

A characterization of Colombian industries under Schumpeter's patterns of innovation

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Table of Contents



1. Introduction and setup
2. Theory and Literature
3. Methodology
4. The Cluster
5. Implications
6. Conclusions

Table of Contents



1. Introduction and setup

2. Theory and Literature

3. Methodology

4. The Cluster

5. Implications

6. Conclusions

Introduction

- ▶ The question I will answer today is **Who drives innovation within an industry?**.
- ▶ I will use Schumpeterian patterns of innovation: **Mark I** and **Mark II**.
- ▶ Characterization exercises "*have been standing the test of time quite well*" (Fontana et al., 2012). **But they are missing in some countries.**
- ▶ I will do it for Colombia, using a cluster algorithm with three indicators commonly used in the literature.
- ▶ **Data sources:** EDIT and EAM surveys (2018). Both **spatial** and **numeric** variables are of interest.

Objectives



Main objective: characterize Colombian industries within the manufacturing sectors as Mark I or Mark II industries.

- ▶ **Combine information** from EAM and EDIT
- ▶ **Construct quantitative analysis** at the firm level
- ▶ **Group industries** through a cluster algorithm
- ▶ **Inquire** on potential policy implications, based on both spatial and numeric results

Table of Contents



1. Introduction and setup
2. Theory and Literature
3. Methodology
4. The Cluster
5. Implications
6. Conclusions

Innovation



The concept of innovation:

- ▶ ***"New or improved product or process (or a combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)"*** OECD (2018, p.20)
- ▶ Innovative activities: Activities to reach innovation

Market Structure and Innovation

Mark I

- ▶ Small firms are the drivers of innovation (Schumpeter, 1911).
- ▶ Perfect competition, **radical** innovations... something new (Schumpeter, 1942)

Mark II

- ▶ Large firms are the drivers of innovation (Schumpeter, 1942).
- ▶ Monopoly/Oligopoly, **incremental** innovations... enhancements of existing elements (Kirzner, 1973)

(Later on, we will see how to measure this)

Market Structure and Innovation



Backend of these marks:

- ▶ Fontana et al. (2012): Turbulence vs Stability
- ▶ Arrow replacement effect (1962)
- ▶ Baumol proposition (2004)
- ▶ Gilbert (2006) incentives to innovate based on potential profits
- ▶ Shapiro's revisit (2012): Unifying principle... **competition**

Innovation systems



- ▶ A set of interactions that foster, create, transform and diffuse knowledge on a specific territory (Nelson, 1993)
- ▶ **National** Innovation Systems (Nelson, 1993) *NSI*
- ▶ **Sectoral** Innovation Systems (Malerba, 2002;2003;2005) *SSI*
- ▶ **Regional** Innovation Systems (Asheim and Gertler, 2006) *RSI*
- ▶ Then, countries are heterogeneous at a regional and sectorial level. Differentiated approaches needed.
- ▶ Concepts of interest: Institutionalism, spatial economics, agglomeration
- ▶ The literature focus is NSI, this article will be at an RSI level

Literature



- ▶ **Market structure as a determinant of innovation** (Loury, 1979; Mansfield, 1963; Raider, 1998)
- ▶ **Previous characterizations:** Malerba and Orsenigo (1996), Breschi et al. (2000), Landström & Schön (2010), Castellaci and Zheng (2010), Corrocher et al. (2007).
- ▶ **Pavitt's alternative** based on **Kondratiev waves** (Archibugi, 2001). **Is it useful?**

Colombia's case



A periphery economy: Pavitt's approach is not suitable

- ▶ Dependence Theory (Ahiakpor, 1985)
- ▶ Empirical evidence sustaining Prebisch-Singer hypothesis (Arezki et al., 2013)
- ▶ Flows of low/high added value goods
- ▶ A lot of weight on commodities and first gen manufactures
- ▶ Innovation in Colombia: firm, industry, domestic market levels

Table of Contents



1. Introduction and setup
2. Theory and Literature
3. Methodology
4. The Cluster
5. Implications
6. Conclusions

Data sources



- ▶ Cross-section, inner join of 2018 **EAM** and manufacture **EDIT**.
- ▶ EAM is a census of firms with > 10 employees or 517 million pesos in sales. EDIT samples EAM sectors and follows OECD guidelines.
- ▶ Small firms and the informal economy are excluded.
- ▶ Each firm has a "Numero de Orden" (NORDEMP) for identification, and an "ID Departamental" (DIVIPOLA) for spatial analysis.

Initial **n = 6405**

Dimensions

Concentration (*CON*):

- ▶ Malerba and Orsenigo (1996)
- ▶ H-H Concentration Index of Market Share of output, innovative activities, labour demand and supply
- ▶ Geometrical mean to smooth values

$$CON = (HH_{ms} * HH_{msa} * HH_{lsd} * HH_{ss})^{1/4} \quad (1)$$

Dimensions

Technological Opportunities (TO)

- ▶ Maleki et al. (2018)
- ▶ Relative change of protection mechanisms
- ▶ Conventional and non-conventional, so we see the larger picture

$$TO = \frac{PM_{1718} + NCPM_{1718}}{PM} \quad (2)$$

Dimensions

Stability (*STA*)

- ▶ The dynamic problem. **EDIT is non comparable**
- ▶ Thus, we need another approach. A static approach
- ▶ Based on Baumol (2004) proposition

$$STA = S_r - S_i \quad (3)$$

Table of Contents



1. Introduction and setup
2. Theory and Literature
3. Methodology
4. The Cluster
5. Implications
6. Conclusions

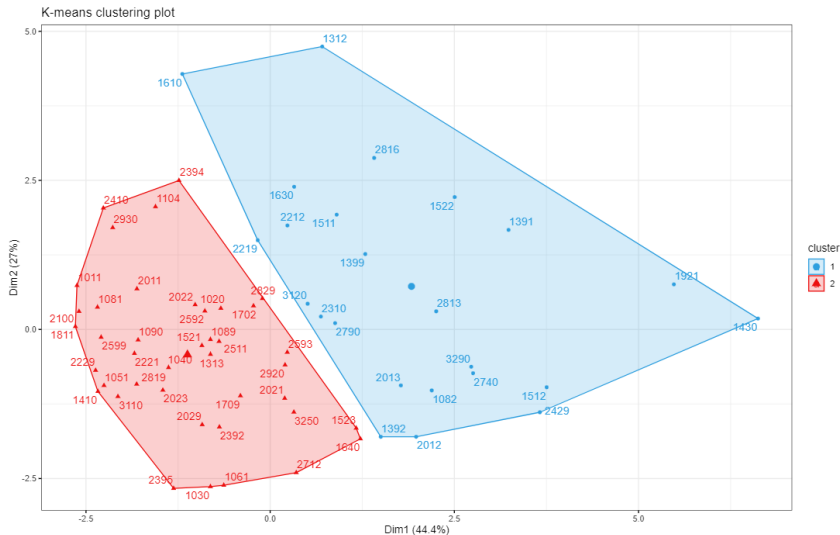
Warming up



- ▶ Some data limitations → Data availability
- ▶ Some industries report zero innovation spending, or have a small amount of firms
- ▶ Filter for industries with less than 20 firms. Resulting **n = 5986**

k-means cluster: Lloyd algorithm, 10 repetitions, standardized euclid distance with low ρ between measures ($< |0.1|$)

Figure: Preliminary characterization of Colombian Manufacture using a two groups k-means clustering method

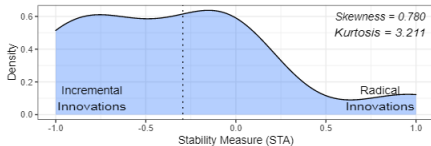


Results

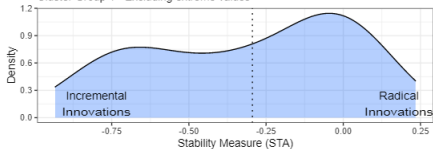


- ▶ Dim1 and Dim2
- ▶ Two groups: Cluster Group 1 (CG1) and Cluster Group 2 (CG2)
 - ▶ **CG1** → $n = 794$
 - ▶ **CG2** → $n = 5192$

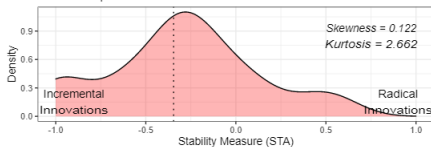
Density of the Stability Measure
Cluster Group 1



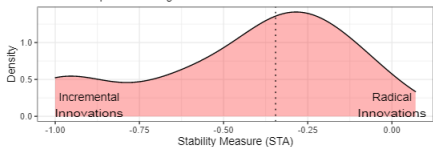
Density of the Stability Measure
Cluster Group 1 - Excluding extreme values



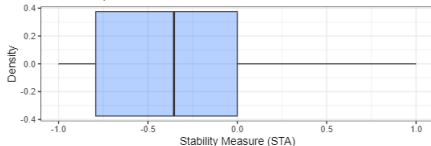
Density of the Stability Measure
Cluster Group 2



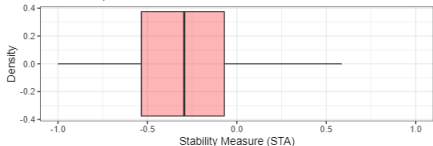
Density of the Stability Measure
Cluster Group 2 - Excluding extreme values



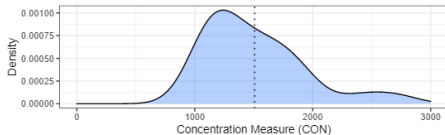
Boxplot of the Stability Measure
Cluster Group 1



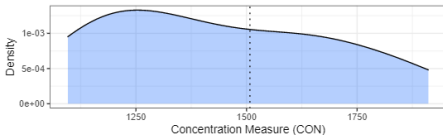
Boxplot of the Stability Measure
Cluster Group 2



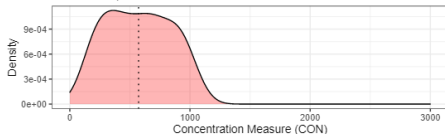
Density of the Concentration Measure
Cluster Group 1



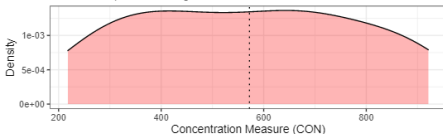
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Cluster Group 1 - Excluding extreme values



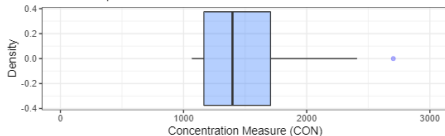
Density of the Concentration Measure
Cluster Group 2



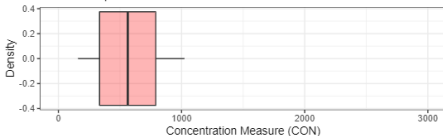
Density of the Concentration Measure
Cluster Group 2 - Excluding extreme values



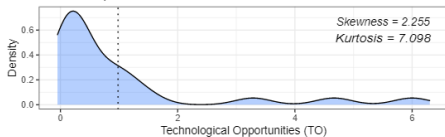
Boxplot of the Concentration Measure
Cluster Group 1



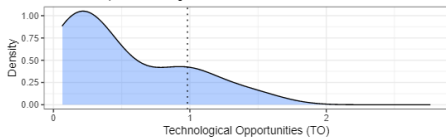
Boxplot of the Concentration Measure
Cluster Group 2



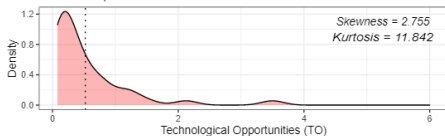
Density of the Technological Opportunities measure
Cluster Group 1



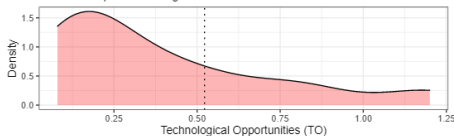
Density of the Technological Opportunities measure
Cluster Group 1 - Excluding extreme values



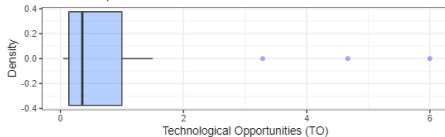
Density of the Technological Opportunities Measure
Cluster Group 2



Density of the Technological Opportunities Measure
Cluster Group 2 - Excluding extreme values



Boxplot of the Technological Opportunities Measure
Cluster Group 1



Boxplot of the Technological Opportunities Measure
Cluster Group 2

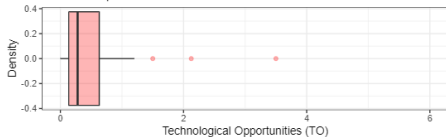


Table of Contents



1. Introduction and setup
2. Theory and Literature
3. Methodology
4. The Cluster
5. Implications
6. Conclusions

General Implications



The most important implication:

- ▶ **Red cluster** (CG2): Mark I industries, small firms drive innovation
- ▶ **Blue cluster** (CG1): Mark II industries, large firms drive innovation

Sectoral trends



Several implications for certain segments:

- ▶ **Groceries, meat, coffee**: Mark I. **Exception** in **Chocolates**. (*Nutresa?*)
- ▶ **First-gen manufacture**: Mark II. **Exception** in **Elaboration and finishing of clothing**
- ▶ **Petroleum**: Mark II (*Ecopetrol?*)
- ▶ **Furnitures and wood products**: Mixed results
- ▶ **Metals and minerals**: Mixed results, but more complex minerals/metals as Mark II

Spatial distribution



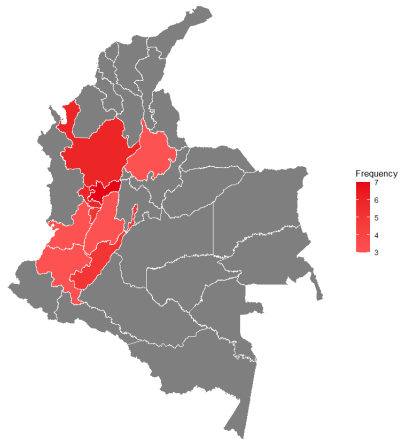
- ▶ The article has +20 maps!
- ▶ **Main finding:** Centre-periphery scheme. Central Andean persists, Cauca follows. The Caribbean falls behind.
- ▶ **Antioquia** as the leader. **Historical factors seem to persist** (Luzardo-Luna, 2019)
- ▶ **Mark II** industries are less disperse in the territory than **Mark I**
- ▶ **Institutionality**, **transport** access, **resource** availability and **urban** centres act as determinants of localization
- ▶ Yes, airports and roads are important. Magdalena navigation is also crucial, but...

Spatial distribution

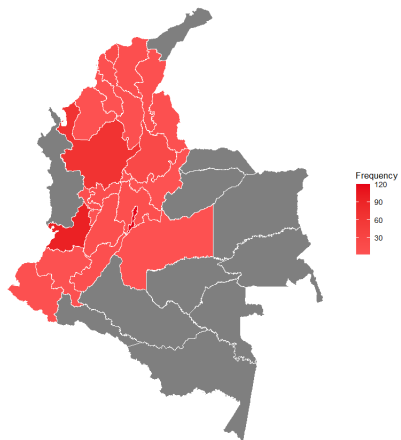


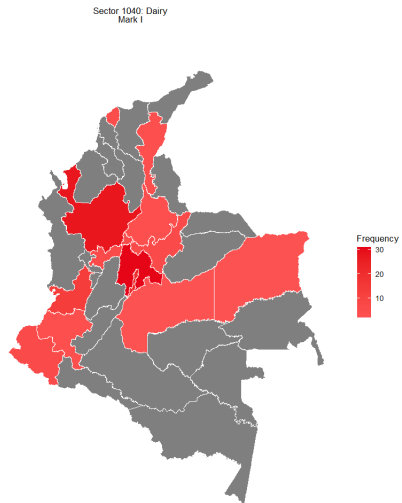
- ▶ **Institutionality seems to be the deciding factor**
- ▶ Where will the rule of law be enforced?
- ▶ Why no industries in southern Colombia? Access to **transport** and **institutionality**
- ▶ Why departments like Sucre, Cordoba or Cesar have little to no agglomerations? **Institutionality** and **human capital**
- ▶ So... **not one size fits all** in this matter.

Sector 1061: Coffee products
Mark I

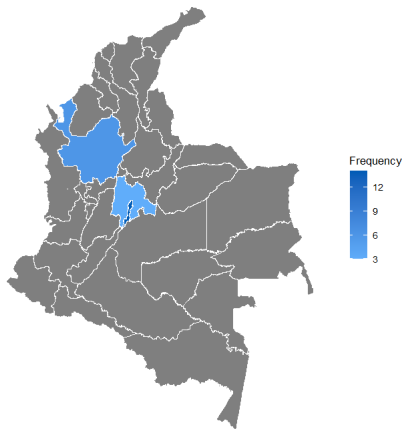


Sector 1081: Bread and related
Mark I

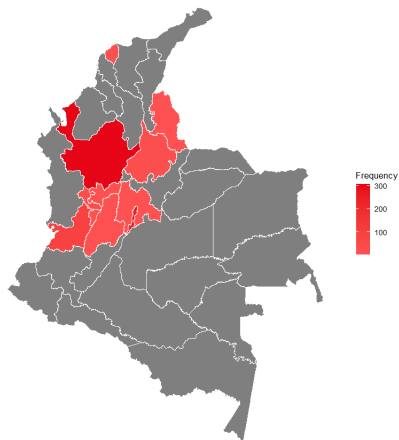




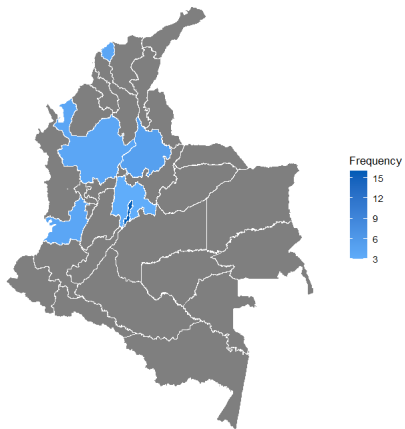
Sector 1312: Elaboration of textiles
Mark II



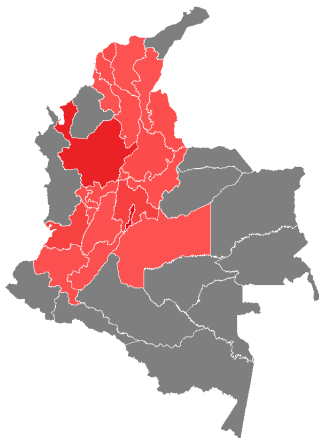
Sector 1410: Elaboration of wearing apparel
Mark I



Sector 1921: Petroleum refining
Mark II



Ferrous Metals and minerals for construction and foundries
(Selected industries) - Mark I



Sector 2429: Non-ferrous metals and other minerals
Mark II

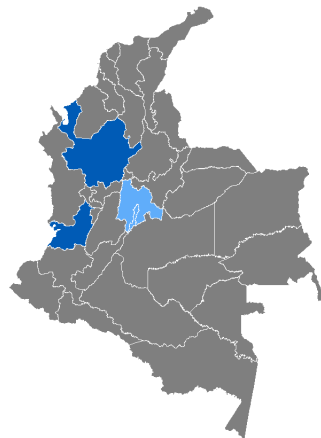


Table of Contents



1. Introduction and setup
2. Theory and Literature
3. Methodology
4. The Cluster
5. Implications
6. Conclusions

Conclusions

Some broad conclusions:

- ▶ We have been able to characterize Colombian industries
- ▶ we found what type of firm drives innovation on each industry. **CG1** has been labeled as **Mark II**. **CG2**, the densest group, gravitates toward **Mark I**.
- ▶ Measures are consistent to what was exposed in the theory and literature. Similarly, results echo with previous works.
- ▶ Intra-sectorial trends and geographical aspects are important for policy elaboration.
- ▶ Spatial distributions shows that **Mark I** industries are more disperse in the territory than **Mark II** ones

Conclusions

- ▶ Policy recommendations agree on the need for heterogeneity in design, echoing with what was said about innovation systems.
- ▶ In other words, incentive architectures and other policy measures should acknowledge differences in geography, institutions, transport access, human capital, among others
- ▶ Where to channel all of this? MinCiencia's **PEDCTI** report
- ▶ The way forward... Econometric models, dynamic models, groundwork for policy-making