International trade, product diversification and coherence of Colombian manufacturing plants

Mercedes Campi[1] Marco Dueñas[2] Fernando Mesa[2]

[1]CONICET and IIEP-Baires, University of Buenos Aires, Argentina
[2]Universidad Jorge Tadeo Lozano, Bogotá-Colombia

Workshop: Innovación, Dinámica Industrial y Política Industrial
UJTL - Bogotá
October 12 - 2018

Aim of the paper

- Analyze the dynamics of Colombian plants for the period 2001-2013, in terms of:
  - Product diversification (scope)
  - Coherence of the diversification patterns
  - Engagement in international or domestic markets
- Estimate the effect of diversification and coherence on plants' performance

Data and descriptive statistics

Data Description

- We use data from the DANE Annual Manufacturing Survey (EAM) that covers the universe of Colombian firms with more than 10 employees
- The data set includes information at the plant level:
  - Total production
  - Occupation
  - Labor productivity: defined as value added per worker
  - Age
  - Whether the plant is unique in the company or part of a multi-plant firm

Diversification and economies of scope

- Diversification is a process through which heterogeneous firms employ capabilities to produce different products or to enter different industries

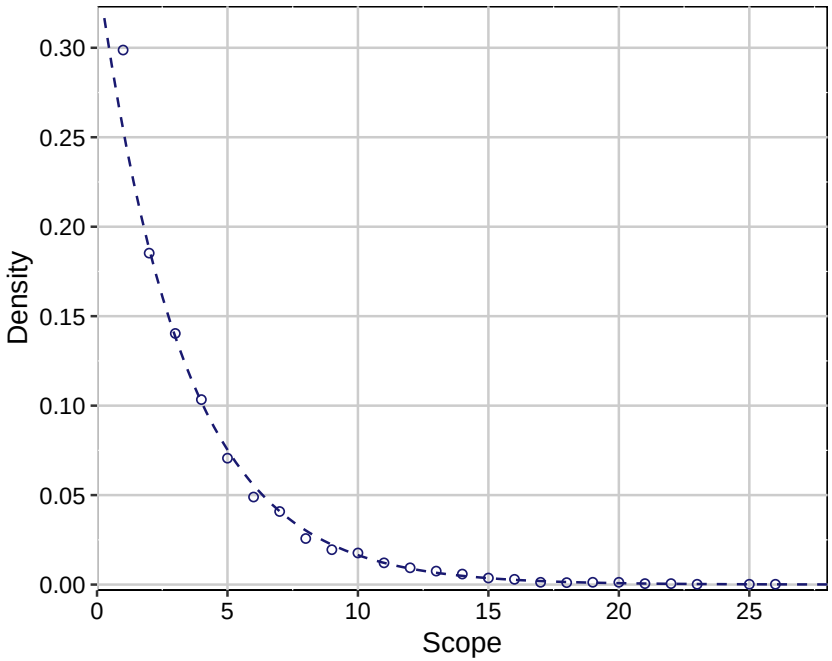
Evolutionary approach

- The existence of transaction costs, excess resources and the desire to achieve economies of scope can lead to diversification
- Diversification will depend on: firm specific capabilities that can be applied for different uses, firms' learning processes, the development of competences, complementary assets, technological opportunities, and the strength of competition in product and capital markets

Theoretical models of trade

- Facing trade liberalization, firms will: reduce the quantity of products that they export, intensify the volume of exports of a limited number of products, increase their market share on this reduced number of products

Distribution of Plants' Scope



- Plant scope is very skew: most firms are single products and very few are diversified in many products
- The distribution resembles an exponential distribution

Descriptive statistics in 2011

Single-product plants

- More than 1/3 produce a single product
- But they only produce 20.47%

	Year: 2011					
	No. Plants	Production		Employees		Labor productivity
Scope	%	%	Average	%	Average	Average (log)
Single-product	36.05	20.47	6.48	22.42	51.67	9.82
Multi-product	63.5	79.53	15.95	77.58	113.93	9.93
2 products	18.6	16.2	9.94	15.4	68.80	9.93
3 products	13.15	15.29	13.27	14.18	89.6	9.93
4 products	8.82	9.62	12.46	10.1	95.16	9.85
5 products	6.04	7.52	14.22	7.17	98.68	9.87
6-10 products	13.06	17.36	15.18	20.67	131.47	9.94
>10 products	4.28	13.55	36.1	10.07	195.23	10.07

Note: The average of production is in million of real Colombian pesos (1999 year of reference).

Product Relatedness

- Taking as input the $N \times K$ binary matrix M with entries m_{ik} taking a value of one when a plant i produces the product k

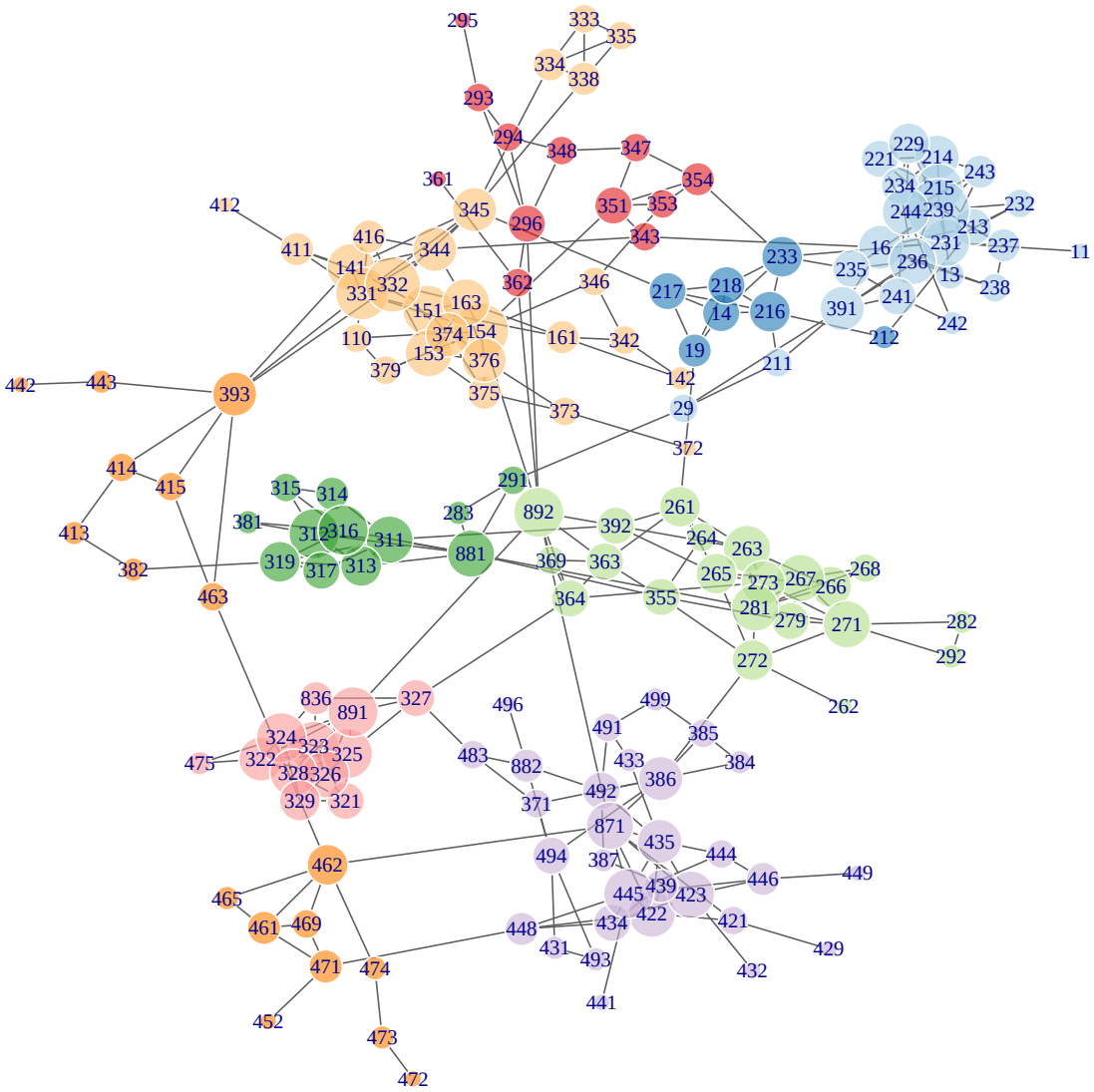
	k_1	k_2	k_3	k_4	k_5
f_1	1	1	1	0	0
f_2	1	0	1	0	1
f_3	0	1	0	1	1
f_4	1	0	1	1	0

- We use the proximity measure between products k and k' (Zaccaria et.al. 2014) defined as:

$$B_{kk'} = \frac{1}{\max(d_k, d_{k'})} \sum_i \frac{M_{ik} M_{ik'}}{d_i};$$

- Thus, relatedness between a pair of products derives from the fact that these two products are frequently produced together

Product relatedness - Product space at 3 digits of CPC (Clasificación Central de Productos)



- Product space of possible empirical trajectories
- Related with plants' capabilities and factor endowments
- Community detection: diversification is expected within the community

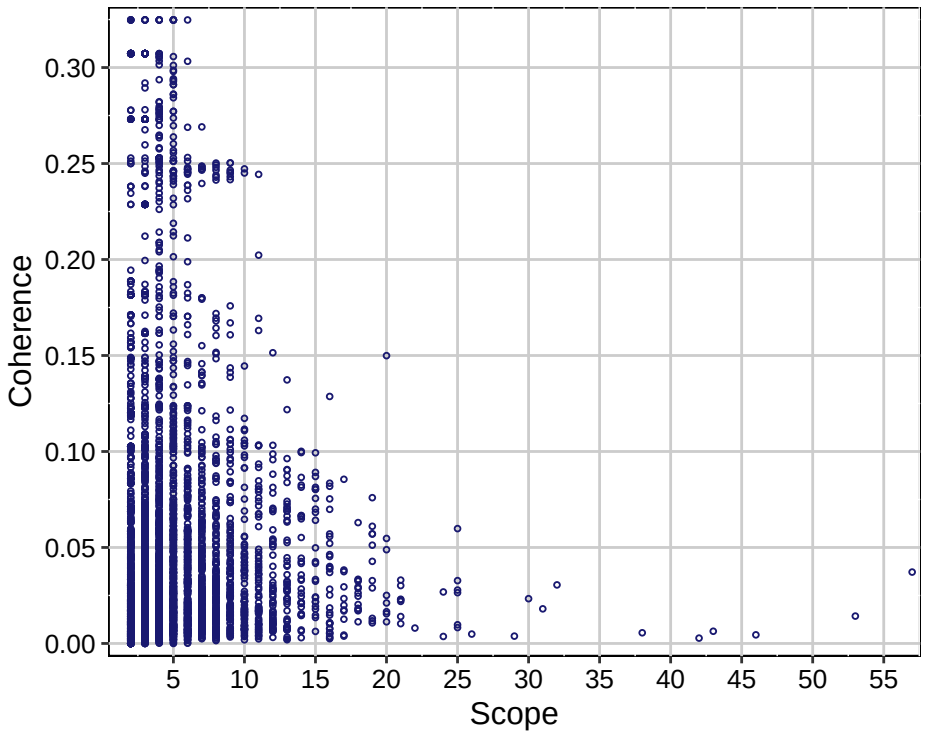
Coherence: plant level

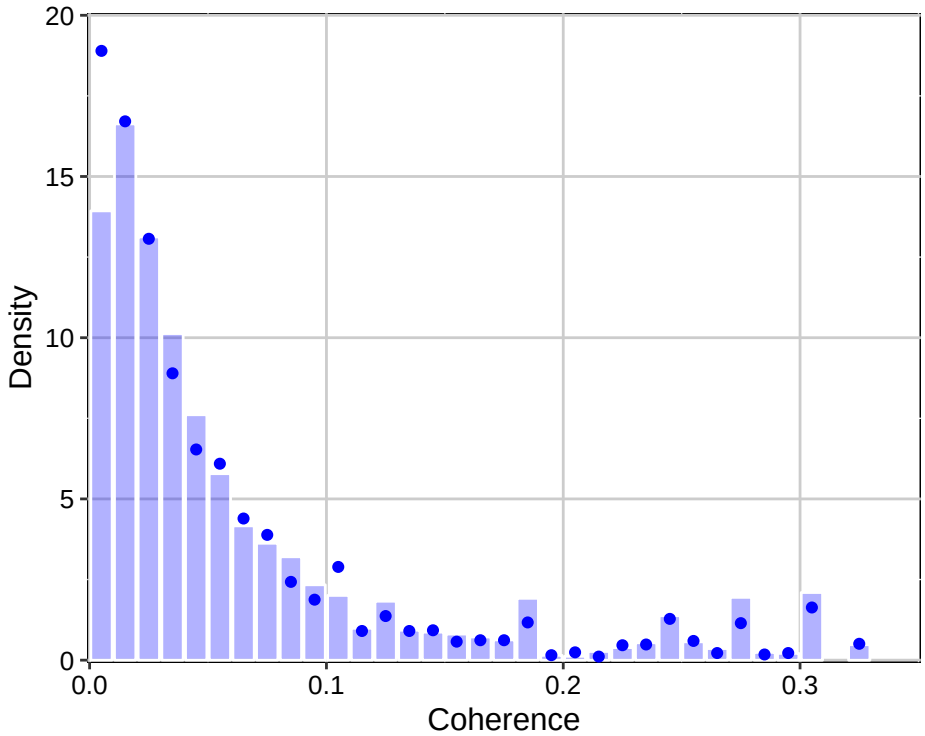
- The degree of relatedness between different products allows us to measure how coherent is the production of multi-product plants
- Defined as:

$$C_i = \frac{1}{\Gamma_i} \sum_{k \in \Omega_i} \sum_{k' \in \Omega_i} Q_{ik} Q_{ik'} B_{kk'}; \tag{1}$$

  where Q_{ik} is the production of product k by plant i, and the normalizing term $\Gamma_i = \sum_{k \in \Omega_i} \sum_{k' \neq k \in \Omega_i} Q_{ik} Q_{ik'}$
- $C_i \to 1$: a coherent plant produces a basket of products that are highly related: $B_{kk'} \to 1$
- $C_i \to 0$: less coherent when the plant produces a basket of low related products: $B_{kk'} \to 0$

Coherence





- Increasing diversification, less coherence
- But also, high heterogeneity at lower scope levels
- Most Colombian plants have low levels of coherence in their production baskets

Global market integration

- We consider different plants according to their engagement in markets:

Domestic market

d_home

Only import

d_imp

Only export

d_exp

Both export and import

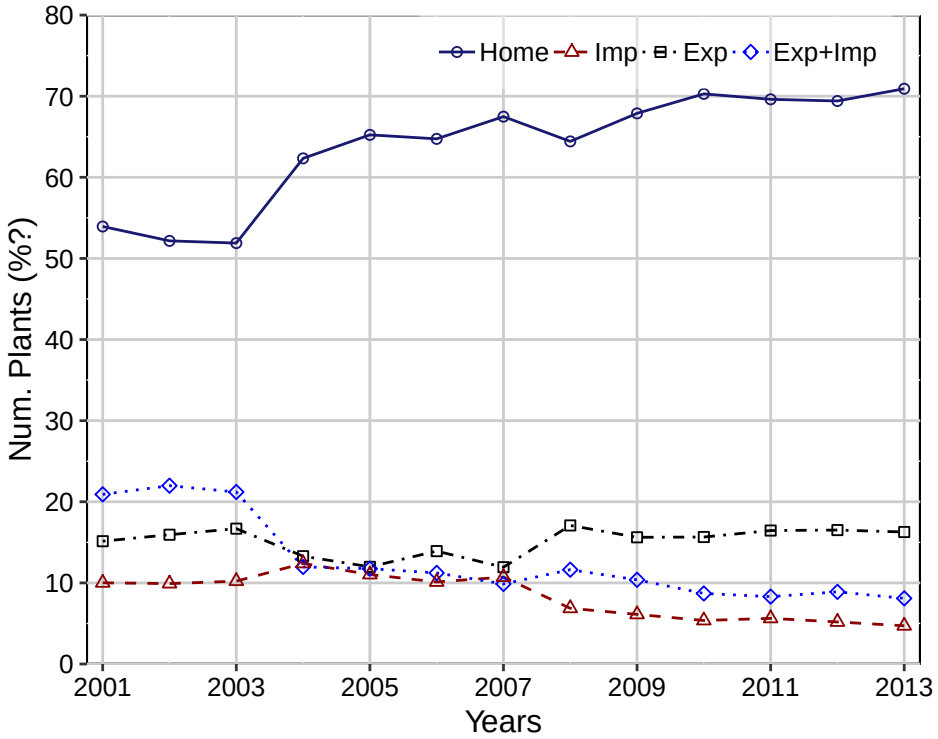
d_imex

Evidence

- Heterogeneity in the performance of the different groups of plants
- Most plants only operate in the domestic market
- But firms that are integrated to global markets have higher shares of production, are more productive, and have higher scope

Global market integration

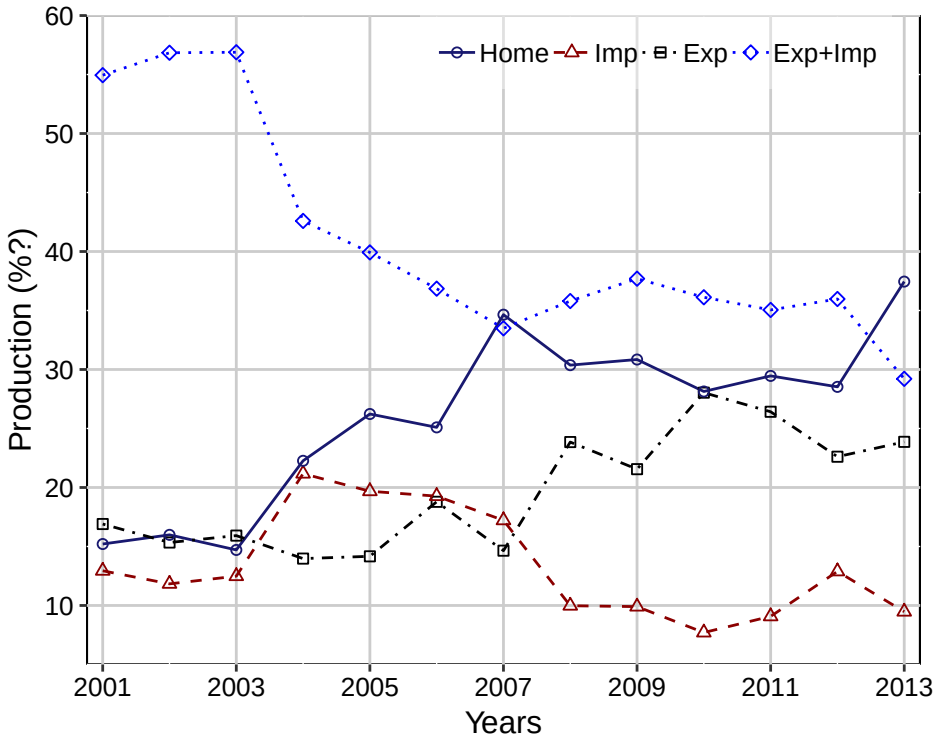
Number of firms



- Most plants only operate in the domestic market

Global market integration

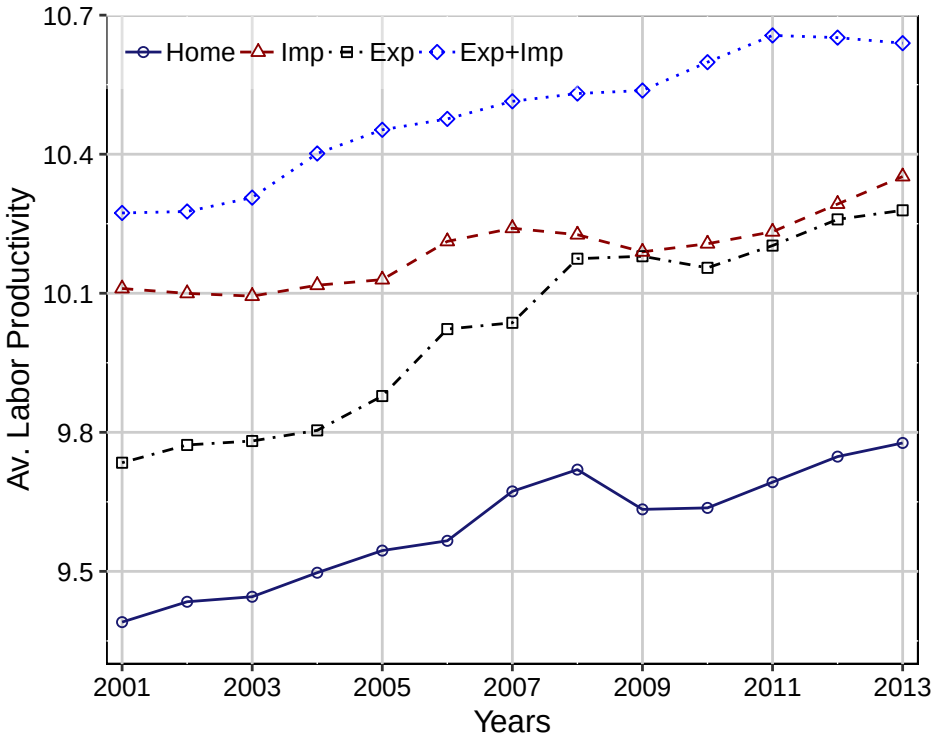
Production



- Plants that only operate in the domestic market show an increasing share in total production
- Plants that both import and export, although having a low share in the total number of plants, have the highest shares in total production (although it decreased)

Global market integration

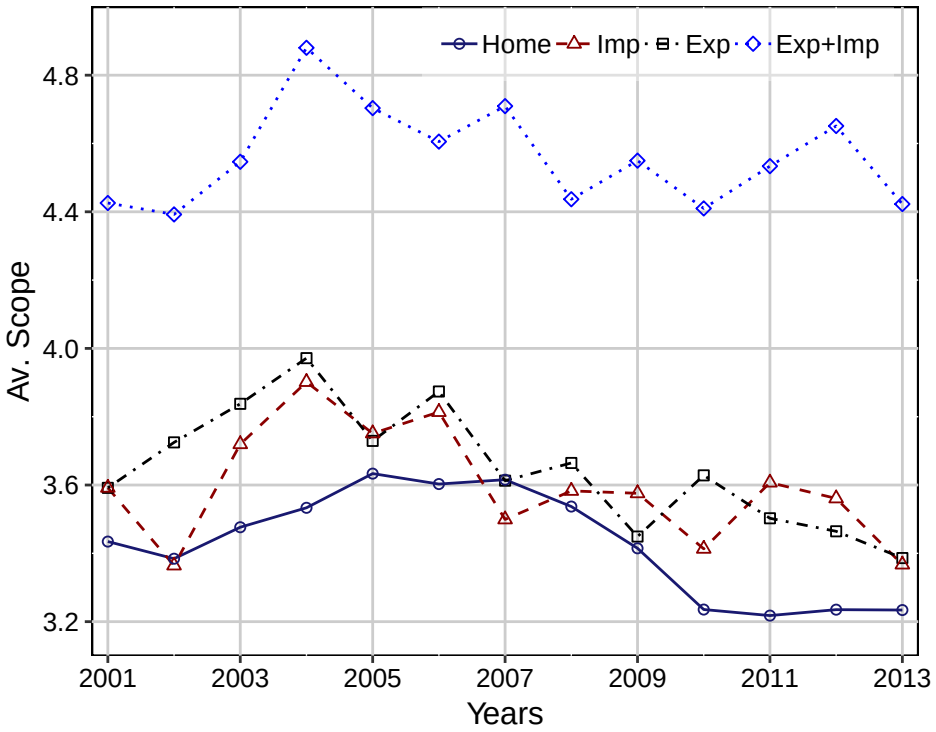
Labor productivity



- Plants that operate in global markets are more productive, especially those that both import and export

Global market integration

Scope



- Plants that import and export have much higher scope
- Plants in the domestic market specialize

Econometric estimations

Econometric Estimations

- Study the effect of diversification and coherence on:
  - productivity
  - productivity growth
- For firms with different types of engagement in external markets
- Including a set of control variables

Econometric Model: Productivity

Dynamic Panel

$$y_{i,t} = \alpha_i + \tau_t + \phi_1 y_{i,t-1} + \phi_2 y_{i,t-2} + \beta_l l_{i,t} + \beta_k k_{i,t} + \mathbf{D}'_{i,t}\theta + \xi n_{i,t} + \epsilon_{i,t};$$

Diff-GMM-estimation – important considerations

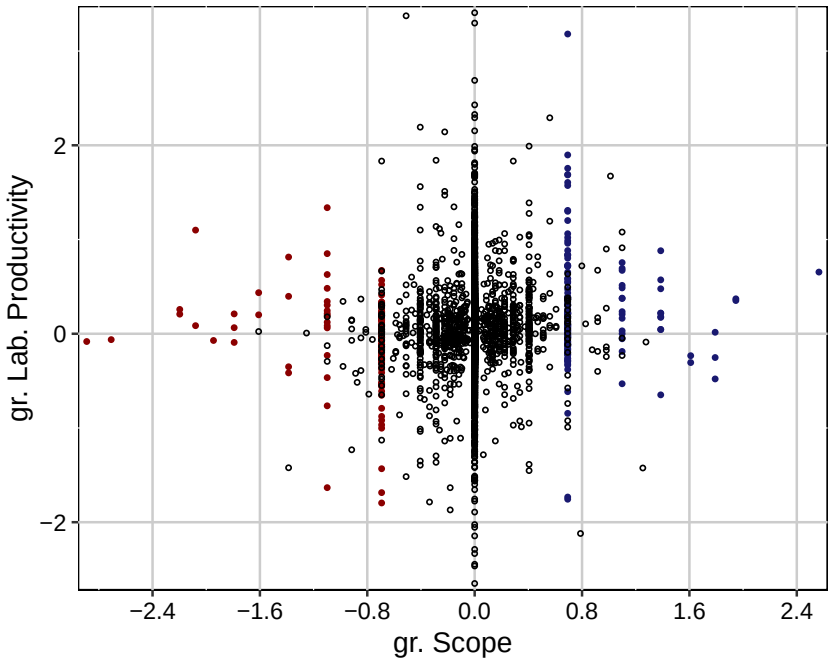
- Capital and labor are assumed endogenous (simultaneity)
- Number of products and global-market dummies are assumed predetermined (dependency with the past)

Productivity: Estimation Results

	Labor Productivity	
Model	(1)	(2)
d_imex	0.062**	0.061**
	(0.024)	(0.024)
d_expo	0.058***	0.059***
	(0.021)	(0.020)
d_impo	0.016	0.017
	(0.022)	(0.022)
log_scope		0.087
		(0.056)
log_capital	0.070	0.036
	(0.106)	(0.104)
log_labor	-0.425***	-0.436***
	(0.132)	(0.132)
$\Delta y_{i,t-1}$	0.321***	0.321***
	(0.027)	(0.027)
$\Delta y_{i,t-2}$	0.037***	0.036***
	(0.012)	(0.012)
Constant	6.505***	7.204***
	(2.481)	(2.414)

- More integrated plants are more productive and have higher average production per product (expected)
- No relationship between diversification and labor productivity
- (Expected) relationship between average production per product and scope

Econometric Model: Productivity growth



- Changes in scope do not seem strongly associated with productivity growth

Dynamic Panel

$$\Delta y_{i,t} = \alpha_i + \phi_1 \Delta y_{i,t-1} + \phi_2 \Delta y_{i,t-2} + \beta_l l_{i,t-1} + \mathbf{D}'_{i,t}\theta + \xi \Delta n_{i,t} + c_{i,t-1}\beta + \epsilon_{i,t};$$

Estimation Results: Performance

Model	Growth Labor Productivity		
d_imex	0.101***	0.116***	0.076**
	(0.032)	(0.033)	(0.039)
d_expo	0.083***	0.088***	0.072**
	(0.027)	(0.028)	(0.034)
d_impo	0.073***	0.059**	0.071**
	(0.028)	(0.029)	(0.035)
$\Delta n_{i,t}$	-0.205		
	(0.144)		
$\Delta n_{i,t}$d_imex		-0.473	
		(0.336)	
$\Delta n_{i,t}$d_expo		-0.017	
		(0.402)	
$\Delta n_{i,t}$d_impo		1.104*	
		(0.605)	
$\Delta n_{i,t}$d_home		-0.366*	
		(0.215)	
$c_{i,t-1}$			0.380*
			(0.198)
log_labor(t-1)	0.277***	0.292***	0.309***
	(0.087)	(0.089)	(0.114)
log_age	-0.275***	-0.274***	-0.310***
	(0.042)	(0.041)	(0.059)
$\Delta y_{i,t-1}$	-0.261***	-0.261***	-0.252***
	(0.013)	(0.013)	(0.015)
$\Delta y_{i,t-2}$	-0.082***	-0.083***	-0.072***
	(0.011)	(0.011)	(0.013)
Constant	-0.234	-0.3	1.021
	(0.328)	(0.332)	(0.815)
Observations	41771	41771	25950
Number of plants	6390	6390	4171

- More integrated plants have higher rates of labor productivity
- Changes in the number of products seem to have no impact on labor productivity. However:
  - negative effect for plants operating in local market
  - positive for plants buying inputs abroad
- Coherent plants have higher labor productivity rates

Preliminary Conclusions

Heterogeneous patterns of plants dynamics

- Colombian plants have heterogeneous features and performances
- We observe some regularities in plants according to their engagement in global markets
- Most plants only operate in the domestic market and show an increasing share in total production. But these plants are also less productive and have low scope, compared to all other plant types
- Conversely, plants that both import and export, although having a low share in the total number of plants, have the highest shares in total production, are the most productive ones, and have much higher scope. Also, plants that only import or export

Preliminary Conclusions

Econometrics, Dynamic Panel

- Firms that are more integrated to external markets perform better compared to domestic firms
- Diversification does not affect productivity but this is not surprising considering the low level of coherence of product baskets
- More coherent firms in the diversification patterns are more productive
- The evidence militates in favor a cor-competence organization of plants

Thank You!