Measuring the impact of quantitative metrics on Global Firm Innovation Rankings: The case of R&D intensity and patents

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Introduction

- Innovation has for a long time been serves as a driver for long term economic growth and development. However, variables that explain how companies are ranked on global innovation rankings remain a debatable subject.

- For that reason, our research aims provide clarity to this debate and better understand the metrics that lead to innovation and firms' positions on innovation rankings.

Literature

During the literature review, we identifies several metrics to measure innovation within companies:

Conventional Metrics:

- ▶ Patents
- ▶ R&D (R&D spending, R&D intensity)
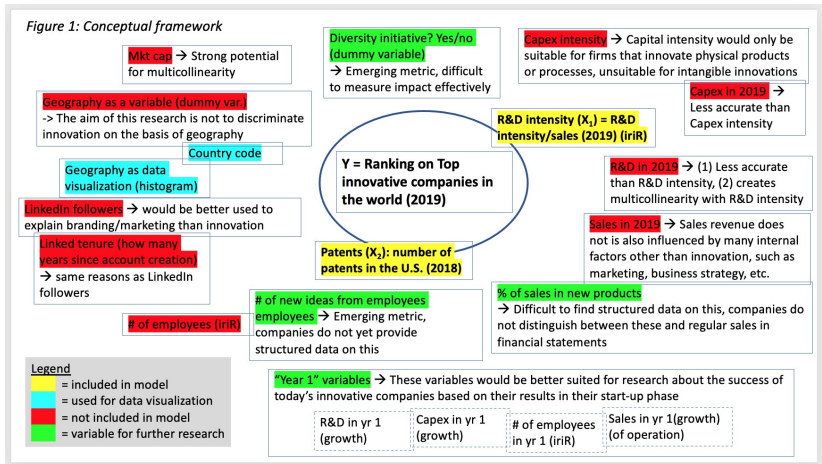
Emerging metrics:

- ▶ Subjective surveys
- ▶ Market cap
- ▶ Serving end users with innovations & other metrics

Research Question

"What is the Impact of number of patents granted in the U.S. and R&D intensity on the ranking of the Top 30 innovative companies"

Conceptual framework

Figure 1: Conceptual framework

Mkt cap → Strong potential for multicollinearity

Geography as a variable (dummy var.) -> The aim of this research is not to discriminate innovation on the basis of geography

Country code

Geography as data visualization (histogram)

LinkedIn followers → would be better used to explain branding/marketing than innovation

Linked tenure (how many years since account creation) → same reasons as LinkedIn followers

# of employees (iriR)

Diversity initiative? Yes/no (dummy variable) → Emerging metric, difficult to measure impact effectively

Y = Ranking on Top innovative companies in the world (2019)

Patents (X_2): number of patents in the U.S. (2018)

# of new ideas from employees employees → Emerging metric, companies do not yet provide structured data on this

Capex intensity → Capital intensity would only be suitable for firms that innovate physical products or processes, unsuitable for intangible innovations

Capex in 2019 → Less accurate than Capex intensity

R&D intensity (X_1) = R&D intensity/sales (2019) (iriR)

R&D in 2019 → (1) Less accurate than R&D intensity, (2) creates multicollinearity with R&D intensity

Sales in 2019 → Sales revenue does not is also influenced by many internal factors other than innovation, such as marketing, business strategy, etc.

% of sales in new products → Difficult to find structured data on this, companies do not distinguish between these and regular sales in financial statements

"Year 1" variables → These variables would be better suited for research about the success of today's innovative companies based on their results in their start-up phase

R&D in yr 1 (growth)	Capex in yr 1 (growth)	# of employees in yr 1 (iriR)	Sales in yr 1(growth) (of operation)

Legend
= included in model
= used for data visualization
= not included in model
= variable for further research

Variables

Variable	Description
rank	ranking of most innovative companies (1 to 30)
country code	ISO code of country
company name	name of the conpmanies
year	time of the ranking (2019)
RD_intensity	R&D intensity of companies in 2019 ()
Patents_2018	number of patents granted to the companies in the US in 2018 (1 = 1000 patents)
indicator	2 = Top 10, 1 = Top 20 & 0 = Top 30
geographical_loc	geographical location of the companies

Models: Ordinal Logistic Regression

In an ordinal logistical regression, the output is the **Odds** of the a giving possible outcome as demonstrate in the following formula:

$$logit(P(Y < i)) = \beta_0 - \beta_1.x_1 - \beta_2.x_2 - \beta_3.x_3 - \epsilon$$

Checking for quadratic effect and interraction in variables:

- Model 1: $logit(P(indicator)) = \beta_0 - \beta_1.RD - \beta_2.patent$
- Model 2: $logit(P(indicator)) = \beta_0 - \beta_1.(RD)^2 - \beta_2.patents$
- Model 3: $logit(P(indicator)) = \beta_0 - \beta_1.RD - \beta_2.(patents)^2$
- Model 4: $logit(P(indicator)) = \beta_0 - \beta_1.RD - \beta_2.patents - \beta_3.(RD.patents)$

Results in R

	Dependent Variables:			
	Indicator			
	Model 1	Model 2	Model 3	Model 4
RD_intensity	-0.05697	-0.05697	-0.05697	-0.069308
Patent_2018	0.72495	0.72495	0.72495	0.63663
RD_intensity . Patent_2018				0.007523
Intercept:				
0|1	-0.2799	-0.2799	-0.2799	-0.4325
1|2	1.167	1.167	1.167	1.0157
Observation	30	30	30	30
Residual Deviance	59.8637	59.8637	59.8637	59.85396
AIC	67.8937	67.8937	67.8937	69.85396

Estimates

The estimates function for model 1 is the following: ($Y = 2$ for "Top 10", 1 for "Top 20" and 0 for "Top 30"):

- ▶ $P(Y < 1) = -0.2799 - (-0.05697).RD - 0.72495.patents$
- ▶ $P(Y < 2) = 1.167 - (-0.05697).RD - 0.72495.patents$

The estimates function for model 4 is the following: ($Y = 2$ for "Top 10", 1 for "Top 20" and 0 for "Top 30"):

- ▶ $P(Y < 1) = -0.4325 - (-0.069308).RD - 0.63663.patents - 0.007523(RD.patents)$
- ▶ $P(Y < 2) = 1.0157 - (-0.069308).RD - 0.63663.patents - 0.007523(RD.patents)$

Interpretation

Since model 1,2 & 3, AIC score is lower than model 4's (**67.8637** < **69.85396**), therefore any of the first 3 model can be consider as the "best" model

With this knowledge, the following statements can be made:

► For every one unit increase in R&D intensity, the odds of being in the upper rank (top 10 or top 20 versus top 30) is multiplied **0.06** (1-0.94)times, holding constant all other variables.

► For every one unit increase in patent, the odds of being in the upper rank (top 10 or top 20 versus top 30) is multiplied **2.06** times, holding constant all other variables.

Discussion

▶ In addition to our reseach question, we have run a research to understand the state of art of the initiatives that could foment innovation and help the countries push up their companies on this list.

▶ Our findings show as the main important constructs to be considered: The Triple Helix Theory, Diversity incentive, and Open Innovation adoption

The Triple Helix Theory

▶ Refers to the university–industry–government triad, the interaction between these parties is at the core of innovation and growth in increasingly knowledge-based societies

Diversity incentive Studies have shown that:

- eliminating the patenting gap of female holders of science and engineering degrees would increase gross domestic product (GDP) per capita by 2.7%

- including more women and African Americans in the initial stage of the innovation process would increase GDP between 0.64 and 3.3% per capita

Open Innovation adoption

► OI represents a shift from that old industry practice, driven by the new increasing opportunities to collaborate with external partners and individuals to find new innovative ideas. Some countries such as the USA, Australia and Singapore established open innovation policies at the national level to leverage an innovation culture.

Conclusion

Our findings are a step in the right direction when answering our initial question.

- ► R&D intensity and patents are considered as closed innovation and this research highlights the need for metrics that measure the effect of open innovation, as well as government support and diversity initiatives.

- ► Such metrics can potentially capture the true essence of innovation and provide insights as to how firms can rise in innovation rankings and how countries can foster innovation to drive economic growth.

Limitations & Further research

Project limitations:

- ▶ Our sample size is statistically significant, but not large enough to make generalizations
- ▶ Our sample is not an accurate representation of the population since most of the companies are large and U.S firms

Further research:

- ▶ Create models using more than two variables to explain innovation
- ▶ Use panel data to evaluate the changes in company rankings over time
- ▶ Define metrics for open innovation and incorporate them to the model creation