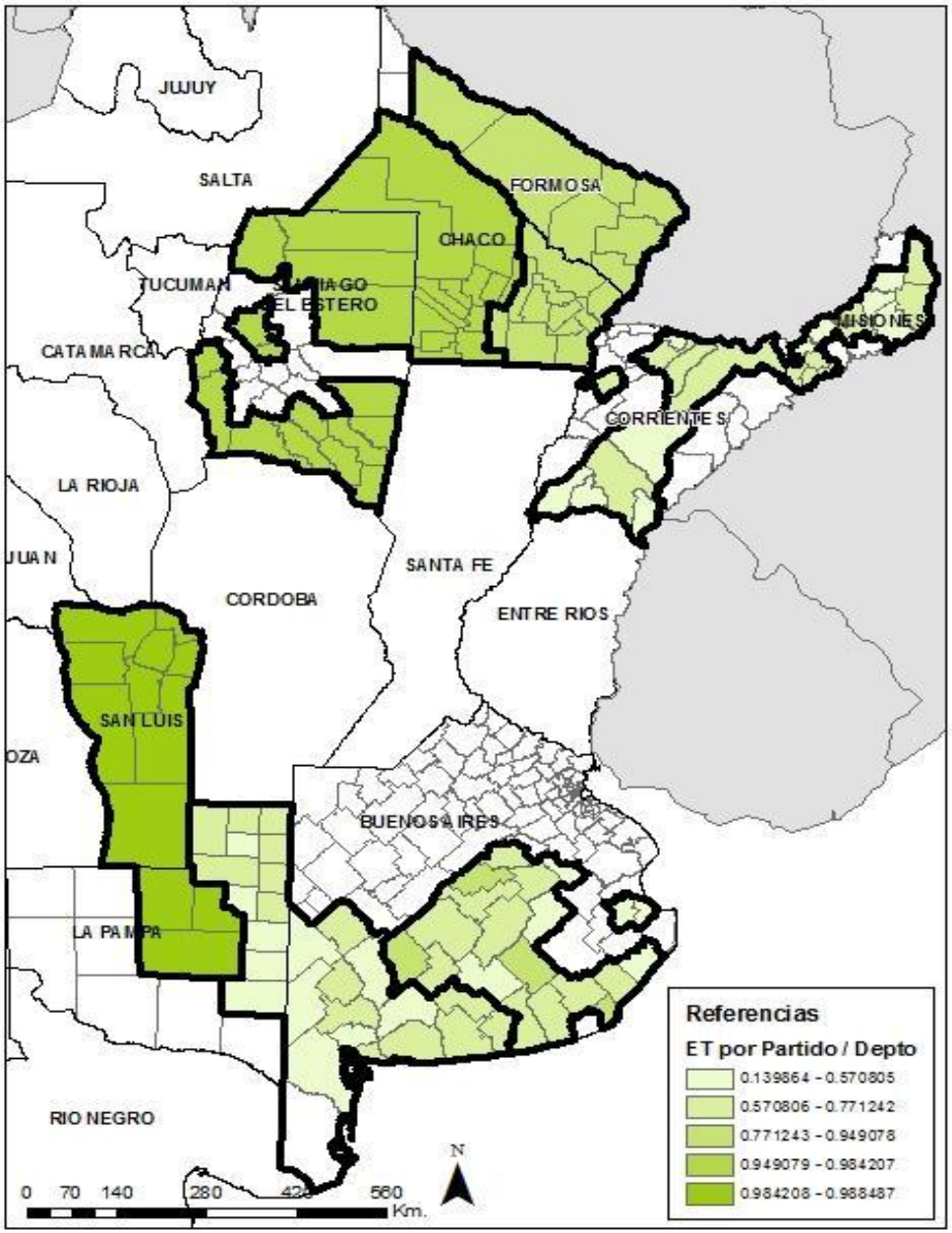
LR test: pooled frontier is not the same as regional frontiers.

Technology differs across regions

Meta-frontier estimation

Significance: (***)1%; (**) 5%; (*) 10%.

Technical Efficiency (TE)



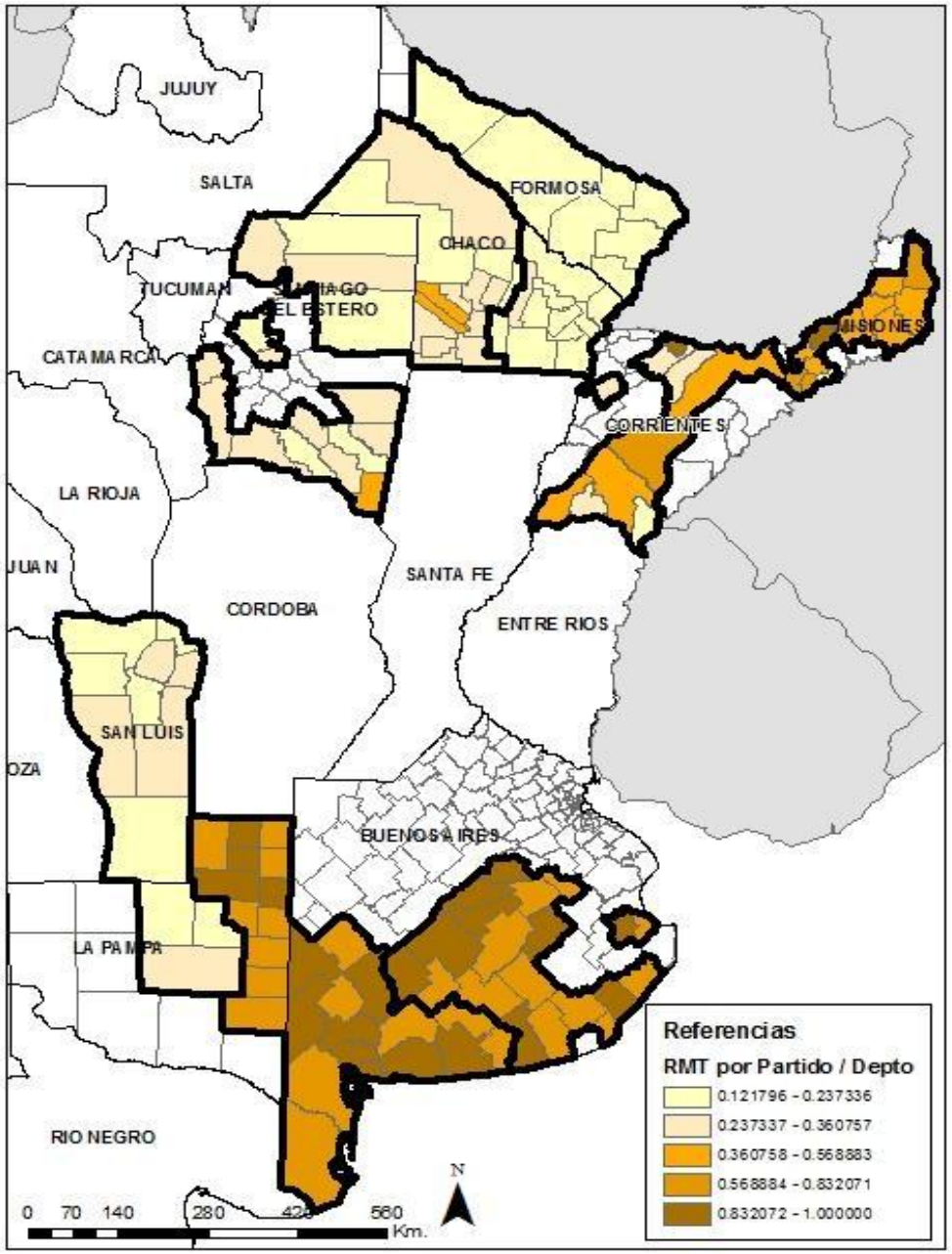
Farms from Buenos Aires **(1)** with 109 kg/ha (**highest average production/ha**) have a TE of 56%,

Santiago del Estero and West Chaco **(3)** with 67 kg/ha TE of 98%,

Formosa and East Chaco **(6)** (35 kg/ha) TE of 94%.

Inverse relationship between TE and Average production

Maps: IES/INTA



Meta-Technology Ratio (MTR)

MTR: the technology available to a given (j-th) group relative to the technology available to all groups under consideration taken together. (1-MTR) is the technology gap.

MTR Buenos Aires **(1)**: 78%,

MTR S. del Estero and W Chaco **(3)**: 27%,

MTR Formosa and East Chaco **(6)** : 19%.

At Buenos Aires the gap (1-MTR) is low (22%).

Marginal regions are efficient but gap is important (75% - 81%).

Maps: IES/

Conclusions

- Partial productivity (kg/ha) and efficiency have an inverse relationship across regions.

- Farms from Buenos Aires (traditional) have relative low efficiency. Can improve TE through management. Example: livestock management software programs.

- Farms from other regions (less productive, but efficient) need new technologies (frontier expansion). Example: better facilities to handle animals or seeds adapted to climate conditions.

- This may occur only if the economic environment promotes investment. New technologies are capital intensive.

Thank you!

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