Cities, collective knowhow and economic development

Computational Social Science Workshop
The University of Chicago
May 17, 2018

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Center for International Development,
Harvard University

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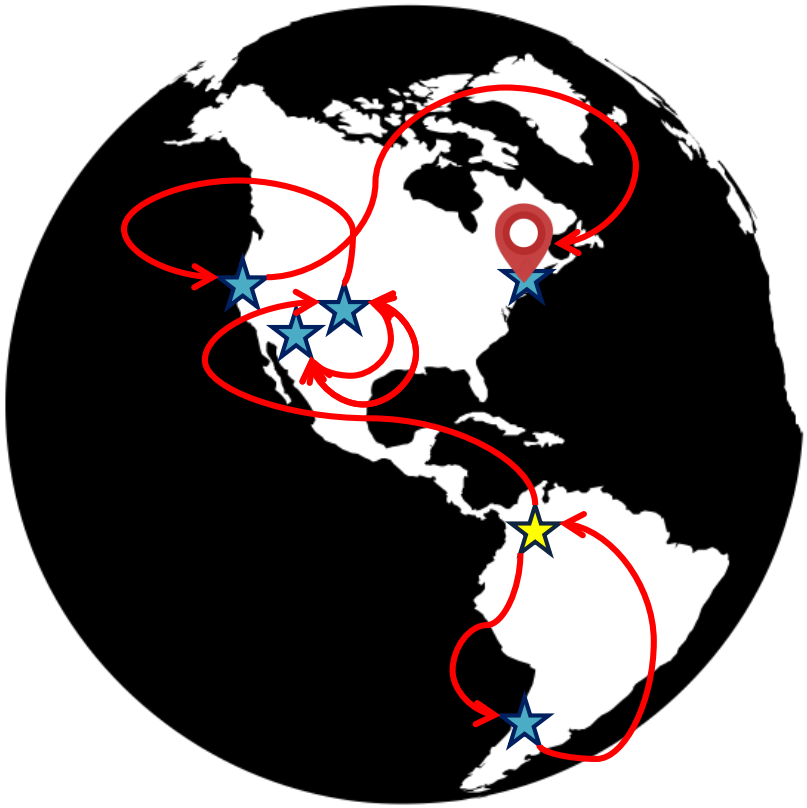
Twitter: @GomezLievano



Where I was born

Where I've lived

Where I am

Where I was born

Where I've lived

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Where I've lived

Where I am

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Where I am


Where I was born
Where I've lived
Where I am

mentors and colleagues

Where I was born

Where I've lived

Where I am

- **Motivation, background, context**
- **Statistics:**
  The “view from above”
- **Dynamics:**
  How do cities diversify?
- **Examples of applied work**

- **Motivation, background, context**
- Statistics:
  The “view from above”
- Dynamics:
  How do cities diversify?
- Examples of applied work

United States

Colombia

United States

Colombia

United States

New York City, NY

Colombia

Bogota D.C.

Between VS. Within

Acemoglu, D., and Dell, M., "Productivity differences between and within countries." *American Economic Journal: Macroeconomics* 2.1 (2010): 169-88.

- Labor **income** across many individuals, across municipalities, across countries.
- Theil inequality index **decomposition**
- Cross-city differences are **twice as large** as cross-country differences

United States

New York City, NY

Colombia

Bogota D.C.

United States

New York City, NY

Holmes County, MS

Colombia

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Vigía del fuerte, Antioquia

Bottom-right photo borrowed from S. Fajardo.

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The broad questions

The broad questions

Differences between cities

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Differences between cities

Why do these differences exist?

The broad questions

Differences between cities

Why do these differences exist?

What do they consist of?

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Differences between cities

Why do these differences exist?

What do they consist of?

How do they originate?

The broad questions

Differences between cities

Why do these differences exist?

What do they consist of?

How do they originate?

How do they change?

The broad questions

Differences between cities

Why do these differences exist?

What do they consist of?

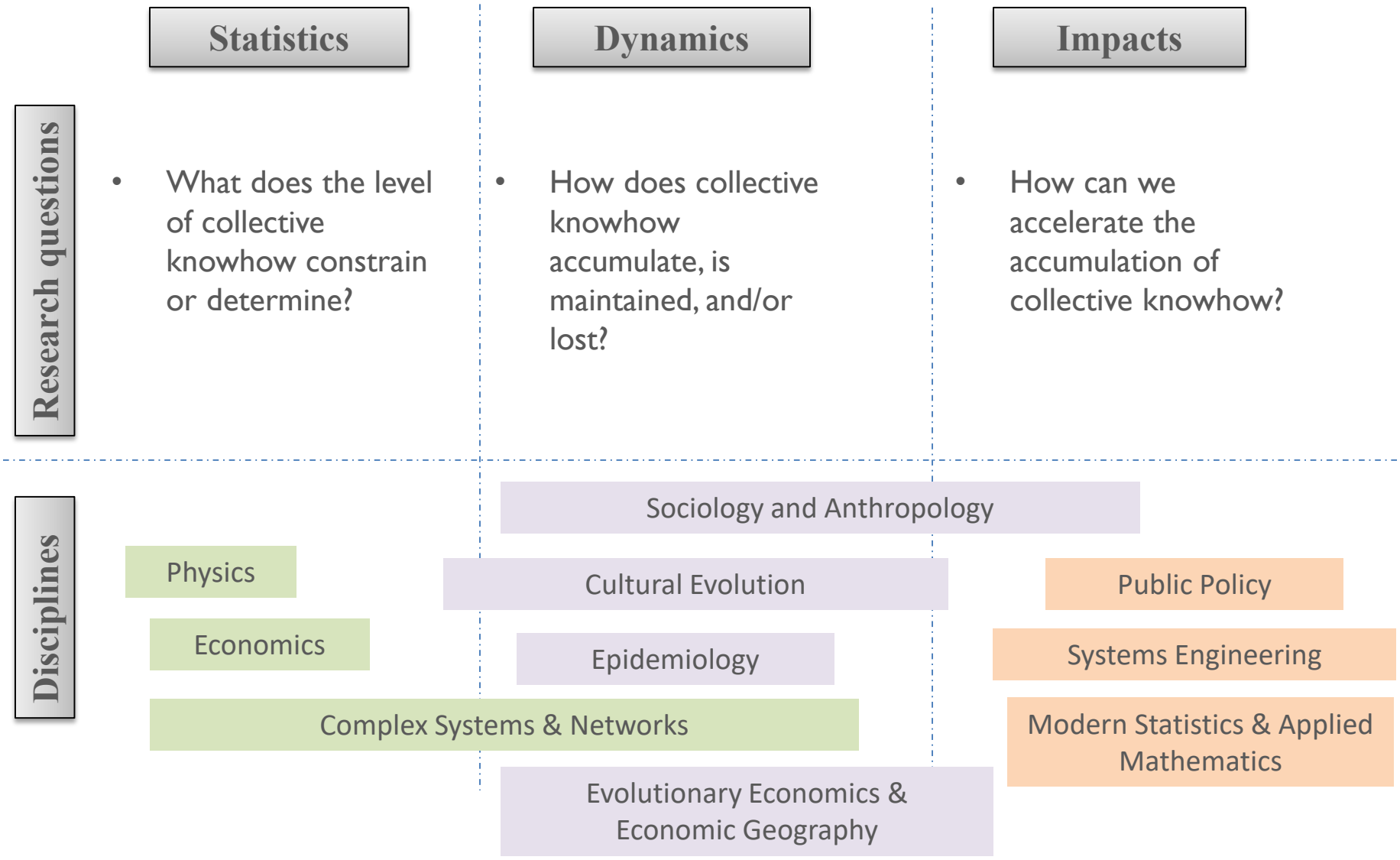
How do they originate?

How do they change?

Can we intervene?

The organizing idea

Differences in “collective knowhow”


Statistics
Dynamics
Impacts
Research questions
• What does the level of collective knowhow constrain or determine?
• How does collective knowhow accumulate, is maintained, and/or lost?
• How can we accelerate the accumulation of collective knowhow?
Disciplines
Sociology and Anthropology
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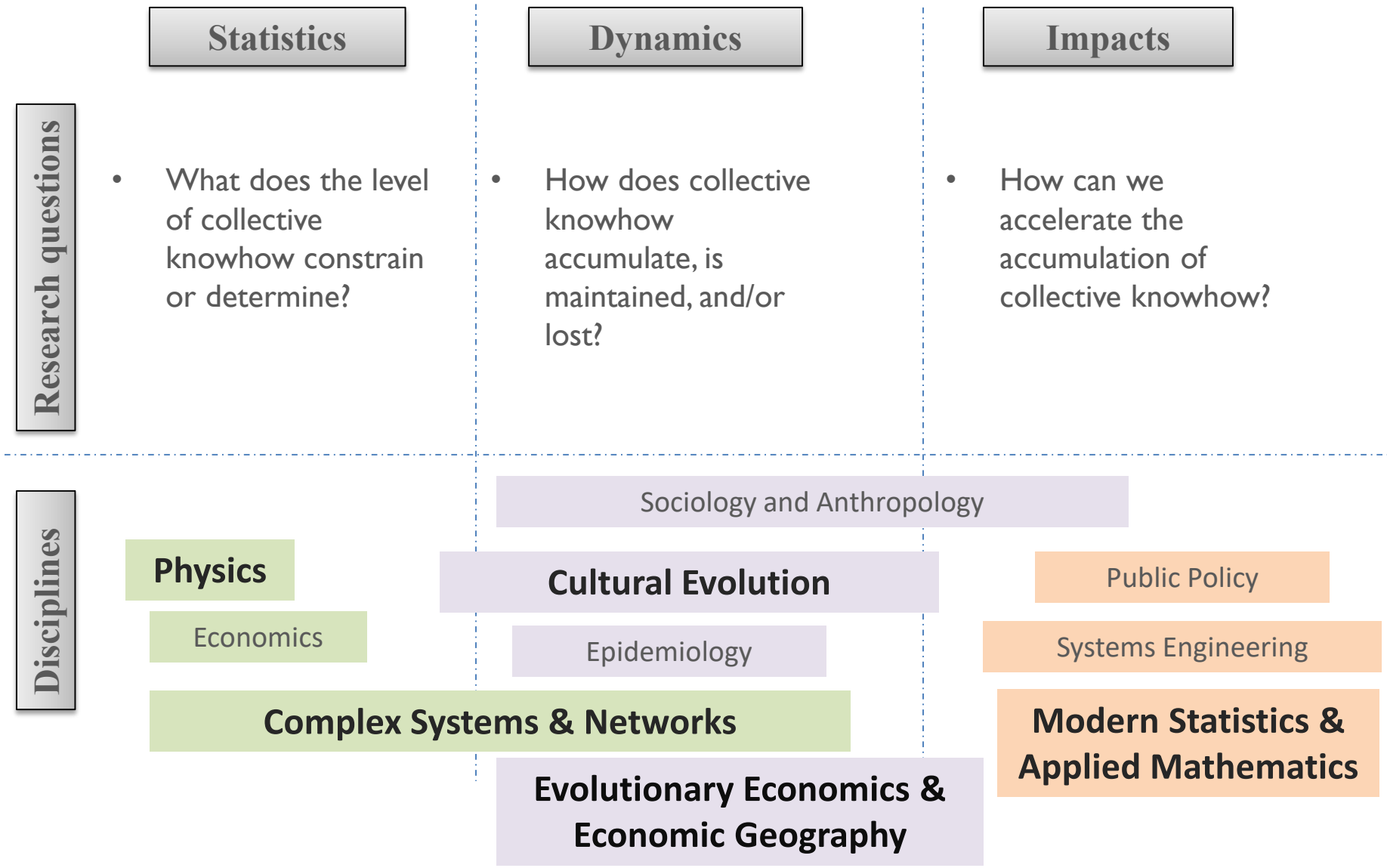
Cultural Evolution
Public Policy
Economics
Epidemiology
Systems Engineering
Complex Systems & Networks
Modern Statistics & Applied Mathematics
Evolutionary Economics & Economic Geography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  The “view from above”
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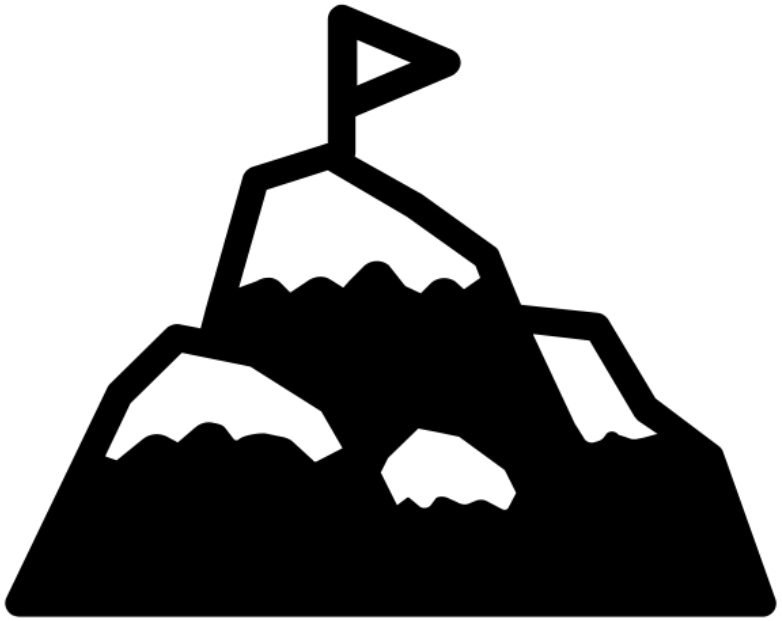
  How do cities diversify?
- Examples of applied work

“TRUTH”



Icons:

Created by Peter van Driel
from Noun Project

Created by Martyn Jasinski
from Noun Project

Traditional approach

Theory: $Y = f_1(X)$ → Empirics: $y_i = \beta_0 + \beta_1 x_{i,1} + \epsilon_i$

Theory: $Y = f_2(X, W)$ → Empirics: $y_i = \beta_0 + \beta_1 x_{i,1} + \beta_2 x_{i,2} + \epsilon_i$

Theory: $Y = f_3(X, W, Z)$ → Empirics: ...

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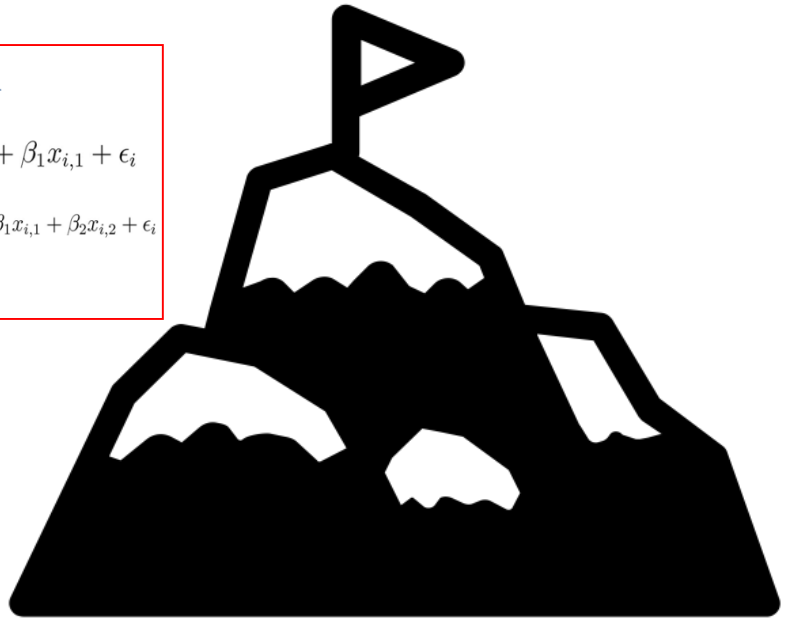

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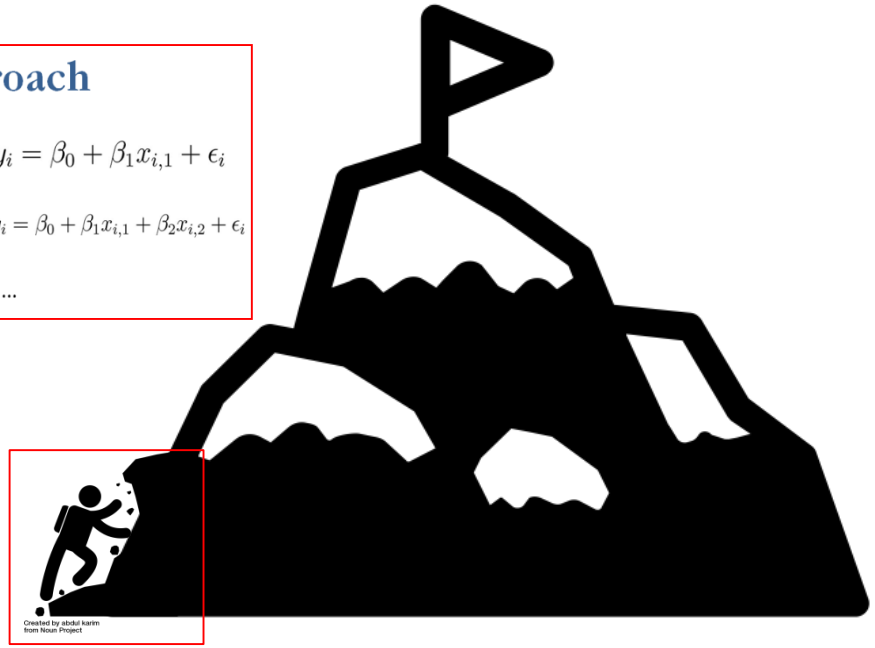

Explaining ***Y*** one variable at a time…

Icons:

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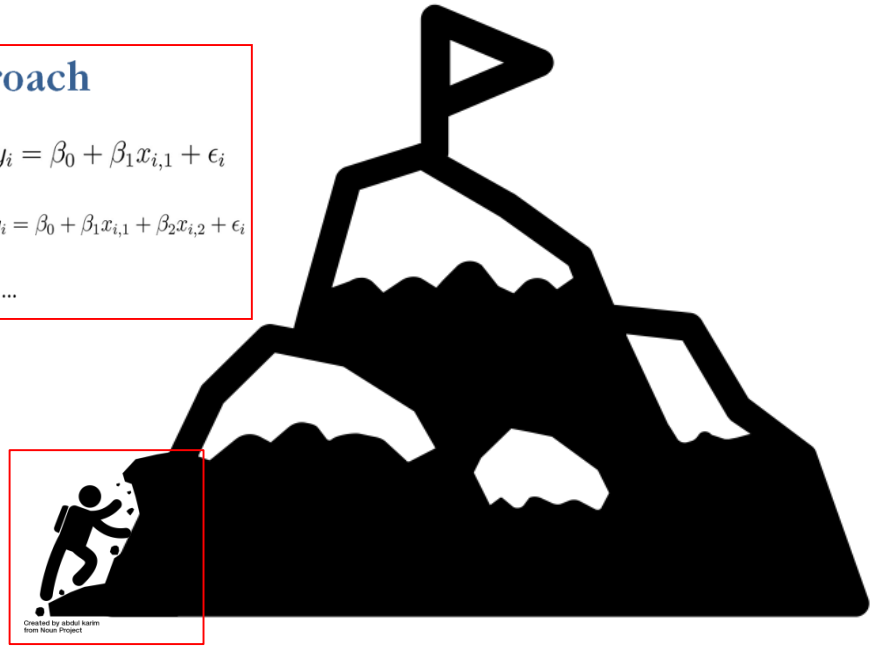
Explicitly assume ***Y*** is the consequence of ***many, many, many explanatory variables***.

$$Y = f(X_1, X_2, X_3, X_4, \ldots \longrightarrow \infty)$$

"TRUTH"



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- Does Y change with the "**scale/size**" of *f*()? How?
- How do the X's **interact**?
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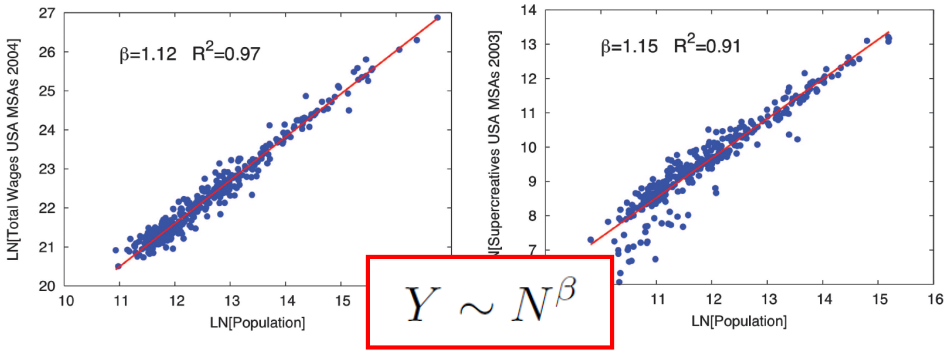
"Scaling Analysis"

- Studying a phenomenon as it changes with scale:
  - Regularities
  - Important underlying mechanisms



Bettencourt, L.M., Lobo, J., Helbing, D., Kühnert, C. and West, G.B., 2007. Growth, innovation, scaling, and the pace of life in cities. *Proceedings of the National Academy of Sciences*, *104*(17), pp.7301-7306.

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With larger city sizes

The "exposure" to the city increases
The density of interactions in space increases

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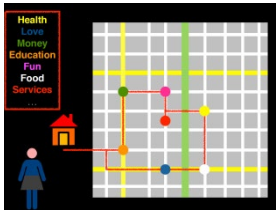

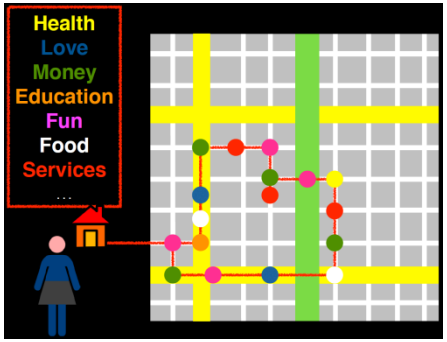

Images created by
Luis Bettencourt

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- $P(Y,N) = P(Y|N)P(N)$

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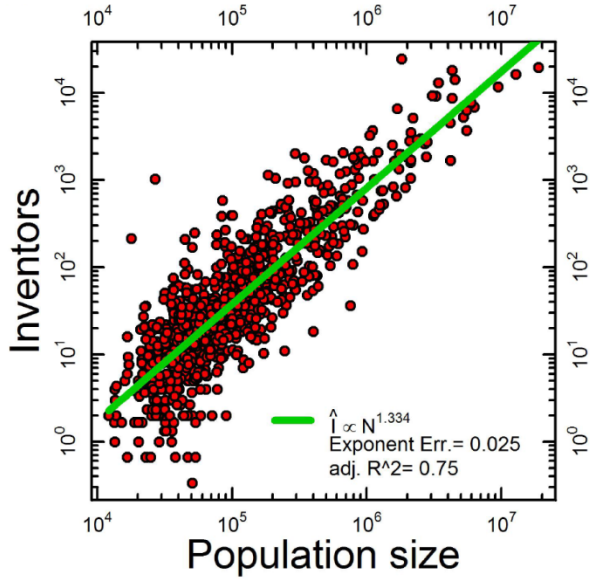

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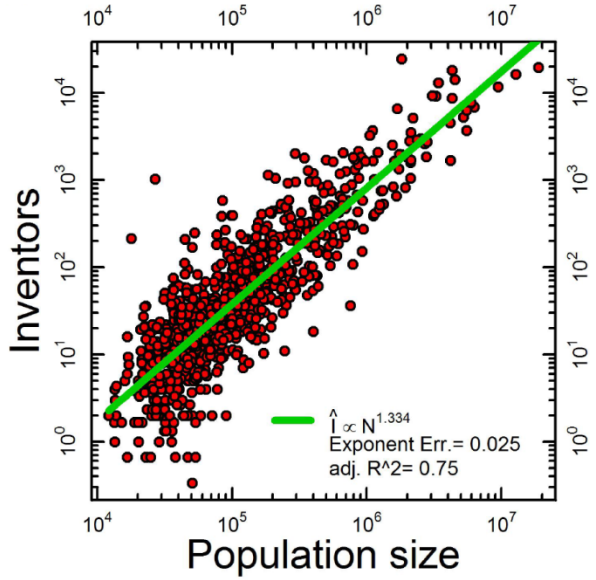

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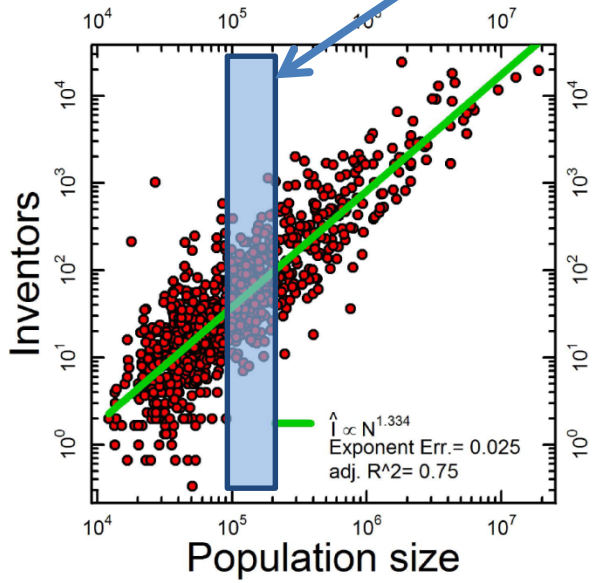

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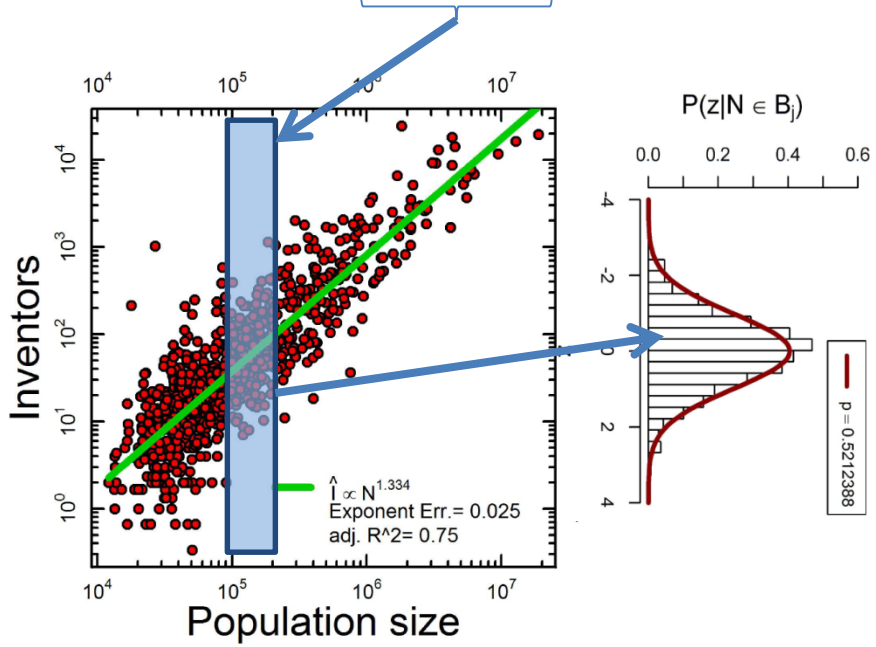

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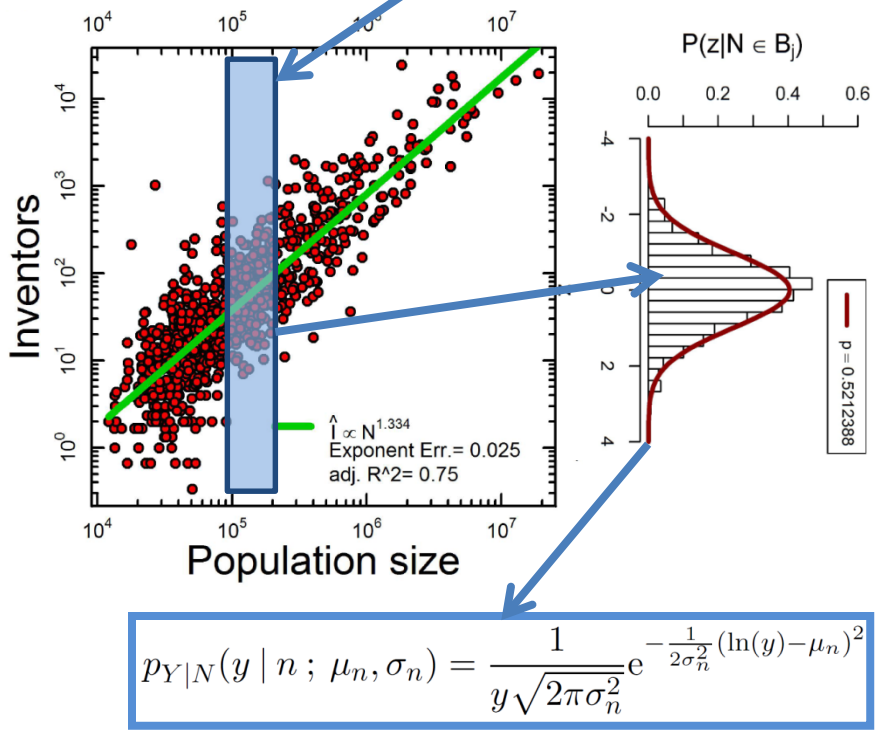

$$p_{Y|N}(y \mid n\,;\, \mu_n, \sigma_n) = \frac{1}{y\sqrt{2\pi\sigma_n^2}} e^{-\frac{1}{2\sigma_n^2}(\ln(y)-\mu_n)^2}$$

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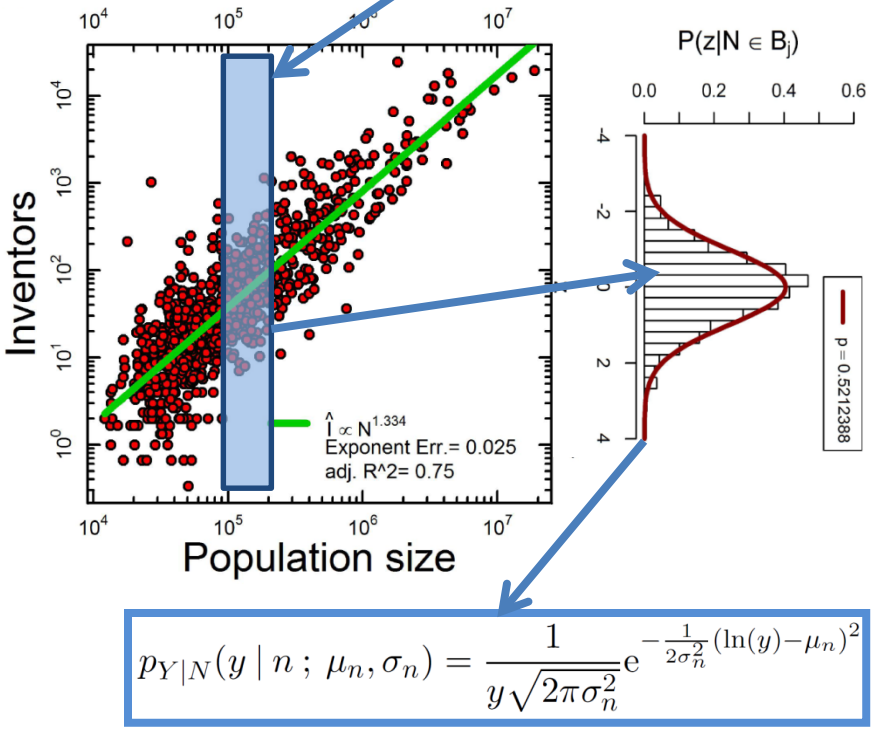

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Factors interact multiplicatively!
X's are **complementary**

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$$Y|N \sim \mathcal{LN}(\mu_N, \sigma)$$
$$E[Y|N] = Y_0 N^{\beta}$$

Complementary interactions!

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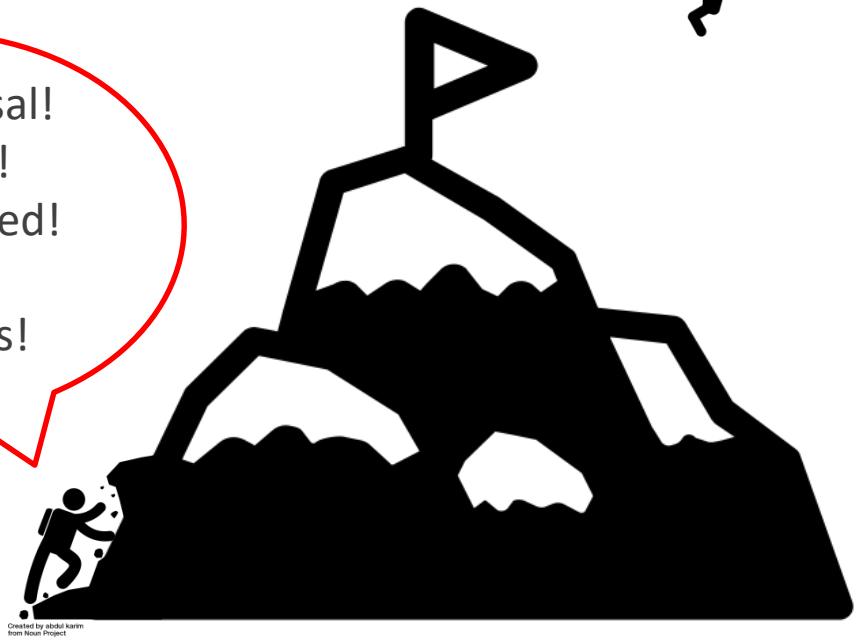
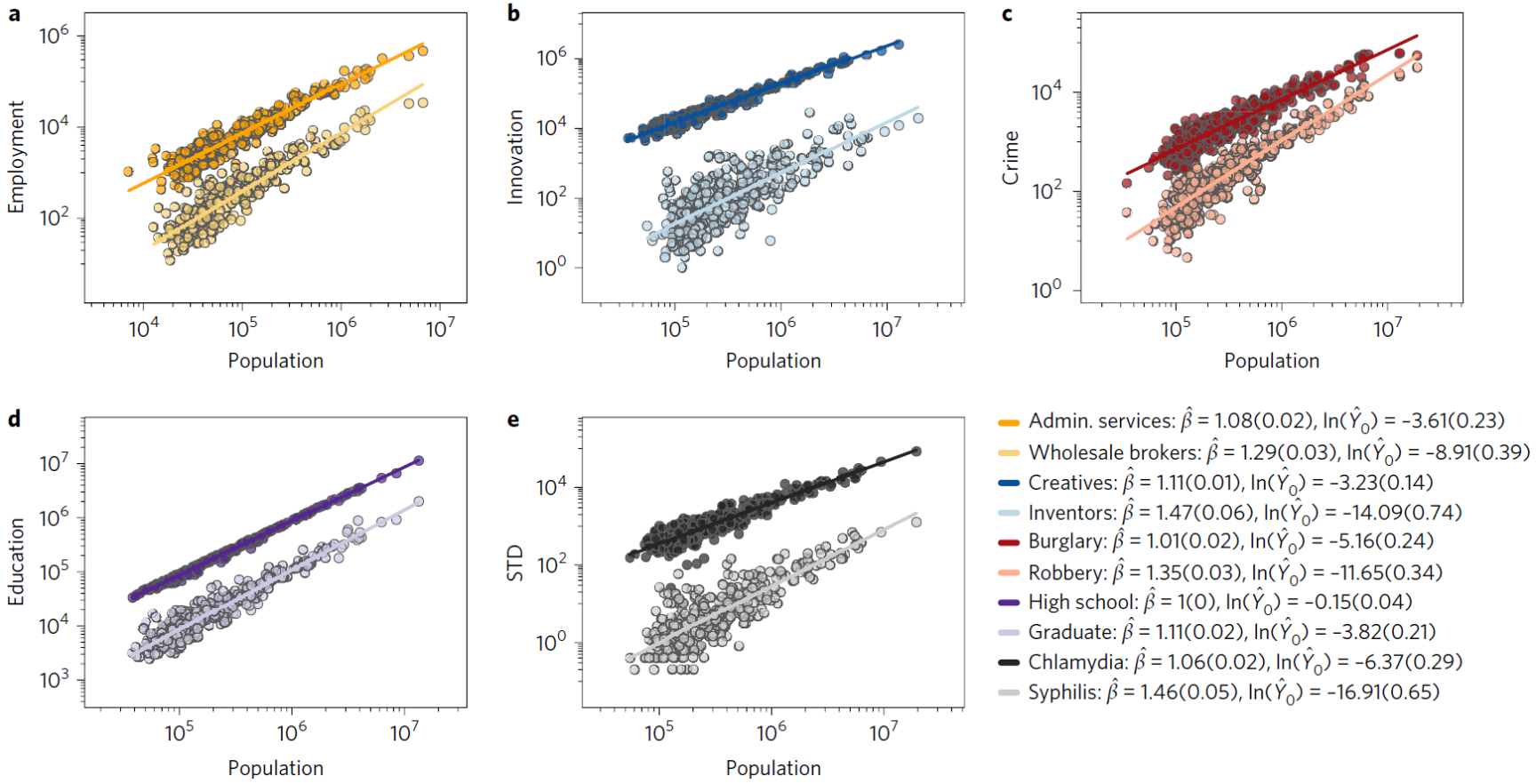
$$E[Y|N] = Y_0 N^{\beta}$$

Complementary interactions!

Not universal!
Not dynamic!
Too aggregated!
Useless!
… Be serious!



Four facts (among others) to try explaining



1. log-log → straight line $Y \sim N^{\beta}$

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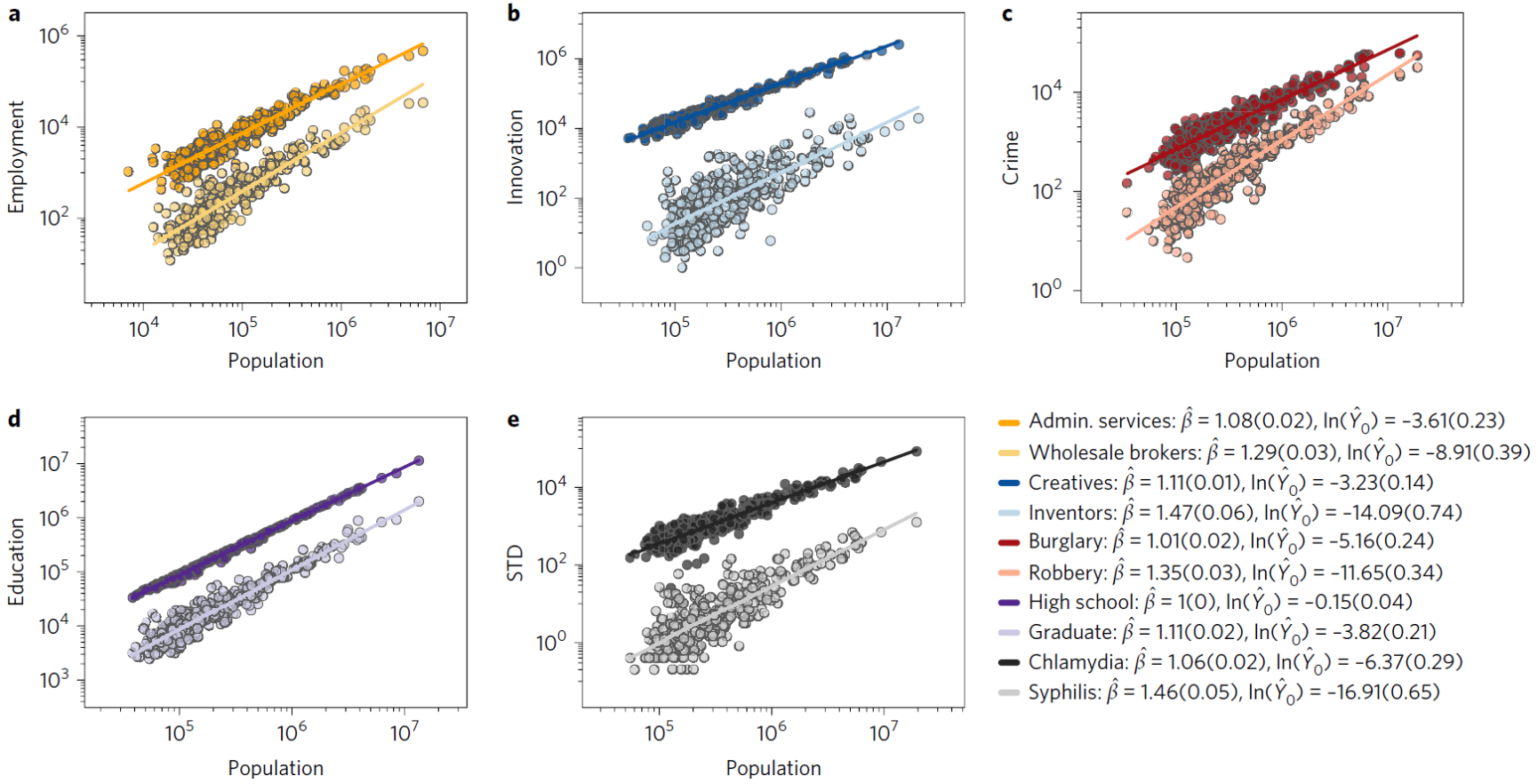

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1. log-log → straight line $Y \sim N^{\beta}$
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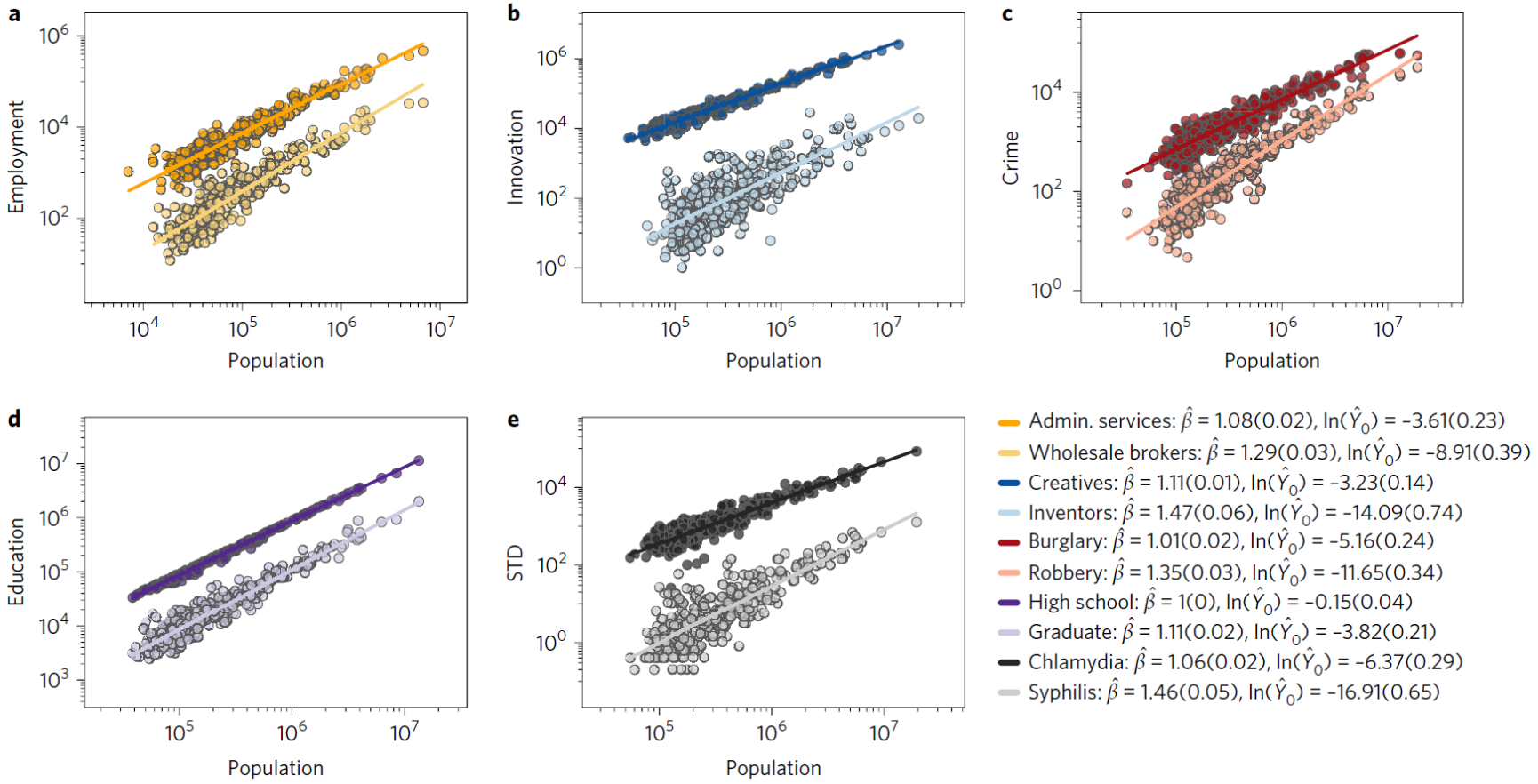

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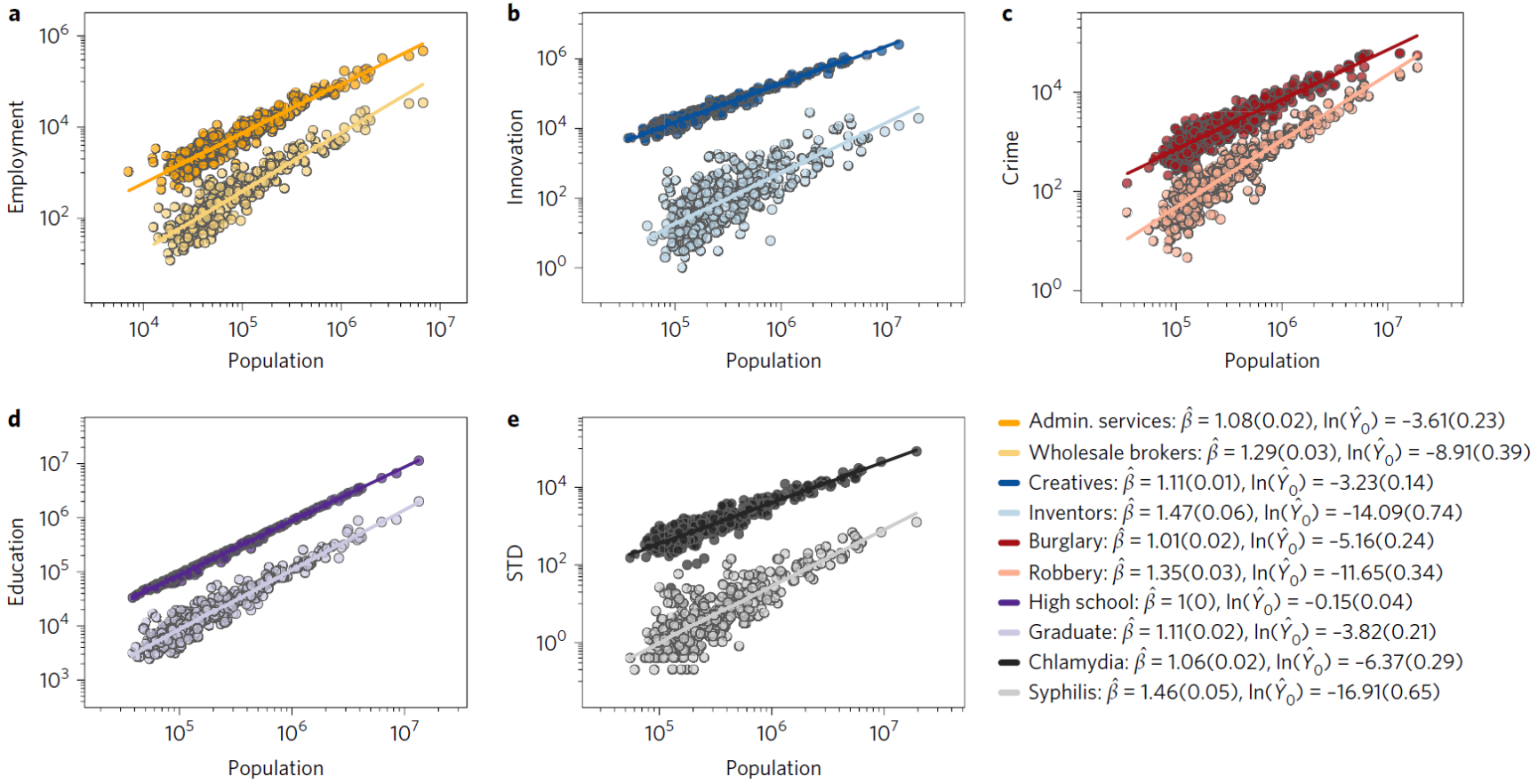

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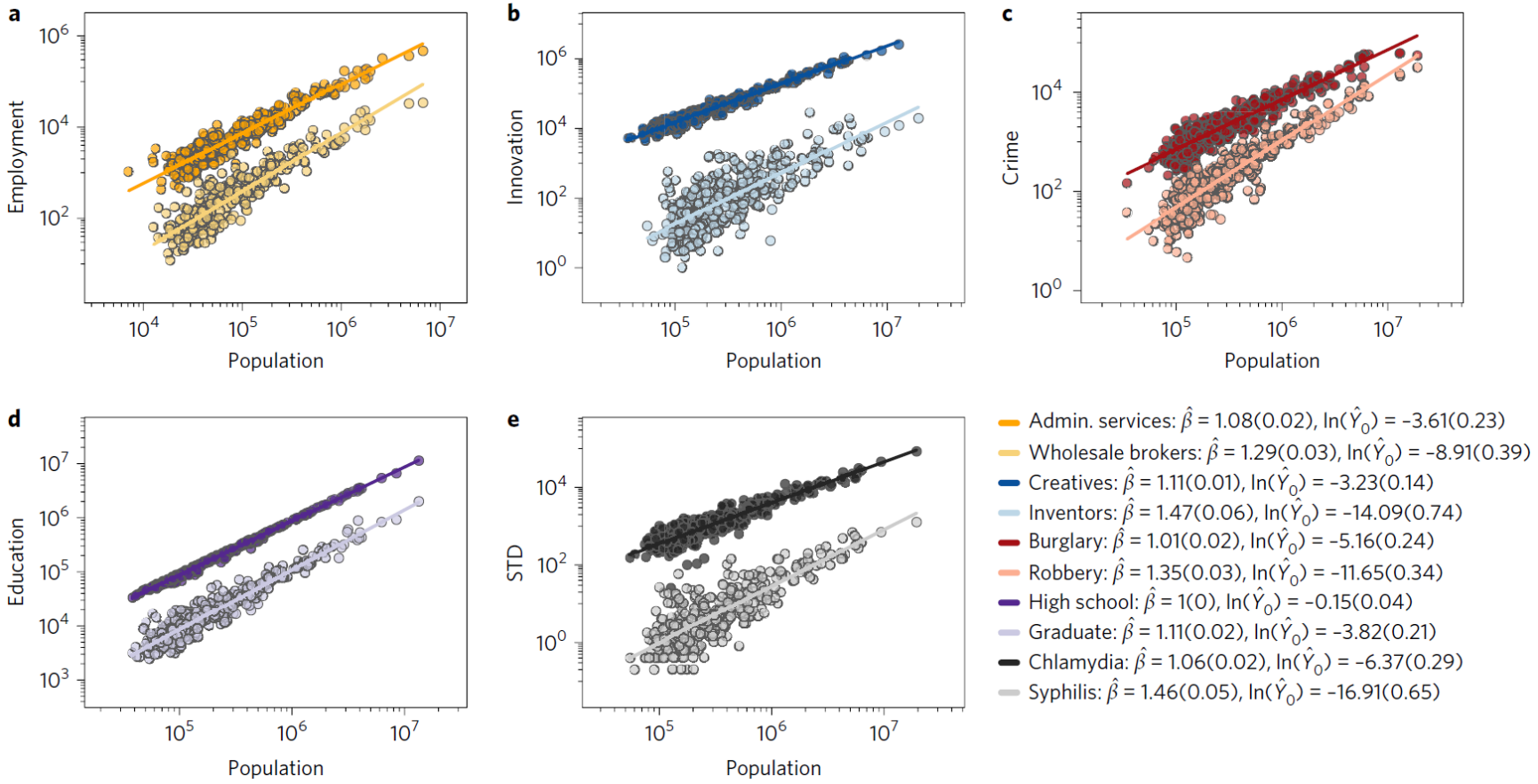
4. with its own dispersion, *why?*



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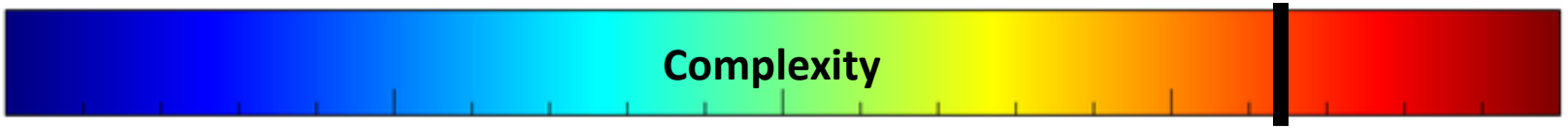

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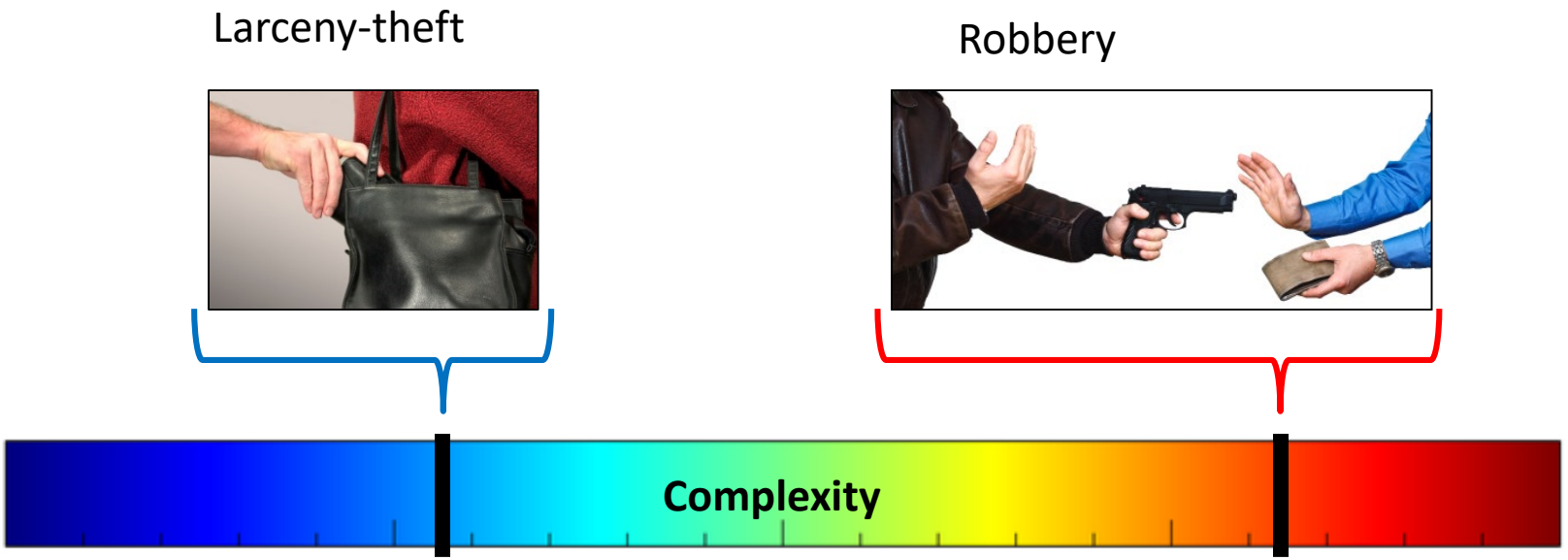

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2. Cities accumulate these factors through a stochastic evolutionary process of variation and selection, and cities are the vessels were these factors combine.

3. And each person in the city is different in the factors they bring to the city. The exposure of people to the city is what generates the outcomes.

=

= ***r***

=

= small ***q***

=

= large ***q***

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The building blocks of economic complexity.
PNAS, 106(25):10570-10575.

Hausmann, R. and Hidalgo, C.A. (2011),
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=

= ***r***

=

= small ***q***

=

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$$\Pr\{X_{i,c,f} = 1\} = e^{-M_f q_i (1 - r_c)}$$

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$$\Pr\{X_{i,c,f} = 1\} = e^{-M_f q_i (1 - r_c)}$$

$$E[Y_{c,f} \mid N_c] = N_c \; e^{-M_f q (1 - r_c)}$$

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How do letters accumulate?

- The parameter ***r*** is a measure of the diversity of letters.

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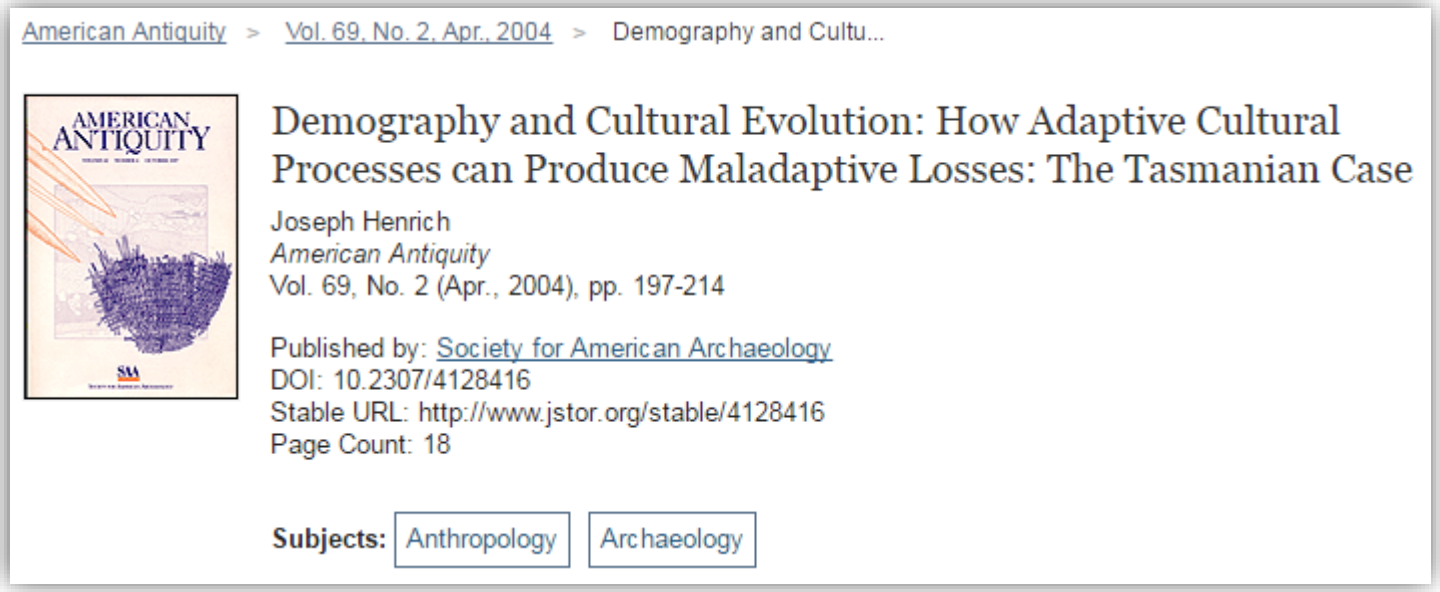
American Antiquity > Vol. 69, No. 2, Apr., 2004 > Demography and Cultu...

Demography and Cultural Evolution: How Adaptive Cultural Processes can Produce Maladaptive Losses: The Tasmanian Case

Joseph Henrich
American Antiquity
Vol. 69, No. 2 (Apr., 2004), pp. 197-214

Published by: Society for American Archaeology
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Subjects: Anthropology | Archaeology

Henrich's (2004) model of "letter" accumulation

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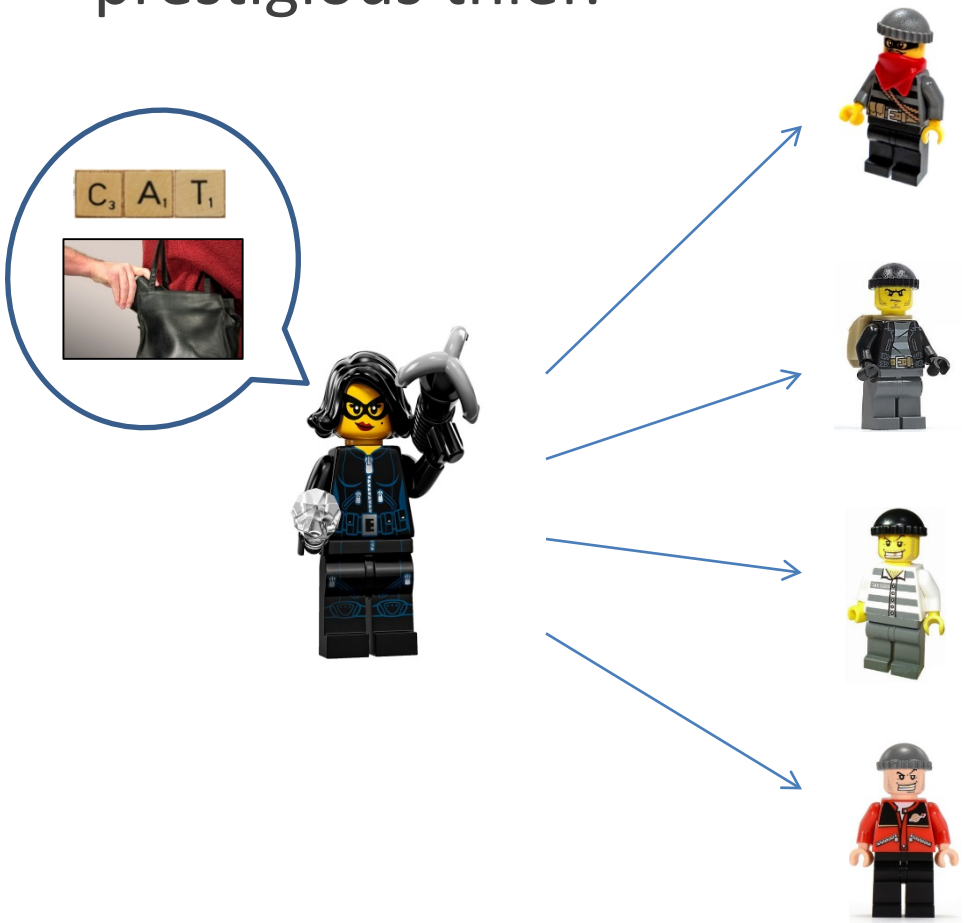

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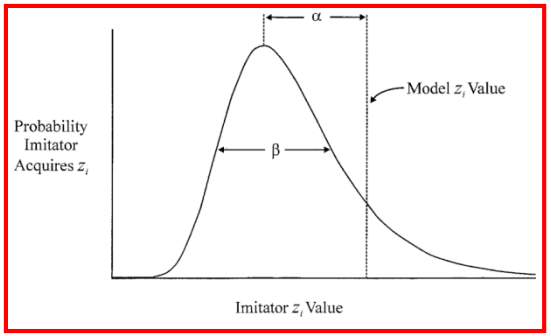


Henrich's (2004) model of "letter" accumulation

- Most skillful and prestigious thief:

$\beta =$

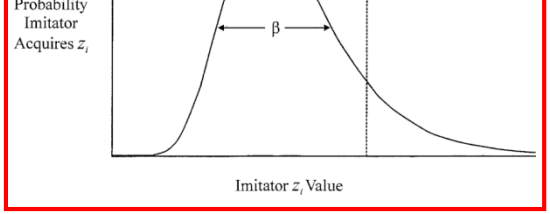
- ***N*** Apprentices (imitators):

$= \alpha$

A1 T

C3 A1 T

A1 C3 T I1 N1 G2



In Henrich's model, collective knowhow (i.e., "# of letters in the place") is a logarithmic function of population size

$$\begin{aligned} r(N) &\propto -\alpha + 0.577\beta + \beta \ln(N) \\ &= a + b \ln(N) \end{aligned}$$

See also:
Shennan (2001),
Henrich & Boyd (2002),
Powell et al. (2009),
Kline & Boyd (2010),
Mesoudi (2011),
Lehman et al. (2011),
Aoki et al. (2011),
Kobayashi & Aoki (2012),
Derex et al. (2013),
Collard et al. (2013),
Kempe & Mesoudi (2014).

Models of economic complexity

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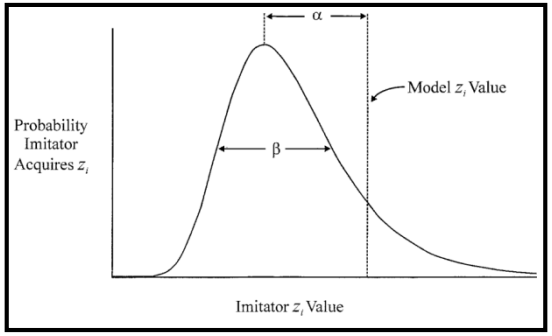
Models of cultural evolution



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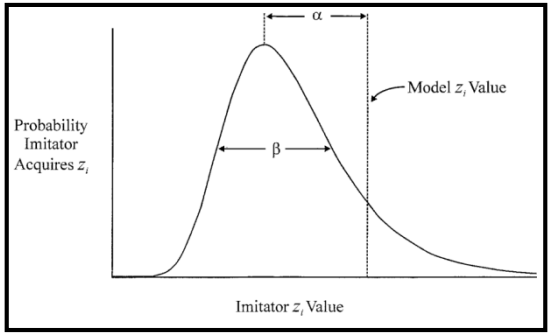

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$$r(N) = a + b\ln(N)$$

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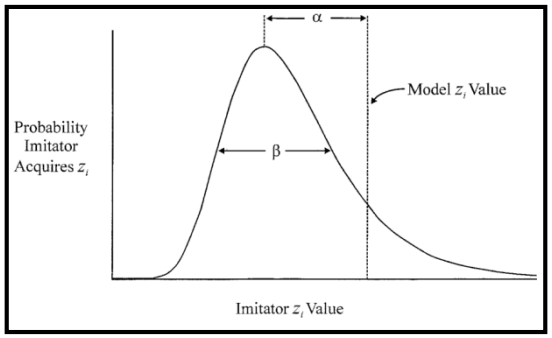

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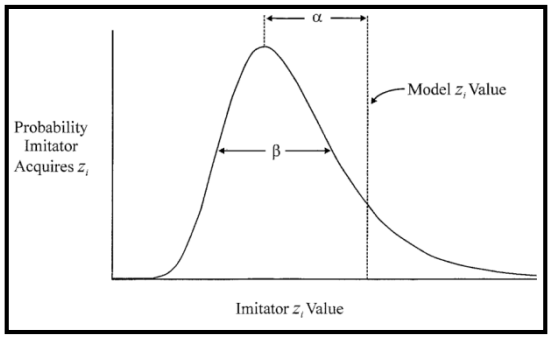

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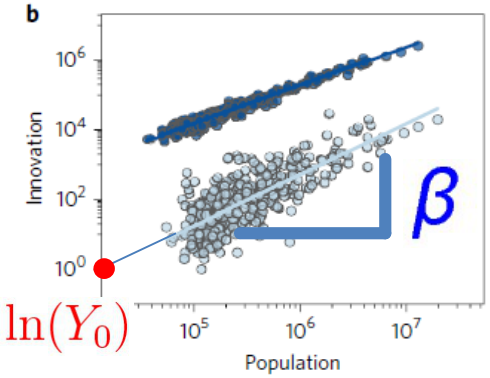

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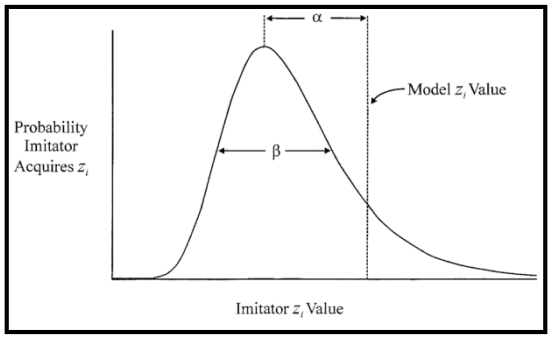

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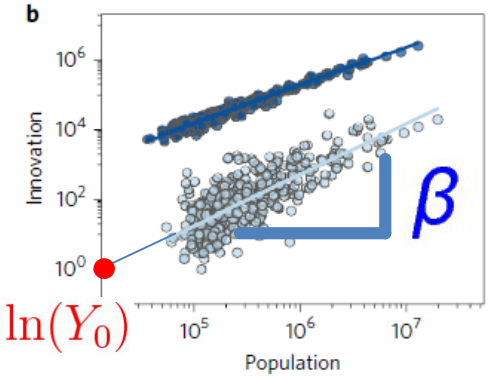

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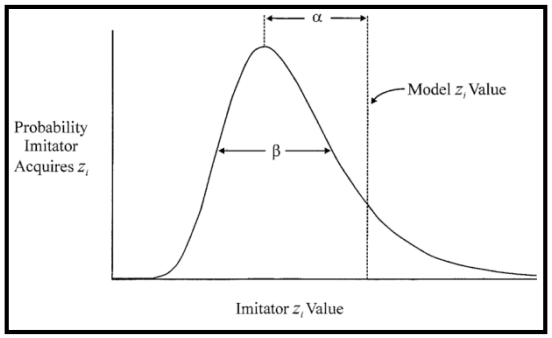

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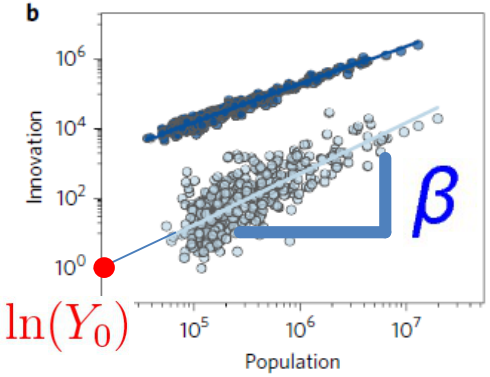

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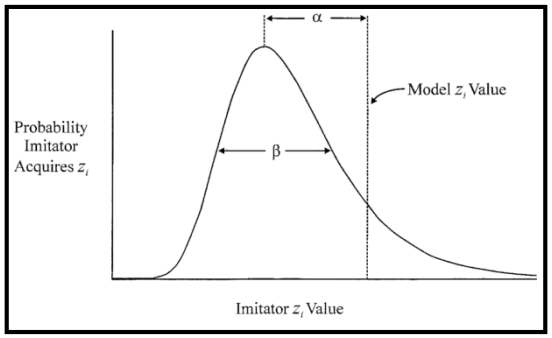

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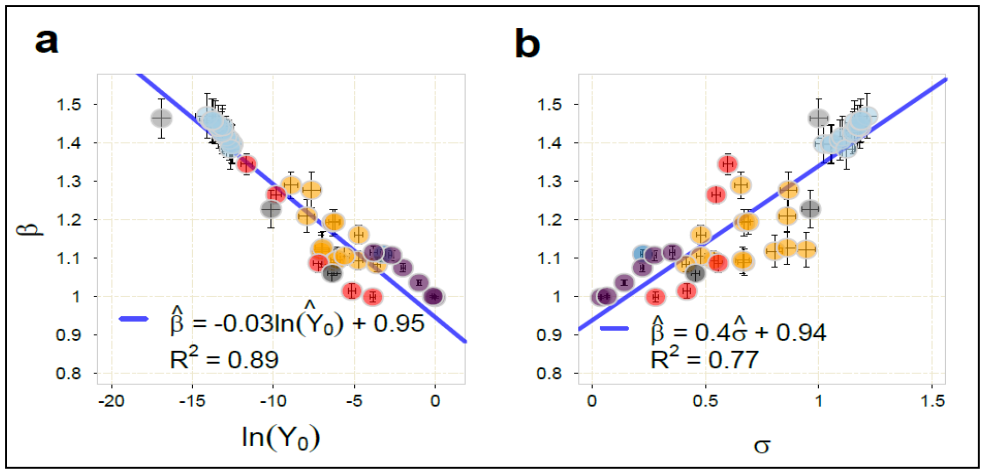

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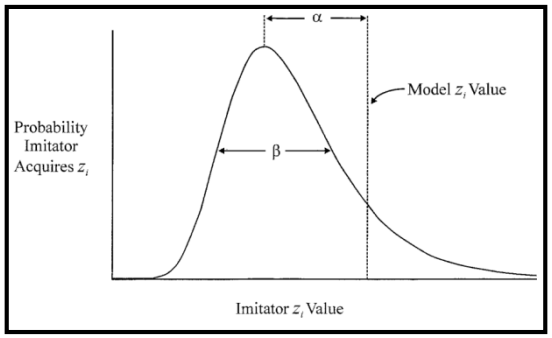

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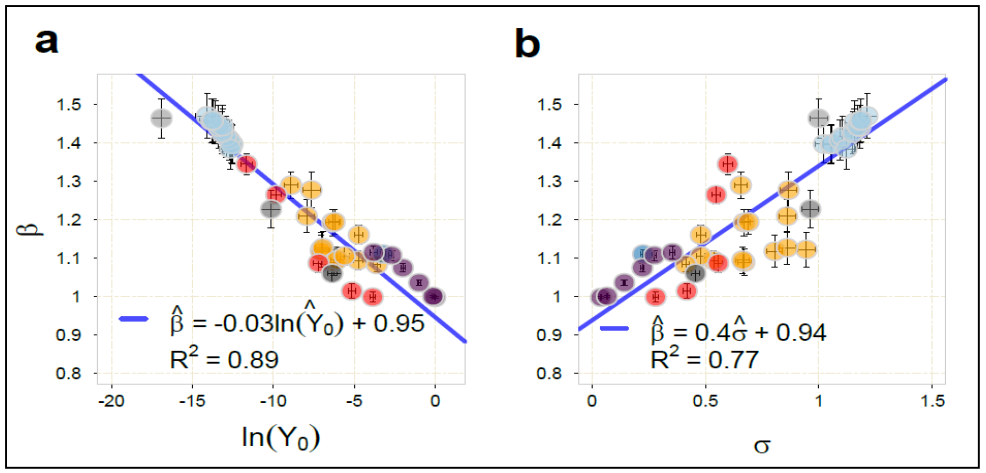

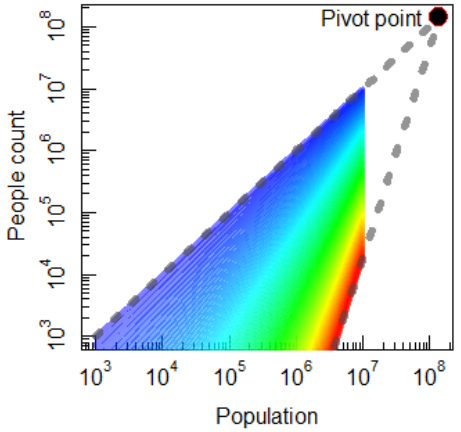

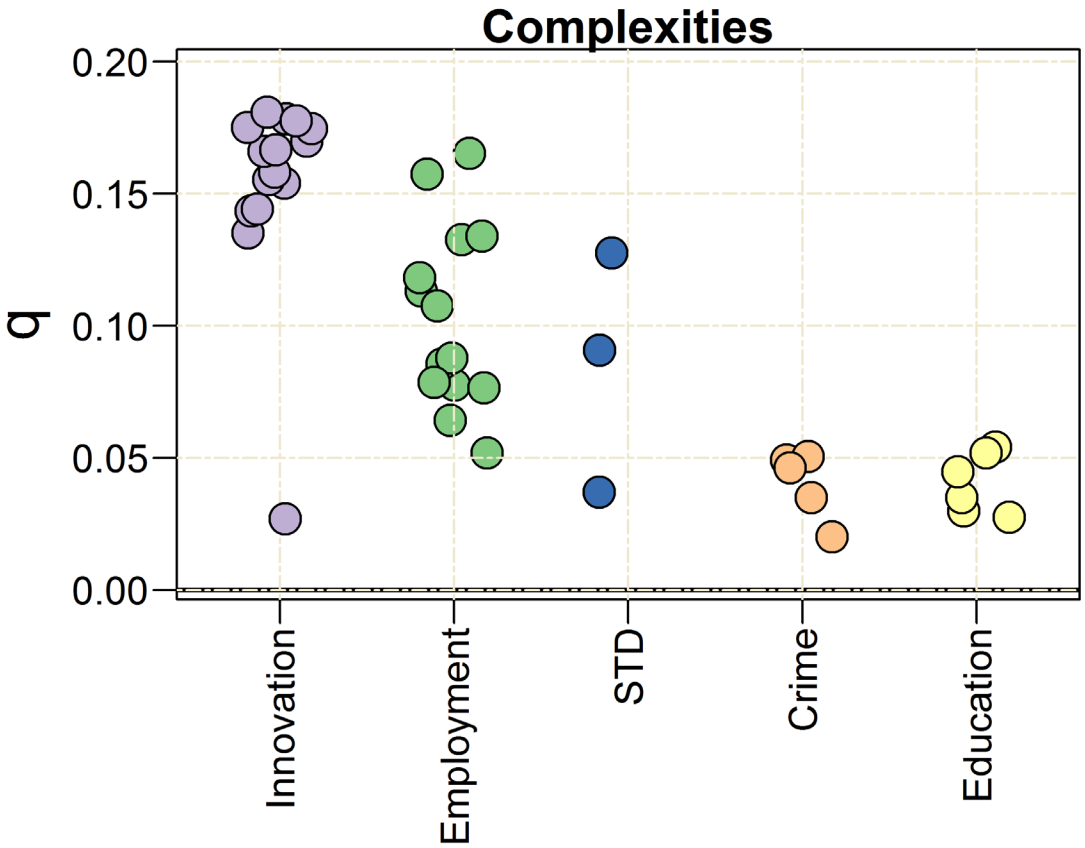
Complexities
q
0.20
0.15
0.10
0.05
0.00
Innovation
Employment
STD
Crime
Education

- Motivation, background, context
- Statistics:
  The “view from above”
- **Dynamics:**
  How do cities diversify?
- Examples of applied work

Places diversify into "similar/related" activities

- Cumulative culture
  (review: Mesoudi, A. (2017). Pursuing Darwin's curious parallel: Prospects for a science of cultural evolution. Proceedings of the National Academy of Sciences, 114(30), 7853-7860)

- Diversification of
  - Exported products
    (Hausmann & Klinger 2006, Hidalgo et al. 2007)
  - Industries
    (Neffke et al. 2011, Neffke & Henning 2013, He & Rigby 2015)
  - Technologies
    (Rigby 2015)
  - Professional occupations
    (Muneepeerakul et al. 2013)

For good reviews:
- Boschma, Ron. (2017). "Relatedness as driver of regional diversification: A research agenda." *Regional Studies* 51, no. 3 (2017): 351-364.
- Bahar, D., Stein, E., Wagner, R. A., & Rosenow, S. (2017). "The Birth and Growth of New Export Clusters: Which Mechanisms Drive Diversification?"

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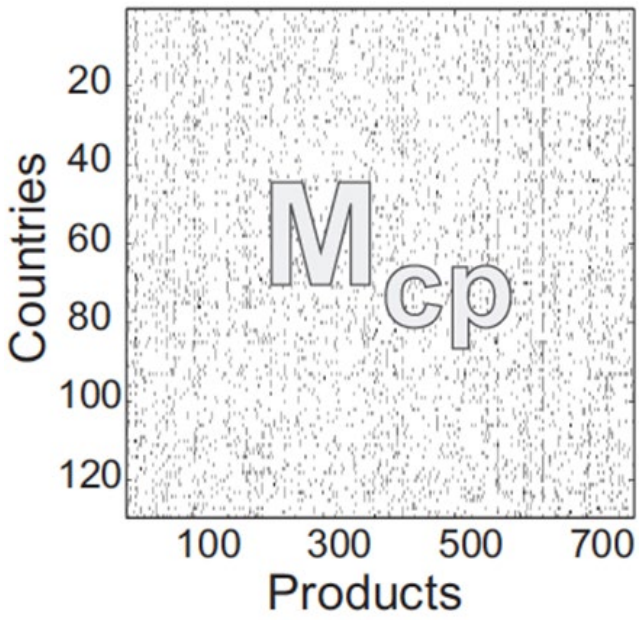

$= f(t)$

Is there a low-dimensional space where we can track the appearance of new products (new links)?

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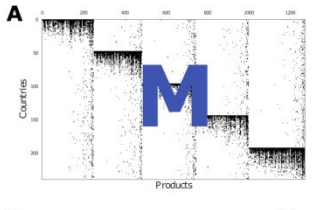

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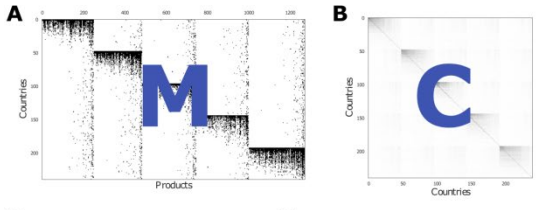

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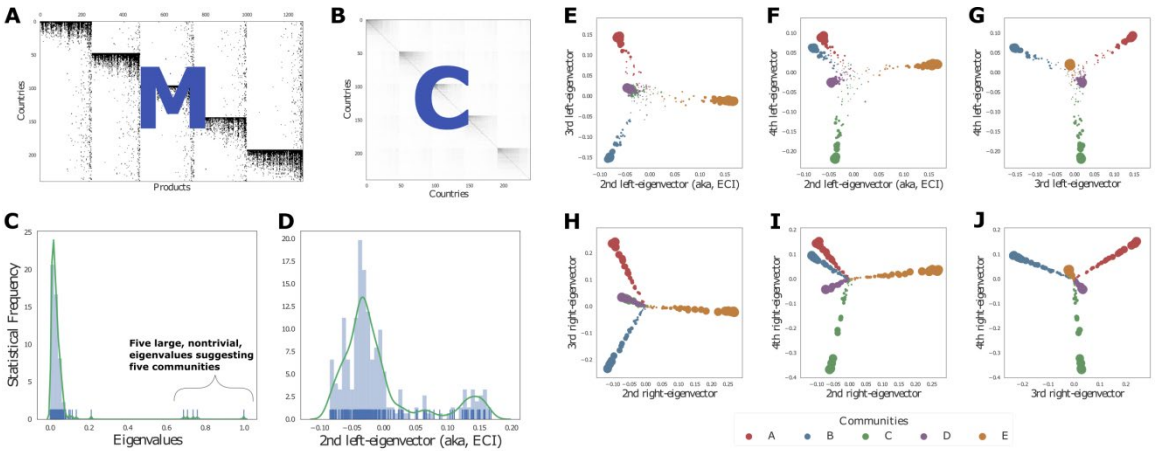

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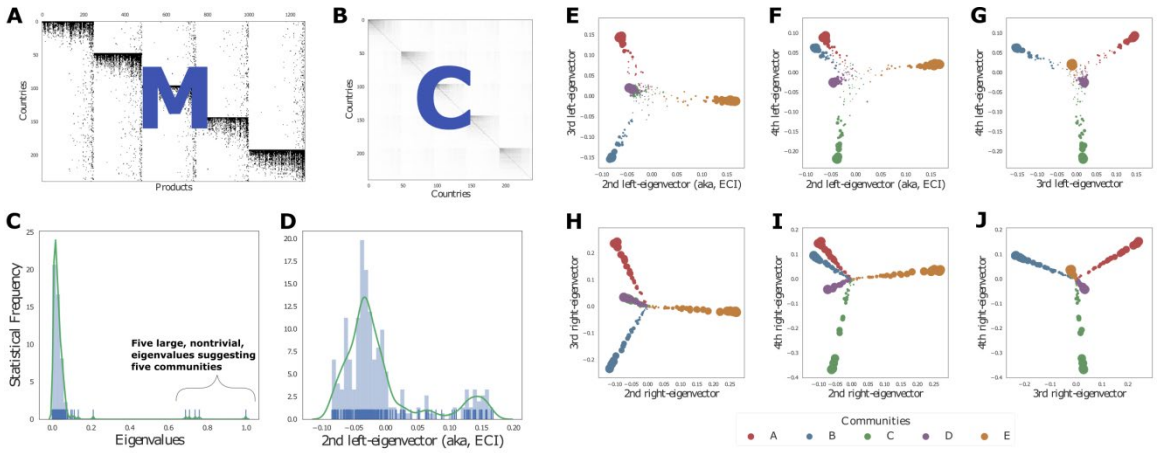

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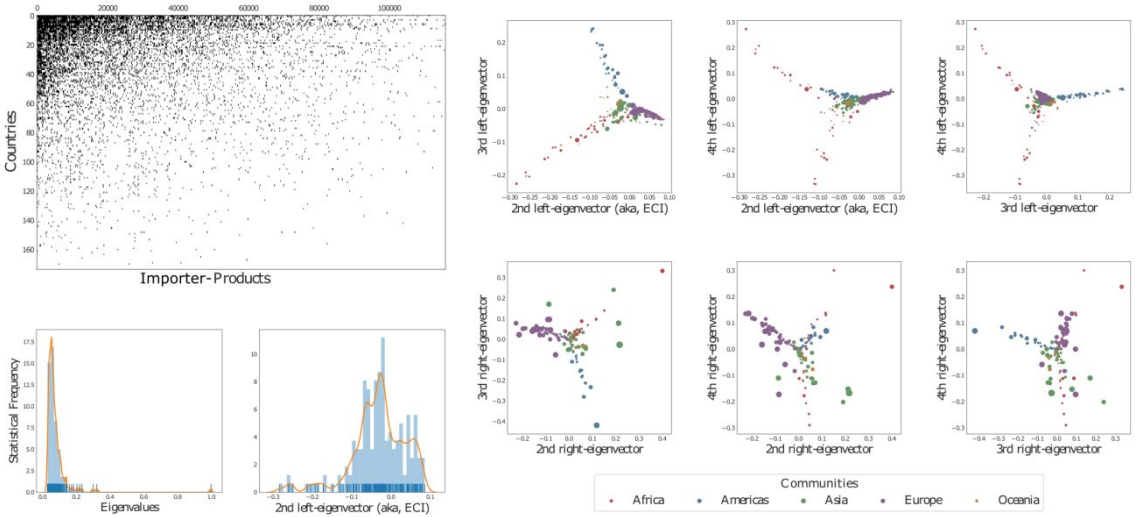

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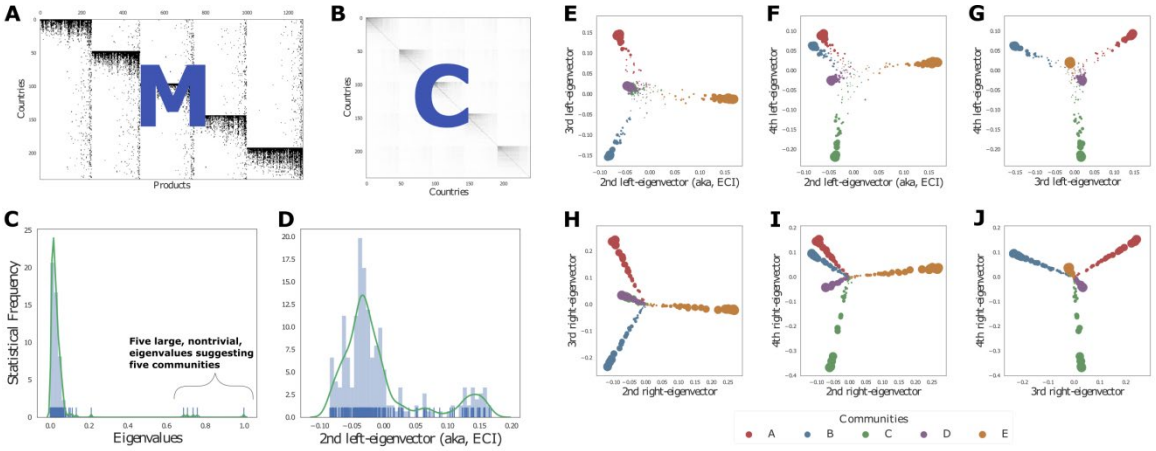

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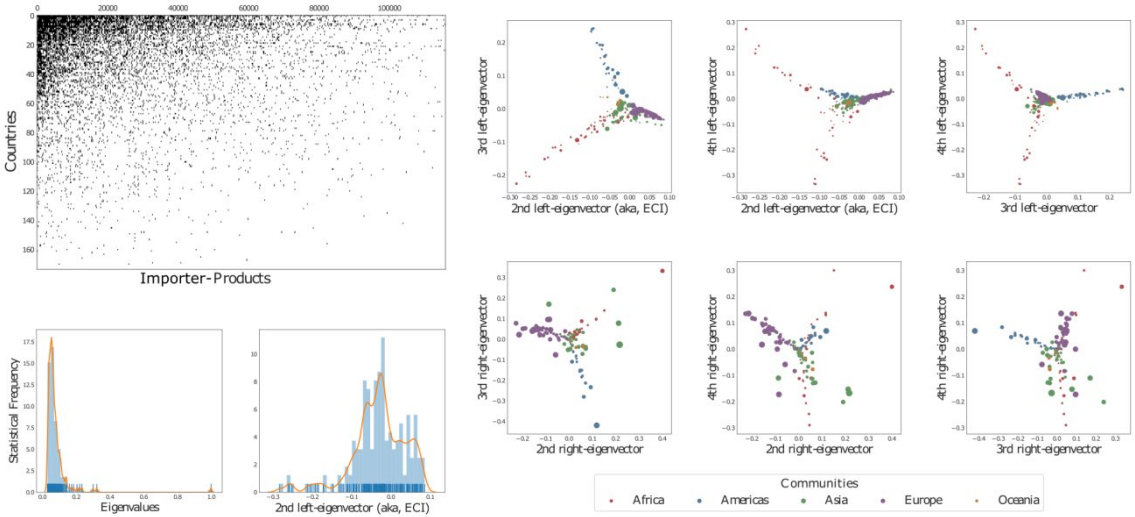

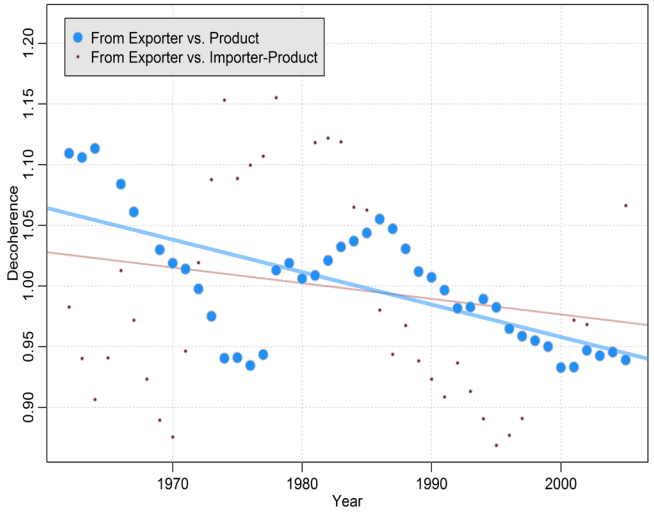

Machine-learned patterns reveal that diversification underlies economic development

Charles D. Brummitt[a], Andrés Gómez-Liévano[b], Ricardo Hausmann[b,c], and Matthew Bonds[a,1]

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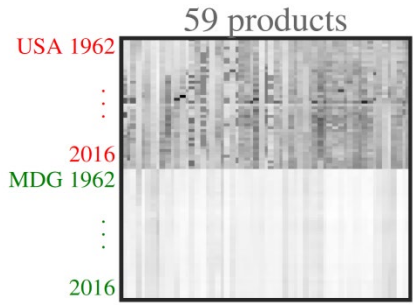

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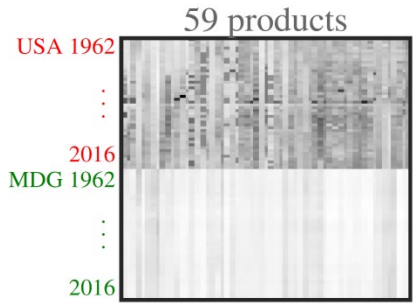

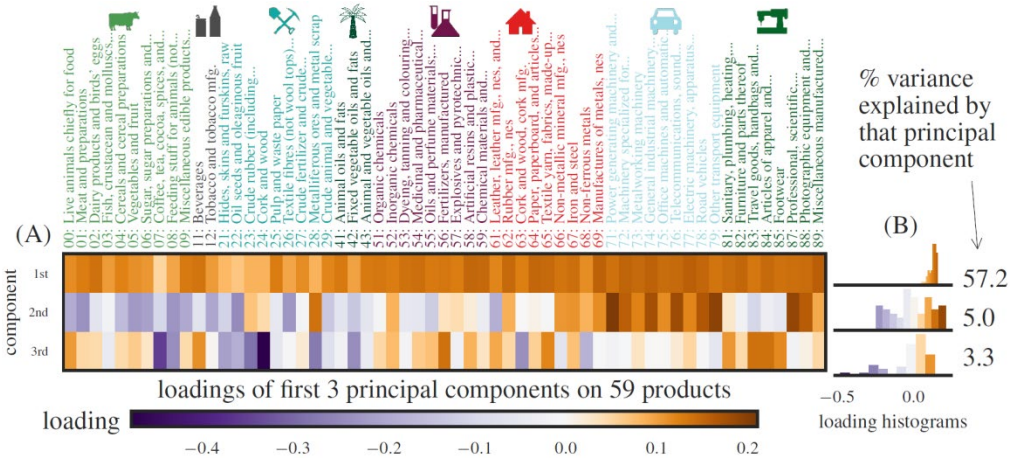

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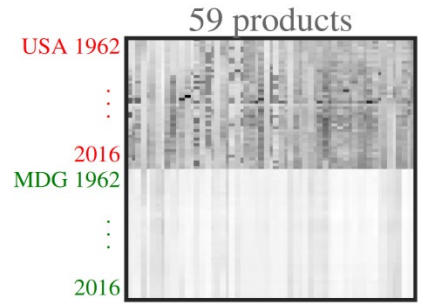

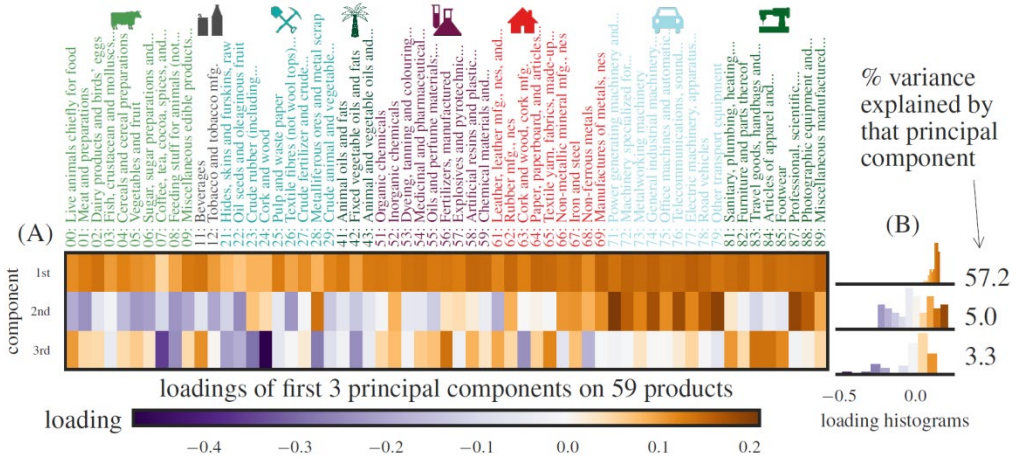

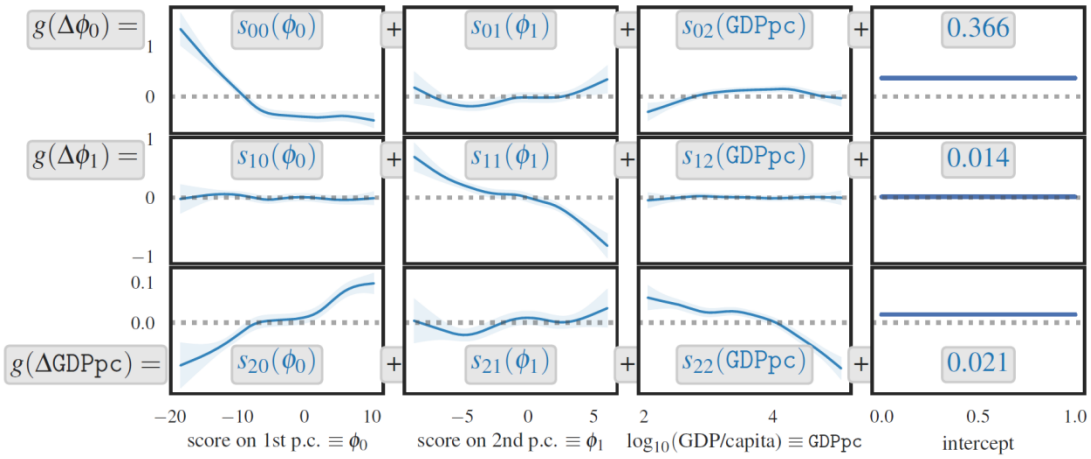

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Colombia ☺

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- **Full** agricultural census (the inputs and outputs of all farms)

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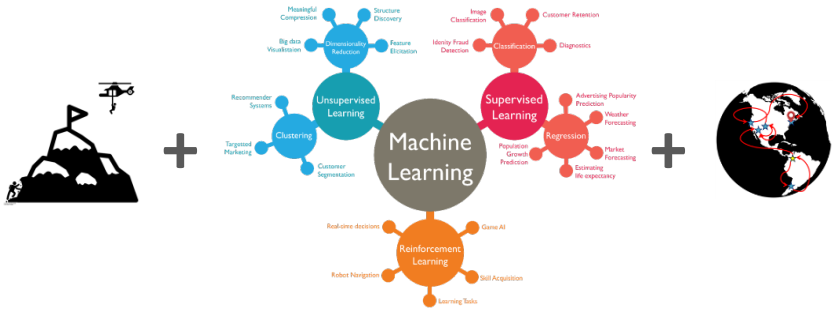

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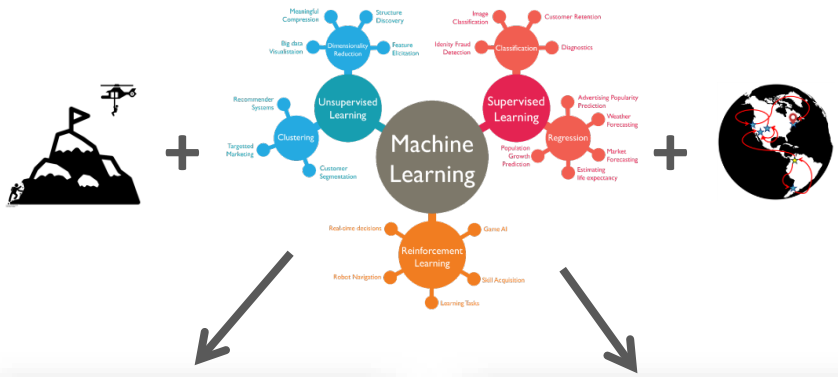

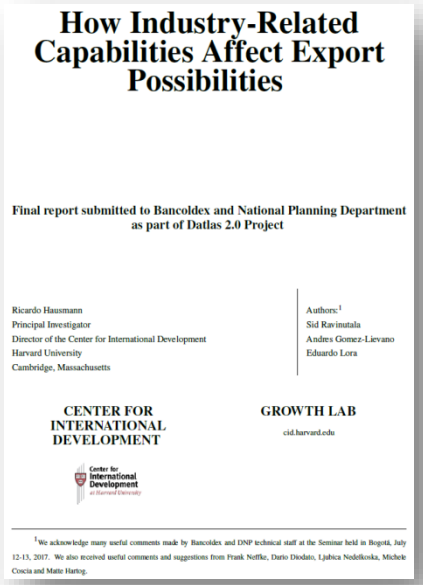

How Industry-Related Capabilities Affect Export Possibilities

Final report submitted to Bancoldex and National Planning Department as part of Datlas 2.0 Project

Ricardo Hausmann
Principal Investigator
Director of the Center for International Development
Harvard University
Cambridge, Massachusetts

Authors:[1]
Sid Ravinutala
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CENTER FOR INTERNATIONAL DEVELOPMENT

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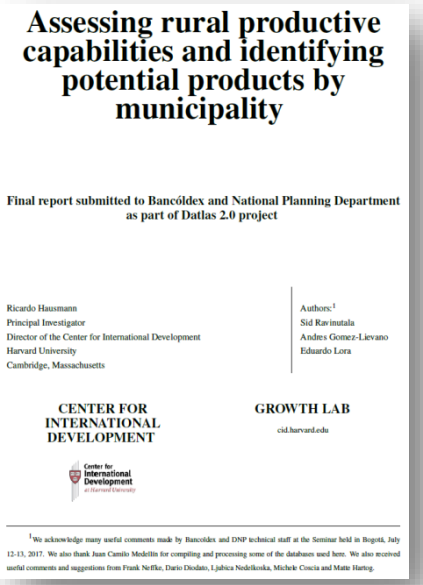

Assessing rural productive capabilities and identifying potential products by municipality

Final report submitted to Bancóldex and National Planning Department as part of Datlas 2.0 project

Ricardo Hausmann
Principal Investigator
Director of the Center for International Development
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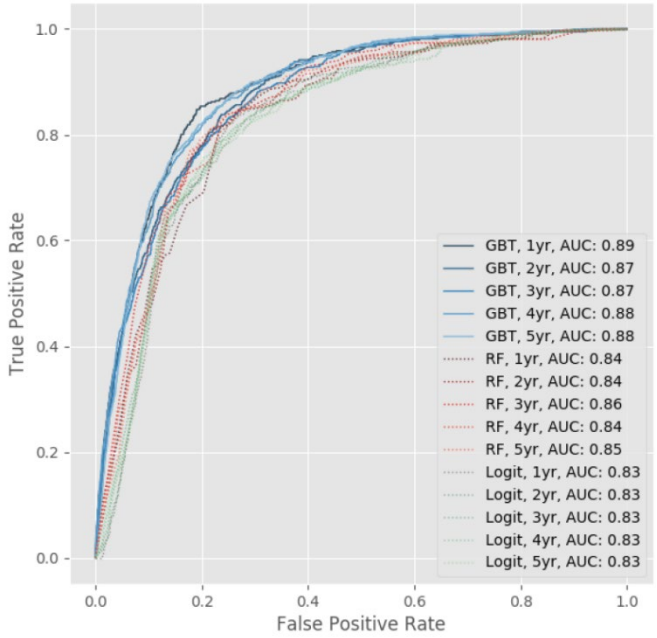
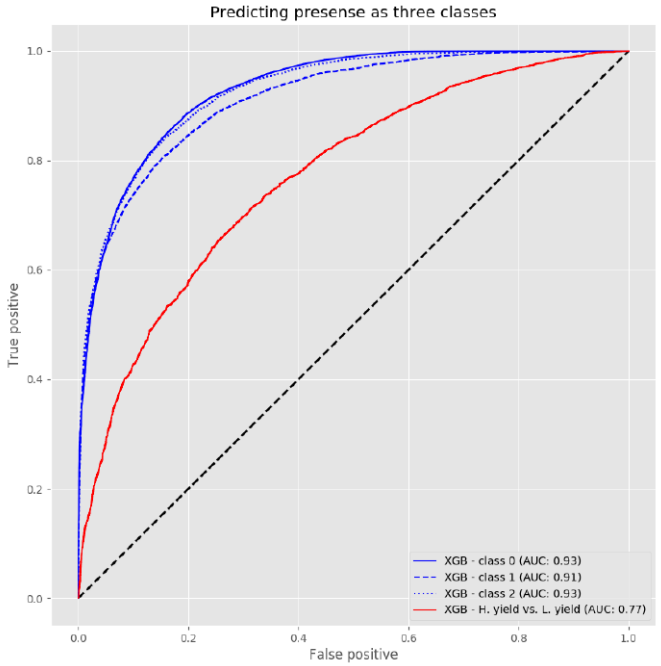
Theory + ML = great results

¿Can city 'C' export international product 'P'?



¿Can municipality '*C*' produce agricultural product '*P*'?



Class 0: 'not produced' vs. other two classes
Class 1: 'produced at low yield' vs. other two classes
Class 2: 'produced at high yield vs. other two classes

Note: the red line shows results from a model predicting high-yield vs. low-yield. Therefore it only considers places where the crop is grown

Figure 17: Predicting three classes of yield

Example: Cúcuta. Exports, employment and its agricultural production

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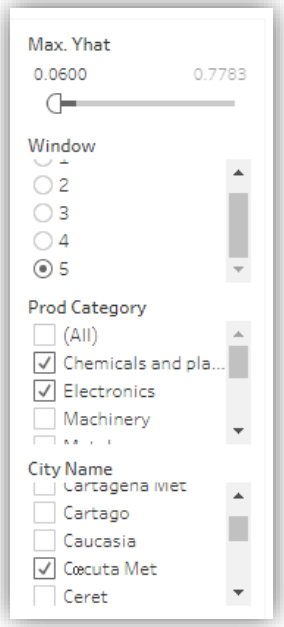

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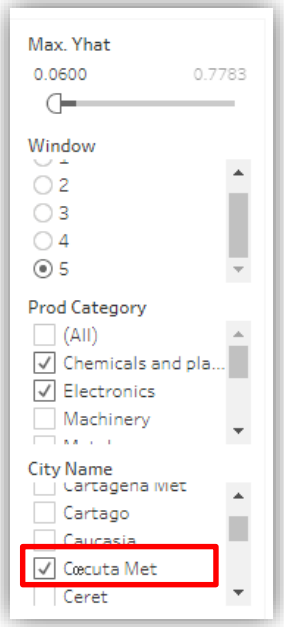

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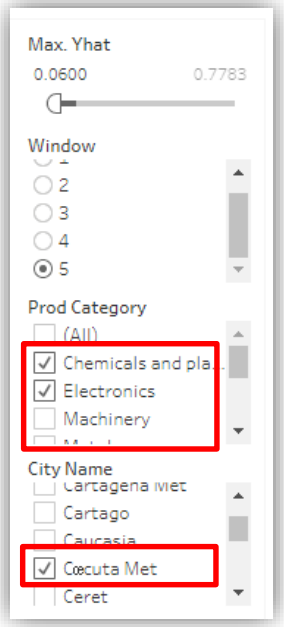

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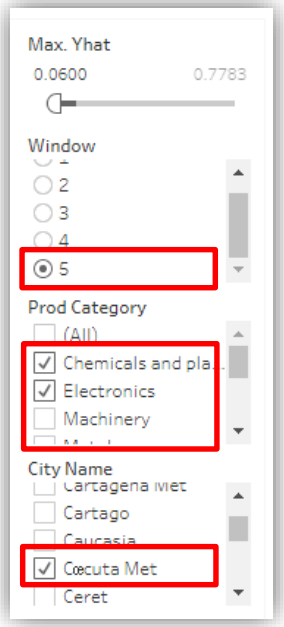

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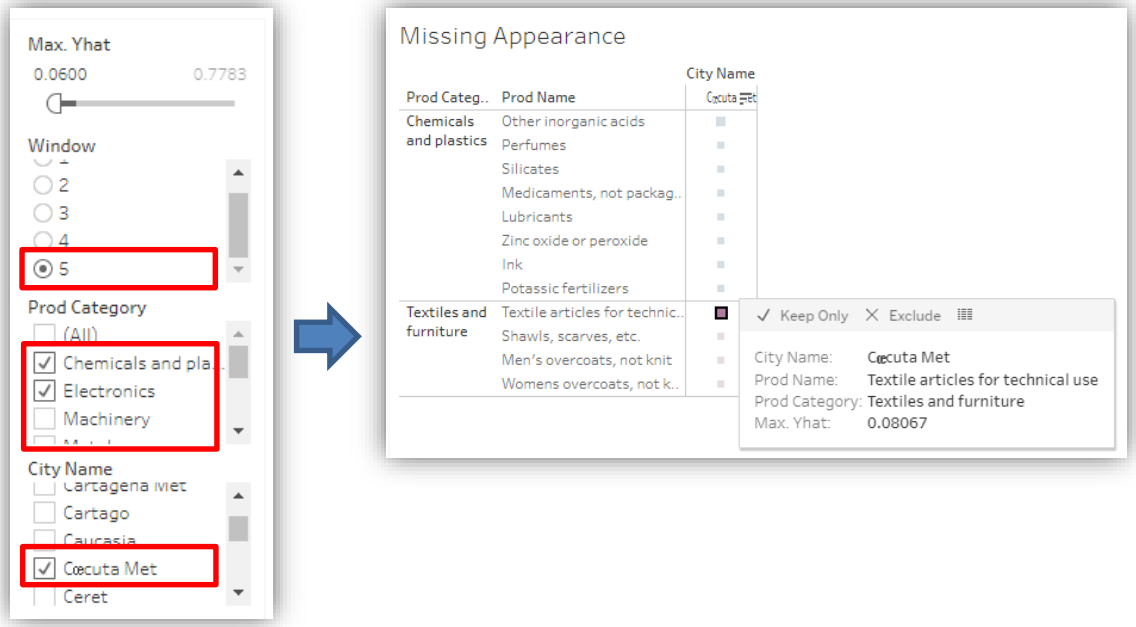

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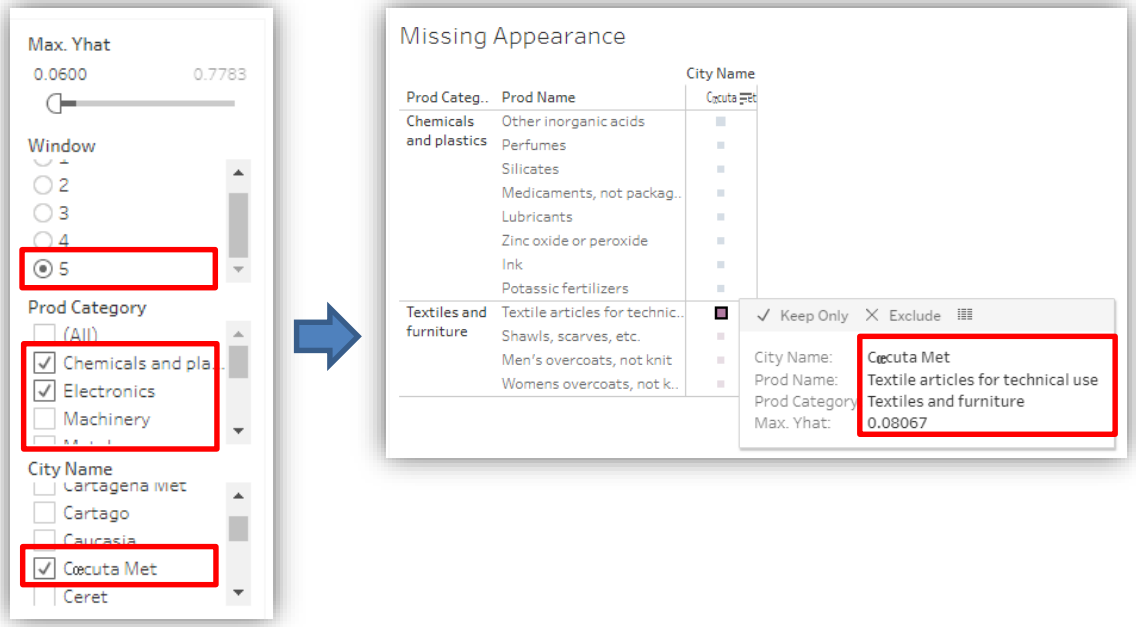

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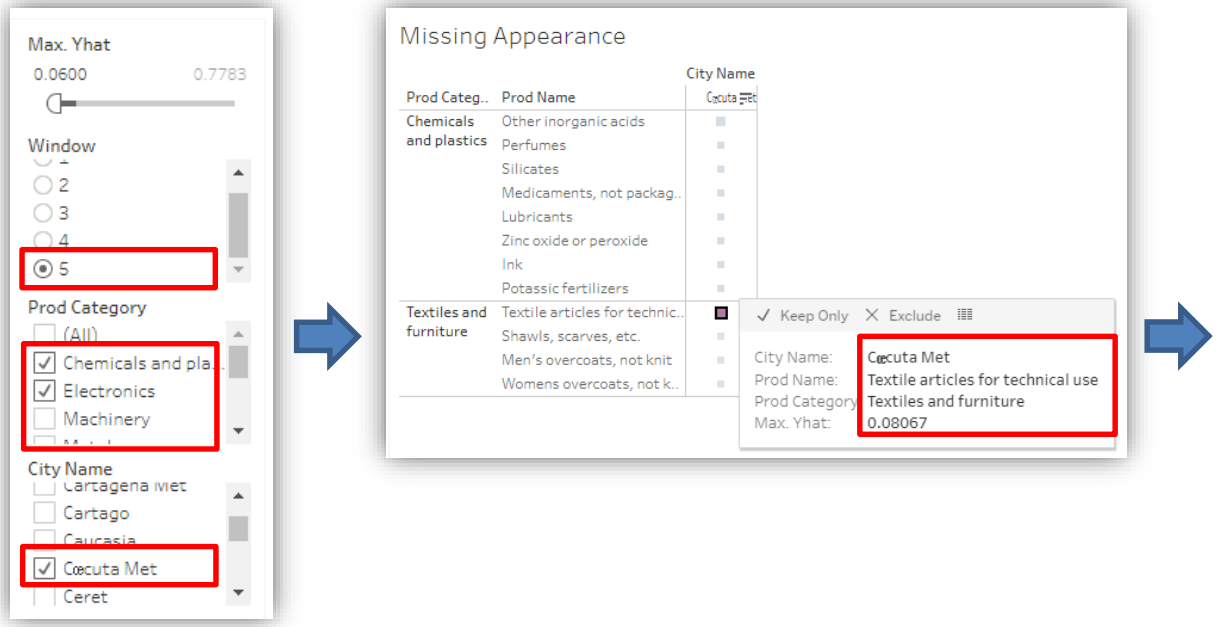

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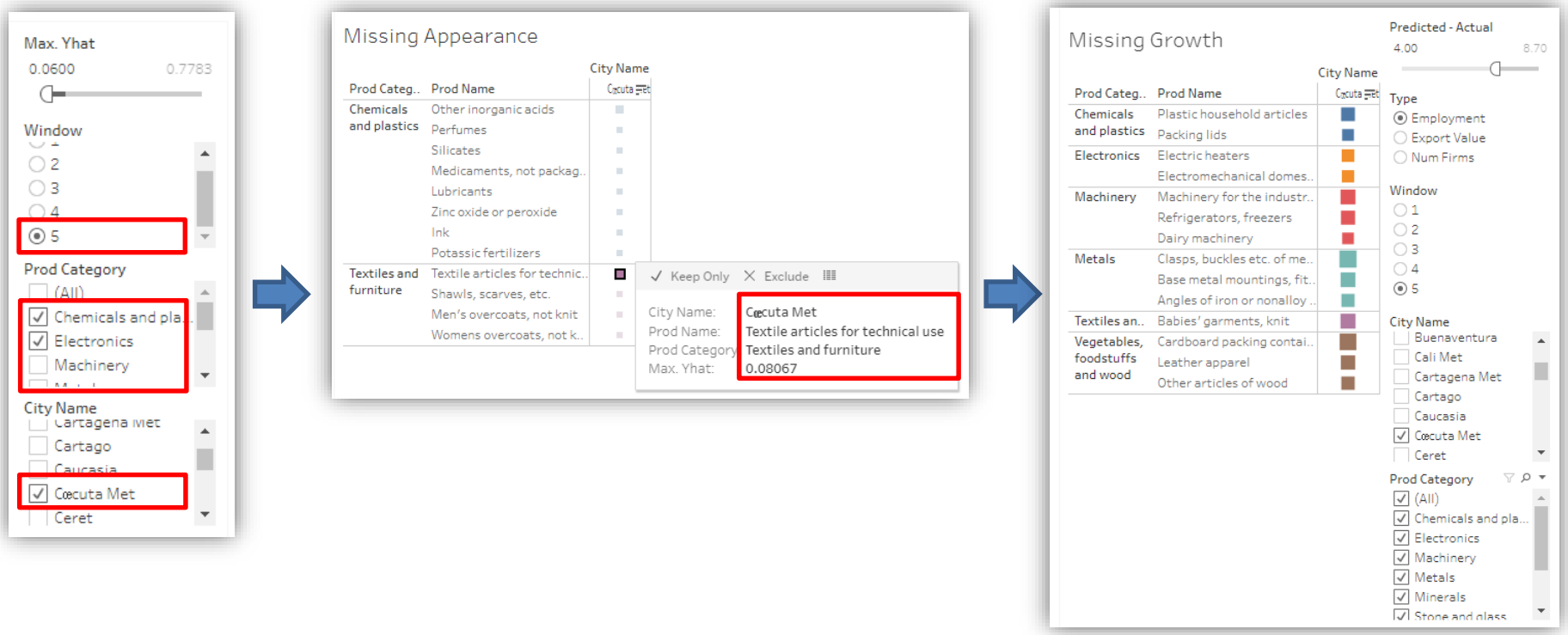

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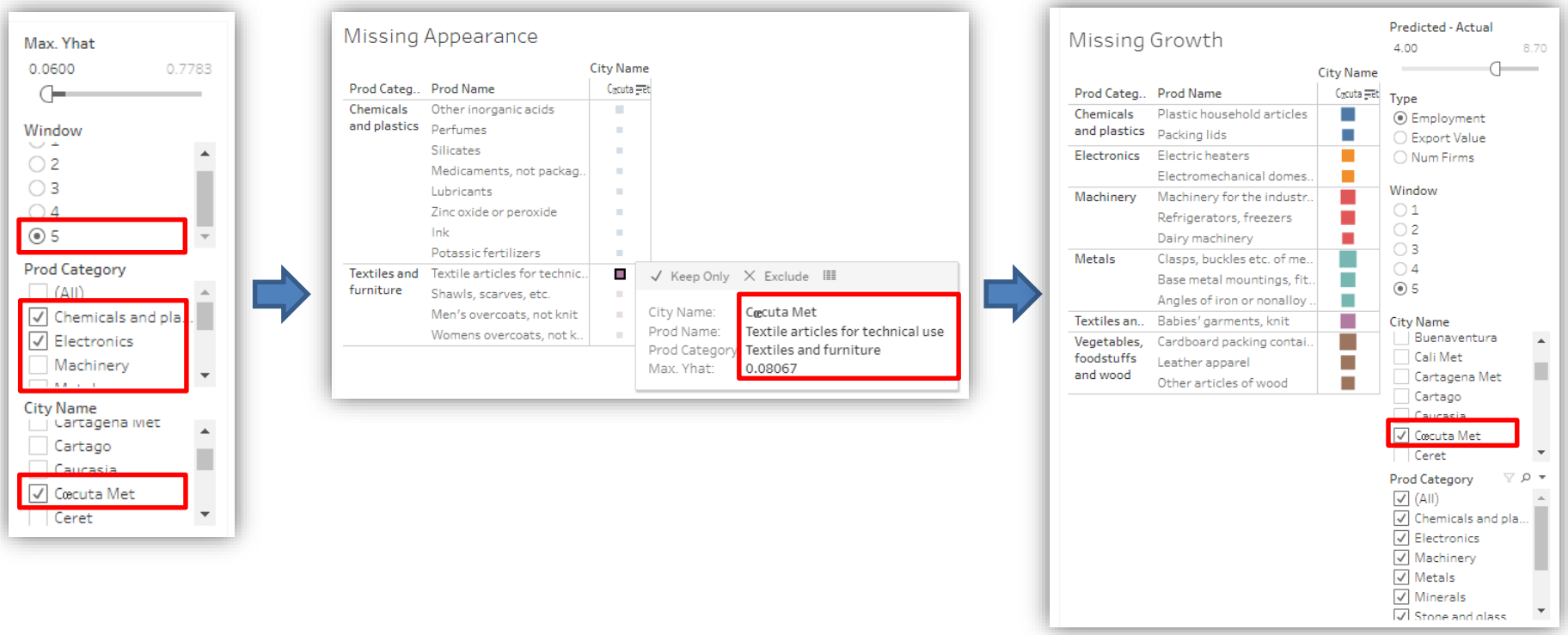

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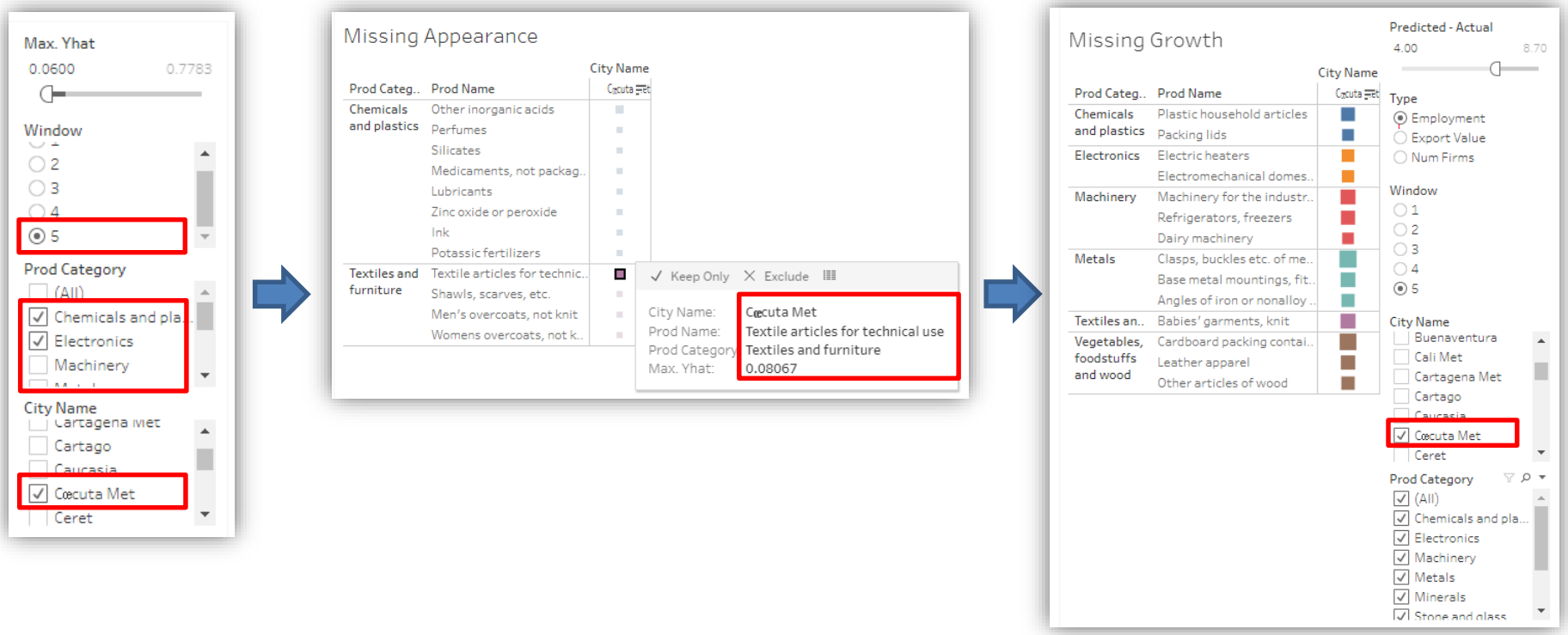

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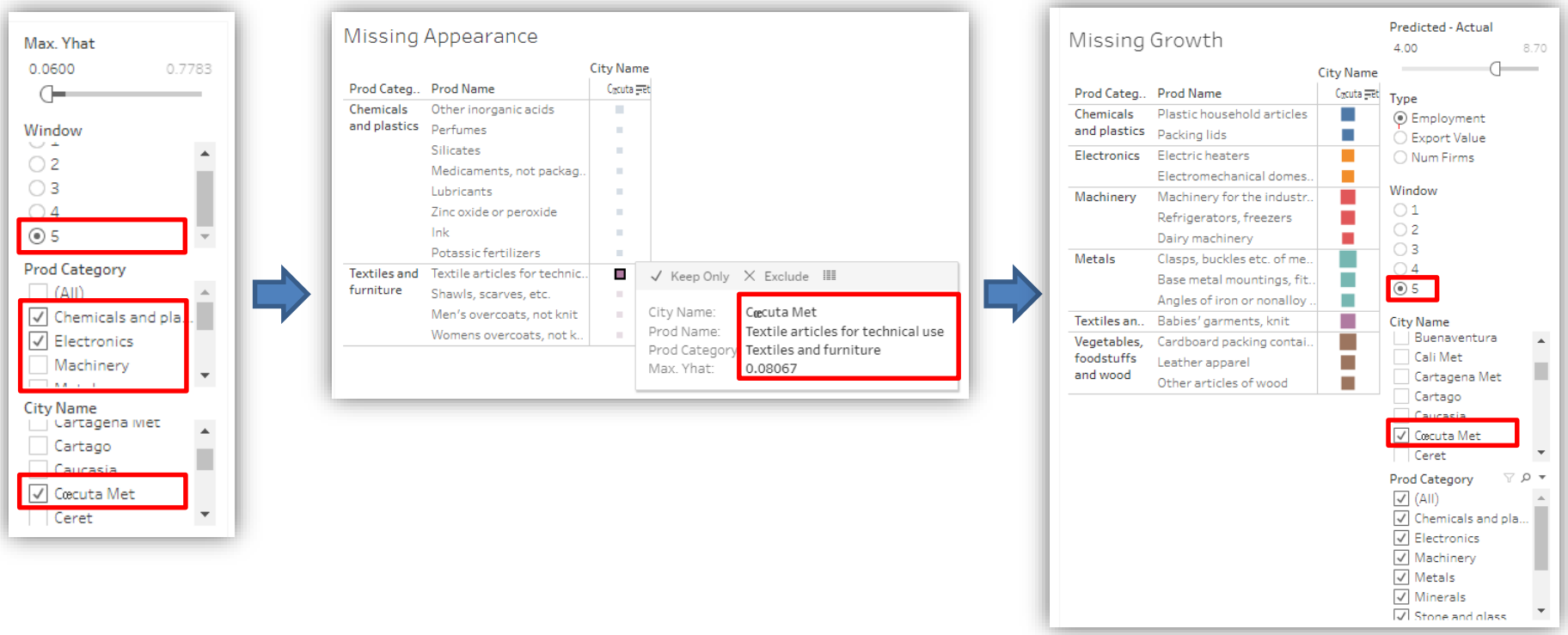

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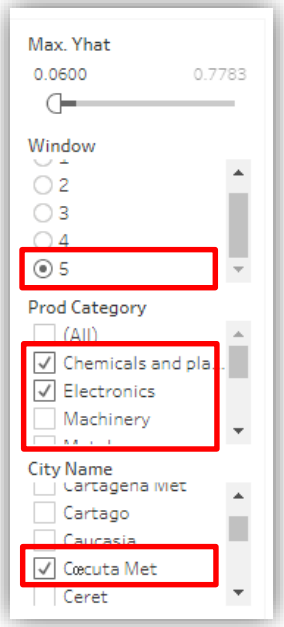

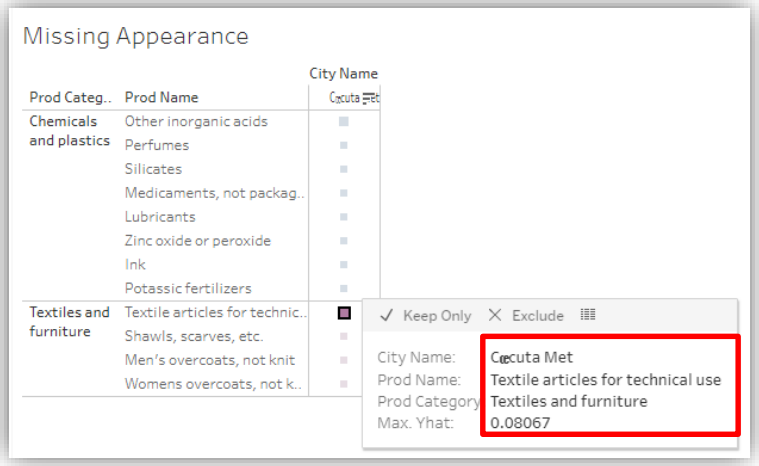

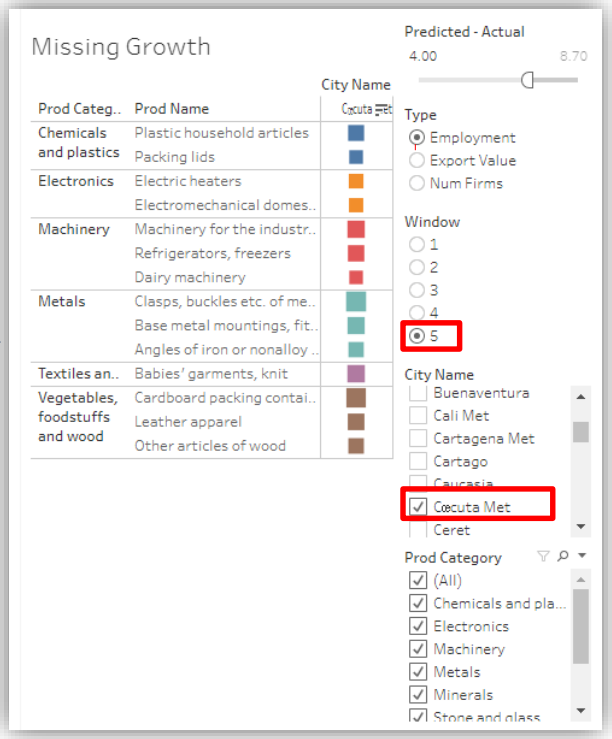

- **Motivation, background, context**
- **Statistics:**
  The “view from above”
- **Dynamics:**
  How do cities diversify?
- **Examples of applied work**

THANK YOU

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