Power law distributions of patents as indicators of Innovation.

Dion O’Neale & Shaun Hendy
Patents as a measure of innovation

Source: triadic patents, OECD
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The data

OECD HAN data set (2011)
• 22 countries
• ~8.7M patent records
• ~824,000 unique patent applicants
• ~1.7M applicant names
Power law distribution of patents

\[ p(x) = Cx^{-\alpha} \]

In summary, we have found that the distribution of patents amongst applicants within OECD countries generally follows a power law, and that these power laws are not universal in that their scaling exponents differ significantly between countries. Using this exponent as a proxy for innovation provides a new way of looking at the structure of national economies and strengthens the analogy between innovating firms and ecosystems.

There have been many studies that have linked the market value or productivity of firms to their stock of knowledge as measured by R&D expenditure and patents held [28]. This suggests that the distributions of productivity and patents are also linked at the firm level. It is remarkable then that the characteristics of the overall patent distributions found here vary so little from country to country, despite the variety of sizes, locations and industrial structures encompassed by this set of countries. In fact it appears that much of the difference between countries can be captured by rather simple measures such as economy-wide research and development expenditures and intensities.

Figure 2. Cumulative density functions and power law fits for the 22 countries in the data set.

Figure 3. Power law exponents, sorted by rank.

Values of \( \alpha \), with their associated estimated uncertainties, for the 22 countries in the EPO HAN data set (black), sorted by \( \alpha \), along with average \( \alpha \) sim values (red), and their associated standard deviations, for simulated data. For each country’s simulation, the growth rate was determined by the ratio \( c \sim N_{\text{app}} / N_{\text{pat}} \) from Tab. 1.

\[ FI x_{\min} = 3 \alpha = 1.98 \pm 0.041 \text{ p} = 0.48 \]
Power law exponents vary between countries
Power law exponents as economic indicators
Power law exponents as economic indicators

Graphical explanation of diversity and ubiquity.

Diversity (k_{c,0}): Diversity is related to the number of products that a country is connected to. This is equal to the number of links that this country has in the network. In this example, using a subset of the 2009 data, the diversity of Netherlands is 5, that of Argentina is 3, and that of Gana is 1.

Ubiquity (k_{p,0}): Ubiquity is related to the number of countries that a product is connected to. This is equal to the number of links that this product has in the network. In this example, using a subset of the 2009 data, the ubiquity of Cheese is 2, that of Fish is 3 and that of Medicaments is 1.

C. Hidalgo & R. Hausmann, PNAS (2009)
Patent distributions from a Yule process

Preferential Attachment + Growth

- New applicants enter with prob. $\gamma$
- New patents enter with prob. $1-\gamma$
- New patents attach preferentially
- Choose $\gamma$ to fix $N_{\text{pat}}$ & $N_{\text{app}}$
Patent distributions from a Yule process

Simulation
Empirical

rank

α

JP
CH
US
FR
BE
AT
DE
FI
CA
DK
IE
GB
SE
IL
NO
ES
IT
CN
PT
CZ
PL
Problems with the Yule process

- No “death” of applicants
- No shared patents
- No additional firm “size” information
Summary

- Power law distribution of patents differs between countries
- Lower power law exponents imply greater economic complexity
- National Investment in R&D is correlated with lower exponents.

D.R.J. O’Neale & S.C. Hendy, PLOS ONE, 7(12), e49501, 2012