

Colombian export capabilities: building the firms-products network

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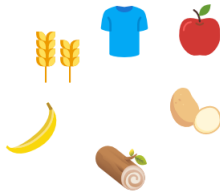
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- ▶ Motivation and previous work
- ▶ Data processing description: towards networks
- ▶ Networks projection: BiCM and statistical tools
- ▶ Network analysis: community structure
- ▶ Conclusions and further research

- ▶ How do the firms of a country export?
- ▶ How specialized are they?
- ▶ With what strategies do they diversify?
- ▶ Analysis of countries exports gave somewhat surprising results

The world trade case

- ▶ Specialization is not clear at a national level
- ▶ Small countries export mostly simple products...



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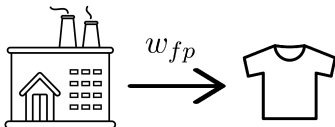
- ▶ Specialization is not clear at a national level
- ▶ Small countries export mostly simple products...
- ▶ ...But developed countries export every kind of product!



Analyzed data

- ▶ In the firms' exports case, one expects more **specialization**
- ▶ Analysis of the Colombian customs data for years 2010-2014
- ▶ Firms identified by a number, products by HS code

- In principle, one has a **weighted network**



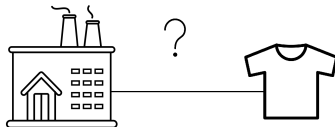
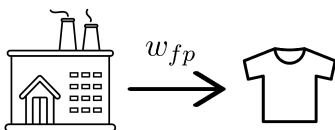
Towards a binary network

- ▶ In principle, one has a **weighted network**
- ▶ To simplify the analysis, binarize exports



Towards a binary network

- ▶ In principle, one has a **weighted network**
- ▶ To simplify the analysis, binarize exports
- ▶ When can we consider a firm to be a *relevant exporter* of a product?



- Use the **Revealed Comparative Advantage** to identify relevant exporters:

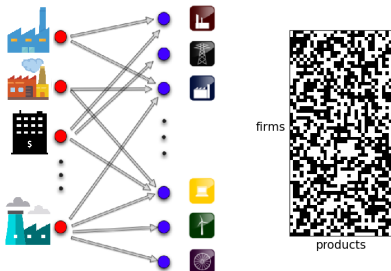
$$RCA_{fp} = \frac{\frac{w_{fp}}{\sum_{p'} w_{fp'}}}{\frac{\sum_{f'} w_{f'p}}{\sum_{f'p'} w_{f'p'}}} = \frac{w_{fp}}{s_f} / \frac{s_p}{W}$$

$RCA_{fp} > 1 \implies$ Draw link from f to p

World trade vs firms' exports

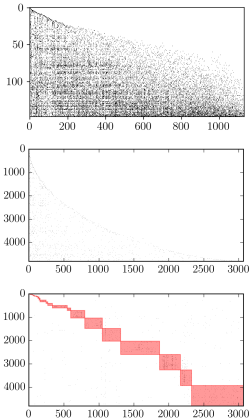
- ▶ WTW case: $RCA > 1 \sim 20\%$ of total exports
- ▶ Colombian firms: $RCA > 1 \sim 90\%$
- ▶ RCA measures how *specialized* is f in exporting p
- ▶ Much bigger specialization of firms than countries

Biadjacency matrix



- ▶ Bipartite networks can be represented with a $f \times p$ *biadjacency matrix* B
- ▶ $B_{ij} = 1$ if $RCA_{ij} > 1$
- ▶ B is not a square matrix!

Matrix properties



- ▶ Rearranging rows and columns it is possible to visualize network features
- ▶ Qualitative difference between countries and firms
- ▶ Community structure detectable in the network

- ▶ Which quantities and patterns are non-trivial in the network?
- ▶ Discount the *degree sequence* information
- ▶ Confront network properties with the averages of the ensemble of graphs with the same degree sequence
- ▶ Most unbiased way¹: **Bipartite Configuration Model**

¹Park J., Newman M. E. J., The statistical mechanics of networks. Phys. Rev. E 70, 066117 (2004)

- ▶ Exponential random graph: each graph G with n nodes has a probability $\mathbb{P}(G) = \frac{e^{-H(G)}}{Z}$
- ▶ $H(G)$ is the Hamiltonian of the system, Z a normalization factor
- ▶ Given the degree sequence of both layers \vec{u}, \vec{d} one has $H(G) = \vec{\alpha} \cdot \vec{u} + \vec{\beta} \cdot \vec{d}$
- ▶ It is possible to factorize the probability

$$\mathbb{P}(G) = \prod_{i,j} \frac{e^{-b_{ij}(\alpha_i + \beta_j)}}{1 - e^{-(\alpha_i + \beta_j)}}$$

- ▶ We have **independent** link probabilities

$$p_{ij} = \frac{e^{-b_{ij}(\alpha_i + \beta_j)}}{1 - e^{-(\alpha_i + \beta_j)}} = \frac{x_i y_j}{1 - x_i y_j}$$

- ▶ No correlations between links, no possible links between nodes of the same layer
- ▶ To find parameters $\vec{\alpha}$ and $\vec{\beta}$ solve equations

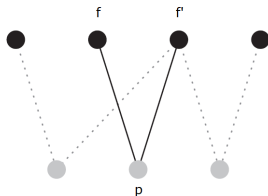
$$u_i = \sum_j p_{ij}$$

$$d_j = \sum_i p_{ij}$$

Nodes similarity

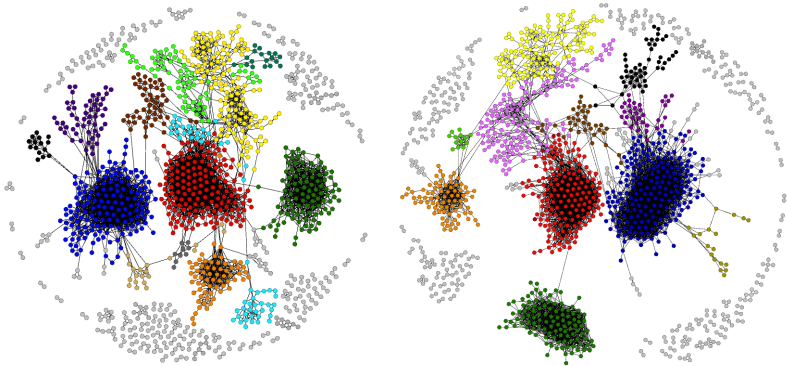
- ▶ Project the network on one layer
- ▶ How **similar** are two nodes?

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- ▶ How **similar** are two nodes?
- ▶ Number of common neighbors must be **statistically significant**
- ▶ Calculate the "*V-motifs*" between each pair of nodes, compare them with the model average



Projected networks

- ▶ Find the most connected couples of nodes via a statistical test
- ▶ Obtain the **projected** firms and products **networks**
- ▶ Only strong correlations will be preserved
- ▶ Community structure easily detectable in monopartite networks: **Louvain** algorithm



- - clothes; ● - fuels, metals and other industrial products; ● - fabrics; ● - soaps, body care products and related chemicals; ● - food; ● - electronic components; ● - chemicals and medicines; ● - furniture for the house and ornaments, in wood and plastic; ● - domestic products, small plastic/metal objects; ● - stationery, mixed printed products and kids' toys; ● - small tools for construction companies (chains, hammers, etc.); ● - refrigerators and other domestic appliances; ● - stone, marble and chemicals for construction companies; ● - bed linens.

- ▶ Confronting with *bipartite* communities
- ▶ Community structure in the projected network has less noise
- ▶ Applicable for any bipartite network

Conclusions, further research

- ▶ Not same surprises as in the world trade case
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- ▶ Statistical projection of the network useful to **detect communities**

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- ▶ Not same surprises as in the world trade case
- ▶ Firms tend to **specialize** more than countries, as expected
- ▶ Statistical projection of the network useful to **detect communities**
- ▶ What happens for **other nations** that export differently on a national basis?
- ▶ How does a **single community** behave?
- ▶ What happens for **large firms**?

Bibliography

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