UNIVERSIDAD DE BOGOTÁ
JORGE TADEO LOZANO

LA TADEO, DONDE LA CIENCIA Y EL ARTE SE ENCUENTRAN

FACULTAD DE CIENCIAS ECONÓMICAS Y ADMINISTRATIVAS
Grupo de Investigación RAET
Red RAET de Universidades

On a methodology for measuring innovation in agricultural firms

Cesar Ariza
Laura Rugeles
Diana Saavedra
Bladimir Guaitero

9th International Conference on Intellectual Capital, Knowledge Management and Organisational Learning

Universidad del Rosario and Universidad Jorge Tadeo Lozano
Bogotá, D.C., 18-19 October 2012

Motivation

- Agriculture, strategic sector:
  - Food security and food safety
  - Bioenergy production and other industries
  - Custody of natural resources

  (World bank 2008a, 2008b; CAF 2006; Londoño 1985; Rugeles 1986; among others).

- Colombia: Overcome major constraints toward modern agriculture.

- Current state: in general, informal economies and low levels of technology, predominance of small productive units.

- Agriculture: fourth economic activity within Colombian GDP, but second place for agriculture & agroindustry (12.5% of GDP).

- Annual growth in the long run has lagged, (Kalmanovitz 2010), particularly in 2009 -2010 (-0.7% and 1.0%).

Motivation

- RAET research group: agribusiness firms and territorial features.
- Current research : agricultural firms in six subsectors and five territories in Colombia (2009-2012) .
- Main objective: examining structure and nature of transactional models of agribusiness and their influence in innovation processes in order to offer key elements towards policy design and innovation management.
- Main difficulty: how to measure innovation in agriculture?
- Agriculture features: biological origin (uncertainty), both supply and client dominated, tropics

Motivation

- This presentation summarizes the methodological tools developed to overcome this difficulty.

- Methodology for measuring innovation in agribusiness firms, built upon two new tools:

  - Innovation matrix
  - Innovation index

Outline

- ✓ Motivation
- ✓ Literature review
- ✓ Innovation Matrix
- ✓ Innovation Index
- ✓ Applications: econometric model to study innovation in agricultural firms
- ✓ Conclusions

Previous research

- Two main types of econometric models.
- Probit (or Logit) models (Avermaete, et al. 2003).
- Ordered Logit models (Nossal & Lim 2011).
- Both families have similarities in their methodology.

A common framework

1. Compile information about presence of types of innovation (varying degrees).

2. Classification system for innovation: Oslo Manual (OECD, European Commission & Eurostat 2005) and Bogotá Manual (Jaramillo, Lugones & Salazar 2001). Focus may differ, rupture level of the innovations (radical and non-radical innovations respectively), type of innovation (product, process, etc). Subgroups may be defined.

3. Classifiying observed innovation activities.

4. Computation of the degree of innovation for every firm. Different models, different rules of computation (weighted average, simple count, thresholds, etc).

Some differences

- Main difference in the 4th point.
- Probit/Logit: discrete measure with 1 and 0 values.
- Ordered Logit: discrete and ranked ordinal values (higher values to firms with better innovation performance).
- Exogenous variables depending on the goals of the researcher
- Examples: features of the firms, (e.g. their size), leaders (e.g. education, etc.), integration to innovation or entrepreneurial networks, aspects of economic sector (size, nature of clients), and regional and sectorial features.

Some shortcomings

- Both methodologies present a degree of arbitrariness.
- Logit/Probit: threshold to decide 1 and 0 values.
- Ordered Logit: final rank of a given firm depends on the rules to assign such rank.
- Main shortcoming: do not taking into account two properties of innovations.
  - Different location in the technological spectrum
  - Different location in the frequency domain

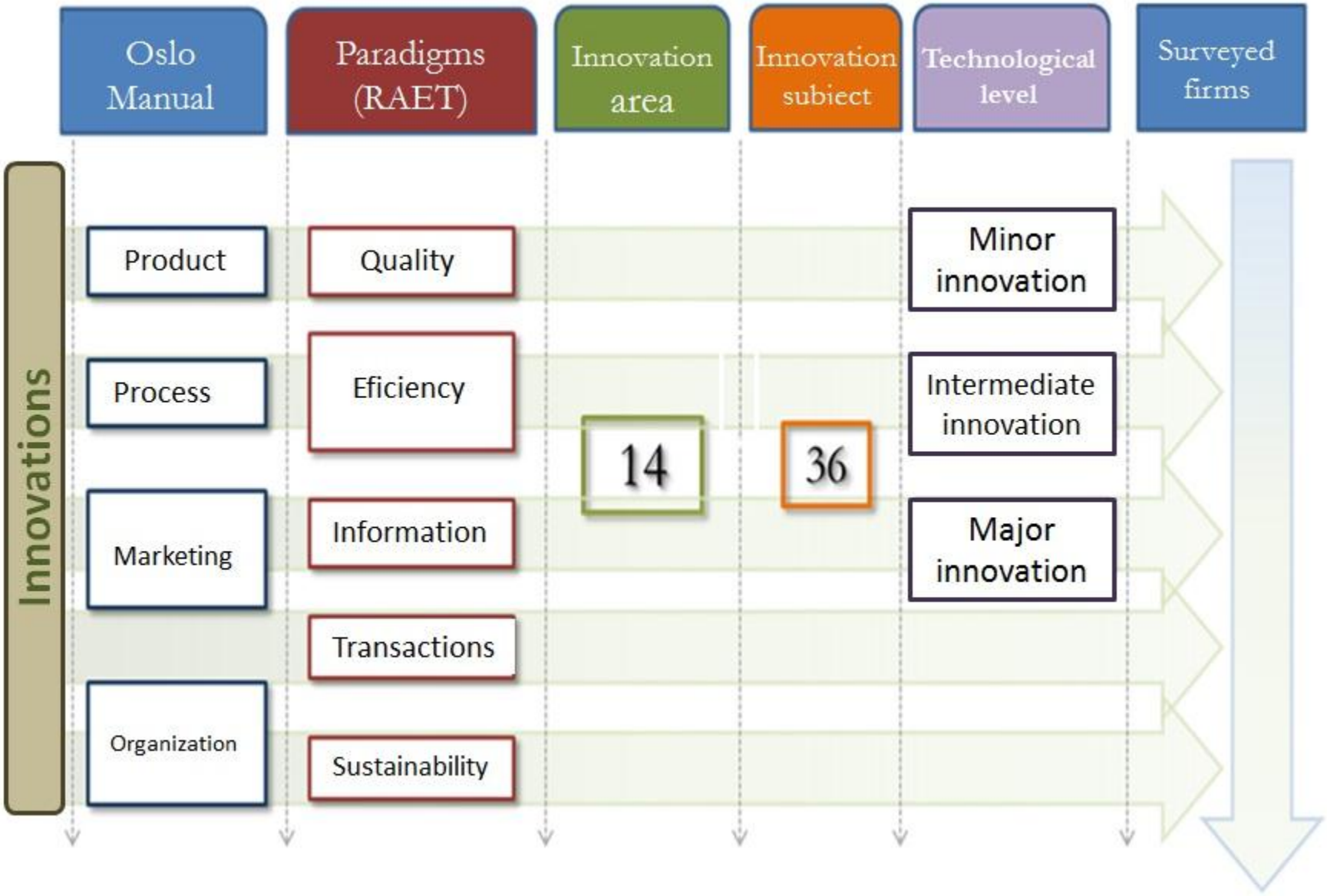
Innovation Matrix

- Our methodology resembles the previous one, with some differences.
- List of innovations: Innovation Matrix.
- Innovation: any change (new or relatively improved) within the firm realm, not necessarily new for its competitors, territory or the world (World Bank, 2008).
- Innovation Matrix is subsector (chain) specific.

Building the Innovation Matrix

- Inputs: surveys, technical or legal recommendations, suggestions of experts.
- Innovation Matrix allows several views: Oslo Manual, technological areas and subjects, paradigms (RAET).
- Technological level: our main point of view.
- Innovations differ from a qualitative point of view.

Different views



Technological level of innovations

- Innovations closest to the technological frontier (advanced technological level): ***major innovations***.
- Innovations mainly implemented by technologically "laggards" firms (Diederen, et al. 2003). Basic technological level: ***minor innovations***.
- Average technological level in a certain aspect (incremental positive changes for the firm): ***intermediate innovations***.
- Based on criteria by experts.

Frequency of innovations

- Frequency analysis.
- Rare innovations, implemented by a handful of firms.
- Popular innovations: huge diffusion.
- No correlation between the two domains of analysis: a synthesis may be achieved.

Innovation Index

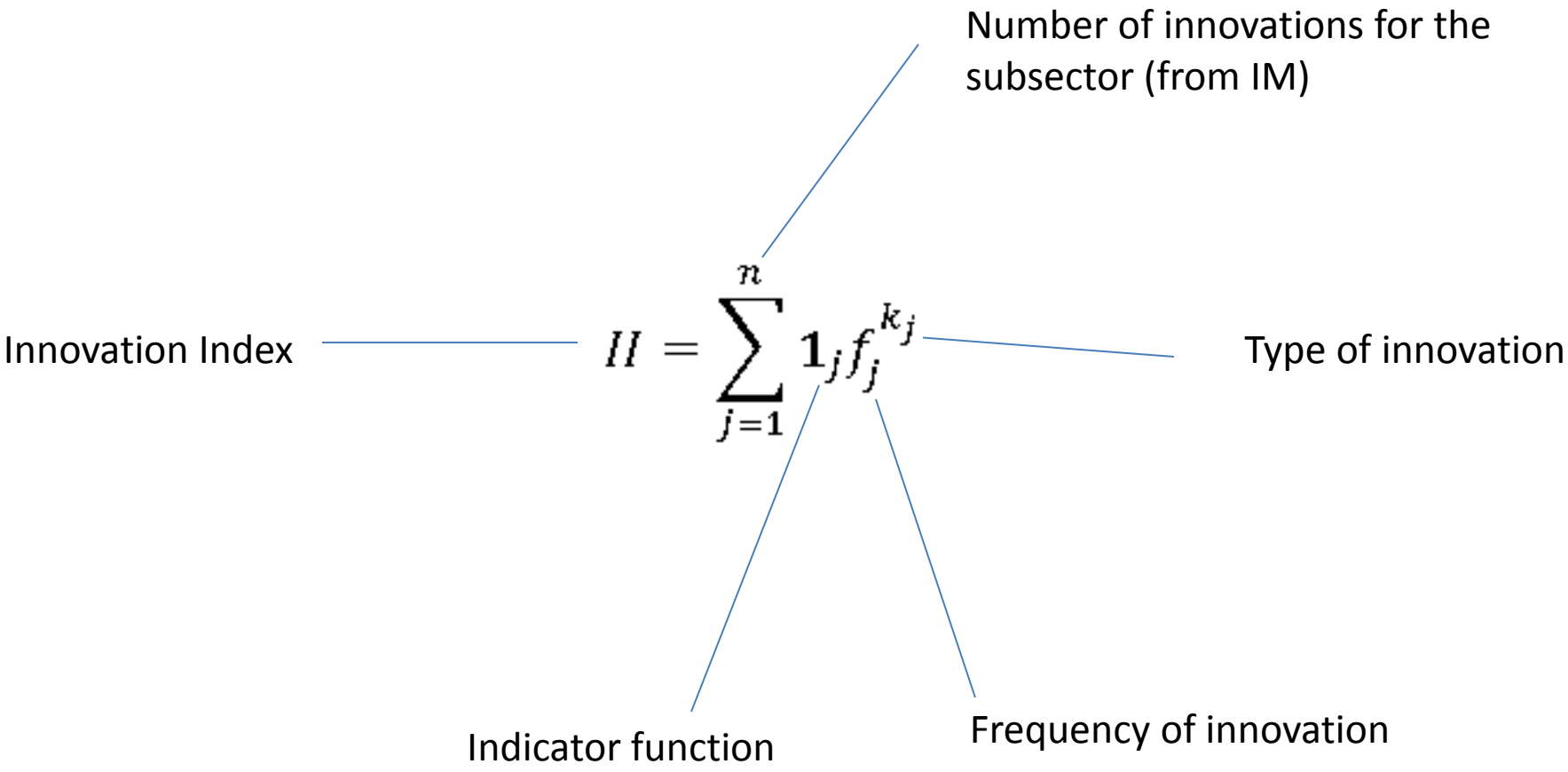
- Index: Single numerical value that summarizes information.
- Our information: technological level and frequency of innovations.
- Some rules: assign higher values to rare and technological advanced innovations.
- Some rules: assign lower values to common and not very advanced innovations.

Summarizing information

- Frequency and technology level may be seen as two axes of a plane.

- Innovation index: summarizes information of the two axes.

Innovation Index: Definition



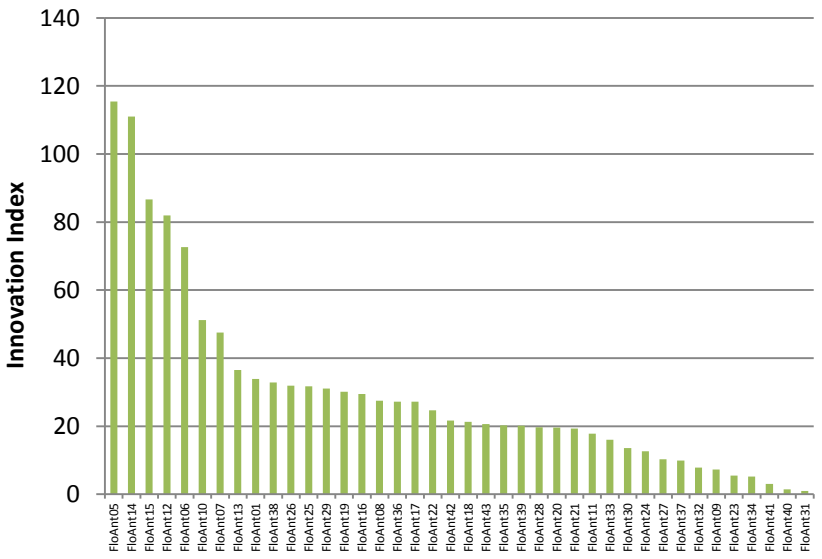
Innovation Index

- Type of innovation defined by a number: major innovations (-1), intermediate (-1/2) and minor (0).
- Rare and major innovations: highest contribution to *II*.
- Minor innovation: contribution of 1 to *II.*
- Every innovation: incremental value, there are not negative innovations.

Innovation Index: results

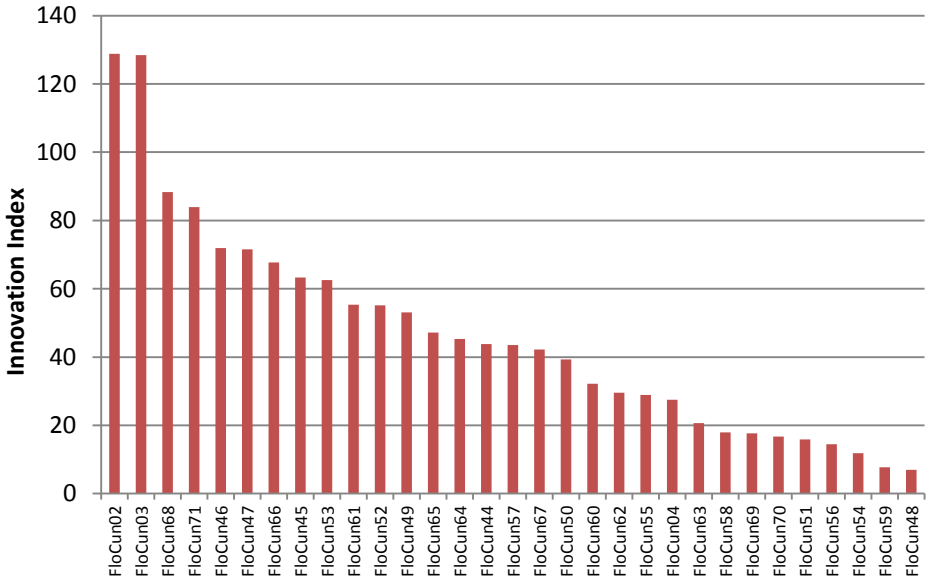
Subsector: flowers

ANTIOQUIA



Average: 30.1
Max. value: 115.45
Min. Value: 1.00

CUNDINAMARCA



Average: 46.42
Max. Value: 128.82
Min. Value: 6.98

Mathematical Properties of *II*

- Minimum value of *II* is 0.

- Maximum value of *II:* a single firm is the only one that implements all possible innovations:

$$II = \sum_{j=1}^{n_1} p^0 + \sum_{j=n_1+1}^{n_1+n_2} p^{\frac{1}{2}} + \sum_{j=n_1+n_2+1}^{n} p$$

$$= n_1 + n_2 p^{\frac{1}{2}} + n_3 p$$

- If all innovations are major: $II_{max} = np$

Further properties of II

- *II* is continuous within the range.
- *II* is dynamic: five years window of observation.
- *II* is a random variable, such as a Consumer Price Index (CPI).

Applications: an econometric model for the innovation

- We present results for 4 out of 6 subsectors analyzed.
- Dependent variable is *II*, since it is continuous a linear regression can be used.
- Key exogenous variable: transactional model used by the firm.
- Controls: nature of the firm, its leader and those that capture their relation to innovation system.
- Key assumptions tested: functional form, heteroscedasticity, normality.

The survey and its features

Number of questions: 75

Type: face to face

Time to complete the survey: 2:30 hours

Who did make it?: group members + experts/subsector

Duration : 12 months

Time frame of observation : 5 years

40 surveys (aprox.) subsector/territory

Random stratified sampling (transactional models).

Our model

$$\log(II) = X\beta + u$$

- where *log* is the natural logarithm of the innovation index *II*, *u* is the disturbance, *X* is a matrix that summarizes all exogenous (explanatory) variables, and β is a vector with the parameters of the model. The estimates *b* represent semi-elasticities of the innovation with respect to the exogenous variables.

Exogenous variables

- Region
- Transactional model
- Scale of Production
- PARTI : Integration to research networks
- VIF: Integration to other firms in the subsector
- R&D
- Education level of the leader
- Age of leader
- Experience of leader

Some results

Variable	Cut Flowers	Palm Oil	Potato	Pork Meat
Constant	1.879961 [0.0000]	2.476425 [0.0000]	2.160563 [0.0000]	3.478122 [0.0000]
Region	0.563451 [0.0037]	—	0.54239 [0.0049]	—
Business Model 2	—	0.782182 [0.0002]	0.474906 [0.0161]	—
Business Model 3	0.401043 [0.0409]	0.709593 [0.0003]	—	0.798013 [0.0008]
Business Model 4	0.780057 [0.0015]	—	—	0.544716 [0.0014]
Scale of production	—	0.000027 [0.0476]	0.000121 [0.0000]	—
PARTI	0.228626 [0.0007]	0.148039 [0.0119]	0.25903 [0.0038]	0.174707 [0.0168]
R&D	0.337052 [0.0434]	0.356451 [0.0523]	—	—
Basic Education	-2.036604 [0.0000]	—	—	—
Technological Oriented Education	0.801274 [0.002]	—	—	—
High School Education	—	—	—	-0.908015 [0.0031]
Postgraduate Education	—	—	1.096886 [0.0312]	—
No Education	—	—	—	-3.339088 [0.0000]
Age of leader	—	-0.01337 [0.0463]	—	—
Experience of leader	0.016322 [0.0557]	—	-0.017204 [0.0207]	-0.020061 [0.0421]
Number of employees	—	0.001818 [0.0006]	—	—
Observations	71	79	75	78
R^2	0.726238	0.561467	0.529611	0.487436
White Robust Variance Computation	No	No	Yes	Yes

Analysis

- Regional factors: cut flowers and potato subsectors.
- Transactional Model: incremental effect (as uncertainty decreases) on the innovation in all subsectors.
- Education of the leader : in general, a positive effect on the *II* (but not for pork meat subsector).
- Participation in research networks: positive effect in all subsectors.
- Research & Development: positive effect only in the cut flowers and palm oil subsectors ("industrialized").
- Age of leaders: negative effects on the *II* (but not for cut flowers).

Conclusions

- Methodology for measuring innovation in agricultural firms.
- Innovation Matrix: a catalogue of innovations, subsector-specific and allowing different views.
- Innovation Matrix: information on qualitative (technological level) and quantitative (observed frequency) of every innovation.
- Innovation Index: a single number that summarizes qualitative and quantitative features of the innovations observed in a given firm within a specific time frame.

Conclusions

- *II* is continuous and can be used as a dependent variable in a semilogarithmic linear regression model.
- Factors driving innovation: subsector-specific, although some of them are quite general (e.g. education fosters innovation, but experience of the leader is ambiguous)
- Some policies will work across the whole agricultural sector, but others must be designed for a given subsector.
- Further developments: application to industrial subsectors and dynamics of innovations (panel data analysis).