Creative Innovation: Happy, Healthy, Wealthy, or Wise?

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Project Definition

As a concept, innovation requires tackling problems in new, creative ways. There are many discussions concerning the concepts of innovation and creativity in terms of breakthroughs in technology, disruption by the gig economy, advances in treating diseases, and more. However, how can creativity be defined in a quantitative manner, and are creative nations by definition also more innovative? Is innovation impacted by educational, personal, financial, and societal structures of a nation? How can all of these relationships be effectively measured in a relatable way? We intend to address those questions by determining innovation across the world by analyzing creativity, and then crafting a means to visually showcase the "what", "why", and "how" of innovation at a country level. Our visualization will also be able to contrast each country's level of innovation to data concerning health (life expectancy), wealth (GDP), wisdom (education), and happiness (quality of life) or a combination thereof. [HQ1]

Research Survey & Project Breakdown

How is innovation quantified? Many measurements have been attempted up to today, including relating the quantity of innovation in a nation to available social capital (1), human capital (2), entrepreneurial orientation & cultural values (3), non-business factors in public and household sectors (4), creativity itself through the generation of a "bohemian" index based on data around performing arts, museums, and more (5), financial markets (6), and resources including investments and seed funding (7). These findings could prove useful to us when building out our innovation index as they provide a wide view into the kinds of factors that have been examined in the past. Others have taken a more comprehensive approach, generating innovation indices based on governmental policies and institutions of several nations (8), or combining a large number of innovation predictors across research, business, and economic sectors into a single synthetic variable (9). These studies are relevant to us as the indices described can be used to compare against our own index. Researchers also spent time focusing on entrepreneurship, which has also been shown to play a significant role in innovation - though the effect was impacted substantially by differences in cultural norms (3). Similarly, the presence of foreign owned companies in a nation (10) and as well as relationships built between subsidiaries of a foreign company and its host (11) also show demonstrable increases in the measure. While interesting, factors such as entrepreneurship, cultural norms, and foreign-owned investment are not a focus of our work. Researchers also discovered that country-specific factors play a role in innovation - for example, it has been shown that lower income countries produce a wider variation of solutions to problems (12), and that the concept of "innovation" in general varies based on economic context when comparing OECD versus developing nations (13). These factors will certainly play a role in our work as we look to create an innovation index that is valid for all nations regardless of economics or level of development.

Quantifying creativity as a concept has been explored via analysis of a similarly wide set of parameters. Pratt & Jeffcutt, for example, found that a set of 13 discrete creative industries such as film and recorded music can be used as an organizing mechanism for predictive attributes (14), while others found that a single mechanism, such as export performance, had an impact on creativity (15). Looking at creative industries will be useful when computing our innovation

index. Additionally, research has shown how certain metrics related to innovation (such as income and education) impact each other positively (16), and whether happiness is correlated to creativity (17). These two studies show relationships to measures of innovation and creativity, and therefore will prove useful to us due to our focus in those areas. Innovation is difficult to quantify; as research has demonstrated, there are many factors that can affect the measure, and they vary by nation. Starting with creativity is our way to lessen the impact of economic factors on developing nations. [HQ2] Through this seven week analysis, we plan to measure innovation through a number of factors tied to both economic and non-economic factors, and then try to identify predictors at a country level. Data will be gathered from a variety of sources and then reduced through the use of regression and graph analysis to compute an innovation index, which can then be used to compare countries in the common measures described below [HQ8]. New in our approach is combining a mix of sources including both creative fields such as film and music and economically-significant measures, like patents, as we look to build an innovation index based on creativity. Our visualization will allow users to view not only our index, but the related measures of life expectancy, GDP, quality of life, and education alone or combined. [HQ3] This approach will be extremely useful to government officials in developing countries as well as investors across the world as they look to build a global marketplace. [HQ4] If successful, a new way of computing innovation through creativity will be introduced. We will be able to validate our findings by comparing them with existing efforts such as Lee et al.'s Bohemian Index (5), and Lopez-Claros & Mata's Innovation Capacity Index (8). [HQ5] Through research, we discovered that many existing studies lacked recent data which could have a significant impact in how innovation is measured due to the global spread of technology, including Saint Paul & Verdier

(16), Almeida & Phene (11), Dahkli & DeClercq (2), DiPietro & Anoruo (15), and Pratt & Jeffcutt (14), while other studies limited their focus to only a few usually wealthy and/or developed nations, including Dachs et al. (10), Rauch et al. (3), Williams & McGuire (18), and Griffiths et al. (7) which impacts the validity of the data on a worldwide scale. Others still compared a wide variety of variables that could introduce unexpected outliers in the data depending on the nation, including Fagerberg et al. (13), Lopez-Claros & Mata (8), Lee et al. (5), Crespo & Crespo (12), Roszko-Wójtowicz & Białek (9), Gault (4), and Polatcan et al. (1). Others focused on only one factor, which reduces the potential for identifying multiple factors contributing to findings, including Hsu et al. (6) and Ceci & Kumar (17). There is a risk that we may not be able to locate a recent enough and broad enough cache of data to confidently produce our results. The payoff of this work includes a visualization that provides a unique perspective into how and where to spark innovation worldwide. [HQ6] The financial cost of this analysis is negligible. [HQ7] Progress will be measured as follows: first, in terms of building and validating the innovation index relative to creativity against existing research; second, the interactive visualization showcasing our findings; and third, the completed report and presentation [HQ9].

Team Division of Work

Research	**All**	30h
Proposal Paper	**Michael**	10h
Data Collect / Clean	**Marc**	25h
Data Integration	**Ricardo/ Minkwon**	25h
Deployment	**Ricardo / Minkwon**	10h
UI Visualization	**Lisa / Cathy**	35h
Data Analysis	**Everyone**	30h
Progress Report	**Michael**	5h
Final Paper	**Michael**	20h
Slides / Presentation	**Cathy / Marc**	15h
Project Management	**Cathy**	10h
Poster	**Lisa**	10h

References & Appendix

1. Polatcan, M., & Balcı, A. (2019). Social Capital Wealth as a Predictor of Innovative Climate in Schools. *International Journal of Contemporary Educational Research*, *6*(1), 183-194.
2. Dakhli, M., & De Clercq, D. (2004). Human capital, social capital, and innovation: a multi-country study. *Entrepreneurship & regional development*, *16*(2), 107-128.
3. Rauch, A., Frese, M., Wang, Z. M., & Unger, J. (2010). National cultural values, firm's cultural orientations, innovation, and performance: testing cultural universals and specific contingencies across five countries. *Frontiers of Entrepreneurship Research*, *30*(15), 4.
4. Gault, F. (2018). Defining and measuring innovation in all sectors of the economy. *Research policy*, *47*(3), 617-622.
5. Lee, S. Y., Florida, R., & Gates, G. (2010). Innovation, human capital, and creativity. *International Review of Public Administration*, *14*(3), 13-24.
6. Hsu, P., Tian, X., & Xu, Y. (2014). Financial development and innovation: Cross-country evidence. *Journal of Financial Economics, 112*(1), 116-135.
7. Griffiths, M., Gundry, L., Kickul, J. and Muñoz Fernandez, A. (2009), "Innovation ecology as a precursor to entrepreneurial growth: A cross-country empirical investigation", Journal of Small Business and Enterprise Development, Vol. 16 No. 3, pp. 375-390.
8. Lopez-Claros, A., & Mata, Y. N. (2010). The innovation capacity index: factors, policies, and institutions driving country innovation. In *The Innovation for Development Report 2009–2010* (pp. 3-65). Palgrave Macmillan, London.
9. Roszko-Wójtowicz, E., & Białek, J. (2016). A multivariate approach in measuring innovation performance. *Zbornik radova Ekonomskog fakulteta u Rijeci, časopis za ekonomsku teoriju i praksu-Proceedings of Rijeka Faculty of Economics, Journal of Economics and Business*, *34*(2), 443-479.
10. Dachs, B., Ebersberger, B., & Lööf, H. (2008). The innovative performance of foreign-owned enterprises in small open economies. *The Journal of Technology Transfer*, *33*(4), 393-406.
11. Almeida, P., & Phene, A. (2004). Subsidiaries and Knowledge Creation: The Influence of the MNC and Host Country on Innovation. *Strategic Management Journal, 25*(8/9), 847-864. Retrieved February 22, 2020, from www.jstor.org/stable/20142164
12. Crespo, N. F., & Crespo, C. F. (2016). Global innovation index: Moving beyond the absolute value of ranking with a fuzzy-set analysis. *Journal of Business Research*, *69*(11), 5265-5271.
13. Fagerberg, J., Srholec, M., & Verspagen, B. (2010). Innovation and economic development. In *Handbook of the Economics of Innovation* (Vol. 2, pp. 833-872). North-Holland.
14. Pratt, A. C., & Jeffcutt, P. (2009). *Creativity, innovation and the cultural economy*. Routledge.
15. DiPietro, W. R., & Anoruo, E. (2006). Creativity, innovation, and export performance. *Journal of Policy Modeling*, *28*(2), 133-139.
16. Saint-Paul, G., & Verdier, T. (1993). Education, democracy and growth. *Journal of development Economics*, *42*(2), 399-407.
17. Ceci, M. W., & Kumar, V. K. (2016). A correlational study of creativity, happiness, motivation, and stress from creative pursuits. *Journal of Happiness Studies*, *17*(2), 609-626.
18. Williams, L.K., McGuire, S.J. Economic creativity and innovation implementation: the entrepreneurial drivers of growth? Evidence from 63 countries. Small Bus Econ 34, 391–412 (2010).

Heilmeier Questions [HQ]

Proposal must answer all 9 of these, or we lose a ton of points. Michael (Miggs) will combine the answers to these as part of Project Summary and Research Survey.

1. What are you trying to do? Articulate your objectives using absolutely no jargon. *We are trying to discover through data analysis the definition of what makes a nation innovative, as well as common factors that could influence the innovativeness of nations around the world (economics, lifestyle, education, health). We do not know for sure if these links exist; we are looking to discover the answer through this project.*

2. How is it done today; what are the limits of current practice? *There are many ways in which innovation of a nation can be measured; we are hoping to utilize a variety of measures to produce a unique picture of what makes a nation innovative as well as identifying potential factors that could have contributed to that result (either correlative or causative).*

3. What's new in your approach? Why will it be successful? *We are utilizing a unique combination of datasets [EXAMPLES] to define the concept of what makes a nation innovative as well as investigating other factors in new ways. Our visualization will express this information in an easily-digestible format which will effectively communicate a large degree of information to users.*

4. Who cares? *Government officials and potential investors in developing areas of the world would find this data interesting in terms of understanding how and where to focus potential investment.*

5. If you're successful, what difference and impact will it make, and how do you measure them (e.g., via user studies, experiments, ground truth data, etc.)? *Our tool would be useful for research and investment purposes to identify characteristics of developing nations that could be primed for significant investment. (NOTE: We should look carefully at certain nations in Africa and SE Asia which are currently receiving large investments in infrastructure and technology and see how those changes are impacting those nations based on our innovation index). We could verify the data through identifying whether the increasing the related factors for innovation show an improvement in our innovation index. We could complement this further data analysis with user studies, etc.*

6. What are the risks and payoffs? *Risks: causation versus correlation - are the measures we are taking actually responsible for innovation, or is innovation responsible for the increases in those measures (e.g. better innovation in medicine leads to better health outcomes)? Recency of studies. However, if a direct link can be proven out through the analysis of the provided data, this could provide a unique viewpoint into how and where to invest in nations around the world.*

7. How much will it cost? *We are using publicly available datasets and research in the preparation and development of our project; the only real cost is time.*

8. How long will it take? *Based on the deliverable timelines of our project, the maximum amount of time this analysis will take is approximately eight weeks.*

9. What are the midterm and final "exams" to check for success? How will progress be measured? *The first checkpoint will be building the innovation index itself and beginning to compare that number against other related datasets. The visualization which showcases innovation of nations around the world and the potential factors related to that finding will serve as the final deliverable.*

Paper Authors, Title, Year	Main Idea	Useful or Not & Why	Shortcomings	Category
Polatcan, M., & Balcı, A. (2019). Social Capital Wealth as a Predictor of Innovative Climate in Schools. *International Journal of Contemporary Educational Research*, *6*(1), 183-194.	Relationship found between social capital and innovative climate	Interesting, potentially applicable in the measures for health; mental health in particular (social capital <-> mental health)	Measuring social capital at societal level is difficult	QI
Crespo, N. F., & Crespo, C. F. (2016). Global innovation index: Moving beyond the absolute value of ranking with a fuzzy-set analysis. *Journal of Business Research*, *69*(11), 5265-5271.	Conditions for increased innovation are different between countries of varying incomes (low income has higher variation in solutions)	Could be used to explain differences in findings between low and high income countries, may necessitate further breaking apart of results	Finding an appropriate criteria to divide countries. Where is the 'cutoff'?	DF
Dakhli, M., & De Clercq, D. (2004). Human capital, social capital, and innovation: a multi-country study. *Entrepreneurship & regional development*, *16*(2), 107-128.	Human capital versus innovation (measures like patents, expenditures, high-tech export)	Human capital has been shown to affect innovation measures	Small dataset (59 countries)	QI

Rauch, A., Frese, M., Wang, Z. M., & Unger, J. (2010). National cultural values, firm's cultural orientations, innovation, and performance: testing cultural universals and specific contingencies across five countries. *Frontiers of Entrepreneurship Research*, *30*(15), 4.	Investigated entrepreneurial orientation and cultural values' relationship to innovation	Again, useful measures for looking at creativity and innovation	Another small dataset, but data uncovered is more detailed than most resources so far.	QI
Pratt, A. C., & Jeffcutt, P. (2009). *Creativity, innovation and the cultural economy*. Routledge.	Cultural economy consists of creative industries that contribute to innovation]	13 creative industries cited as contributors to predicting innovation	Based on 2009 data, so may be limited in terms of 'big tech', may require updating	QC
Dachs, B., Ebersberger, B., & Lööf, H. (2008). The innovative performance of foreign-owned enterprises in small open economies. *The Journal of Technology Transfer*, *33*(4), 393-406.	Relationship between foreign ownership and innovation.	Measurable predictive feature.	Small dataset (5 Nordic countries).	QI
Fagerberg, J., Srholec, M., &	Innovation means different	Can use different attributes to	One model may not cover all	DF

Verspagen, B. (2010). Innovation and economic development. In *Handbook of the Economics of Innovation* (Vol. 2, pp. 833-872). North-Holland.	things based on economic context (OECD vs developing countries)	predict innovation	cases	
William R. DiPietro, Emmanuel Anoruo, Creativity, innovation, and export performance, Journal of Policy Modeling, Volume 28, Issue 2, 2006, Pages 133-139, ISSN 0161-8938	Export performance has a positive relationship with creative activity	Relates creative activity to economic growth	A bit out of date - exports are digital more often now	QC
López-Claros A., Mata Y.N. (2010) The Innovation Capacity Index: Factors, Policies, and Institutions Driving Country Innovation. In: The Innovation for Development Report 2009–2010. Palgrave Macmillan, London	Innovation Capacity Index (ICI) computes innovation based on policies and institutions.	Well-defined framework of measuring innovation that we can use as a starting point.	Doesn't factor in all of what we're looking at. Policies and institutions vary based on nations.	QI
Sam Youl Lee, Richard Florida	Innovation is a joint product of	Measures of creativity	Only focuses on human capital.	QI

& Gary Gates (2010) Innovation, Human Capital, and Creativity, International Review of Public Administration, 14:3, 13-24	human capital and creativity.	(bohemian index) and diversity (gay index) are generated.	What other factors are at play?	
Williams, L.K., McGuire, S.J. Economic creativity and innovation implementation: the entrepreneurial drivers of growth? Evidence from 63 countries. Small Bus Econ 34, 391–412 (2010).	NA	NA	NA	
Hsu, P., Tian, X., & Xu, Y. (2014). Financial development and innovation: Cross-country evidence. *Journal of Financial Economics, 112*(1), 116-135.	Relationship between financial market and technological innovation	Economics is shown to influence tech innovation (patents & R+D expenses)	There may be other metrics that could impact these measures.	QI
Almeida, P., & Phene, A. (2004). Subsidiaries and Knowledge Creation: The Influence of the MNC and Host	Innovation relationship with technological richness of int'l companies, subsidiary knowledge	Maps back to papers showing relationship between level of innovation and foreign companies	Old data	QI

Country on Innovation. *Strategic Management Journal, 25*(8/9), 847-864.	related to host country, technical diversity with host country	(foreign ownership)		
Griffiths, M., Gundry, L., Kickul, J. and Muñoz Fernandez, A. (2009), "Innovation ecology as a precursor to entrepreneurial growth: A cross-country empirical investigation", Journal of Small Business and Enterprise Development, Vol. 16 No. 3, pp. 375-390.	Governmental, economic, and technological factors in innovation (resources, human capital, seed funding)	New variables like seed funding introduced.	Old data, 1995-2005	QI
Saint-Paul, G., & Verdier, T. (1993). Education, democracy and growth. *Journal of development Economics*, *42*(2), 399-407.	Paper gives a formula on how their statistics follow that voting, education, growth and income rise together.	We want to look at relationships between wealth and education, this shows they rise together	Old data (90s and before)	
Gault, F. (2018). Defining and measuring innovation in all sectors of the economy. *Research policy*, *47*(3), 617-622.	applies a systems approach to measure innovation across all economic sectors, not just the business sector	we can extend our analysis to other types of innovation, including public sector and household sector innovation. Especially important as	lack of consistent datasets across countries across sectors	QI

		developing countries have smaller business sectors.		
Roszko-Wójtowicz, E., & Białek, J. (2016). A multivariate approach in measuring innovation performance. *Zbornik radova Ekonomskog fakulteta u Rijeci, časopis za ekonomsku teoriju i praksu-Proceedings of Rijeka Faculty of Economics, Journal of Economics and Business*, *34*(2), 443-479.	it is a good idea to combine similar innovation predictors into a synthetic variable through the use of cluster or factor analysis in order to avoid colinearity.	this provides a methodology to derive the most impactful variables	this was done using European data, will attempt to extend this to other regions.	

Visualization Concepts

These visual concepts are ideas that may be implemented given time and possibility.


Innovation "pie chart", show the top 5-10 countries and everyone else as a slice of the lightbulb. This gives the main point of innovation and who is doing the best at innovating in the world.

$00k & a BS

is the inflection point of an

innovative society

Finding the influx point of average income and level of education that jumps the country into "innovative". If we find there's a gulf between innovative and not, we can find the other values. Finding a statement that someone can compare to themself individually makes this more impactful.
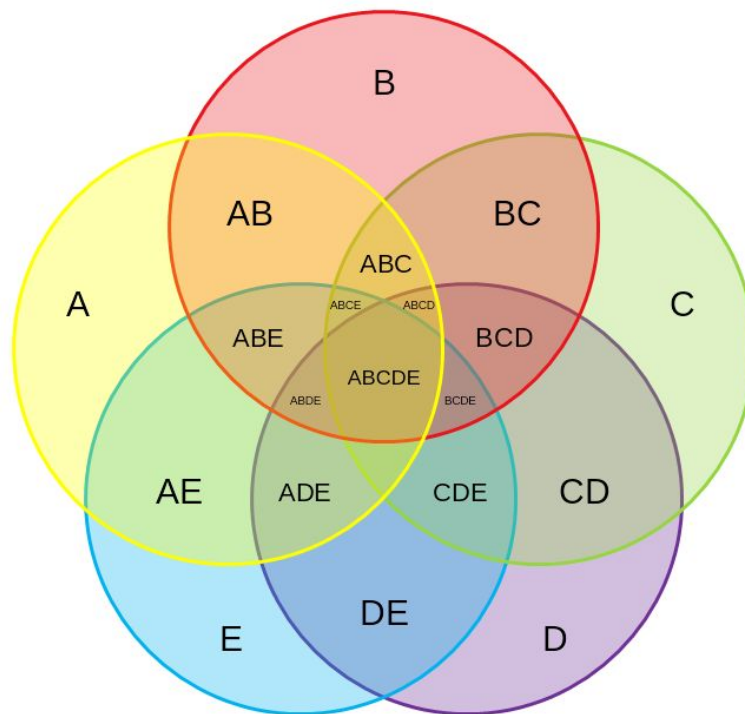
Depending on what and how many indices we have, have a venn diagram show an example of each section in the graph that fits those overlaps. Above example with 5 circles. Having a graph like this points examples of countries at different levels on each of the indices.
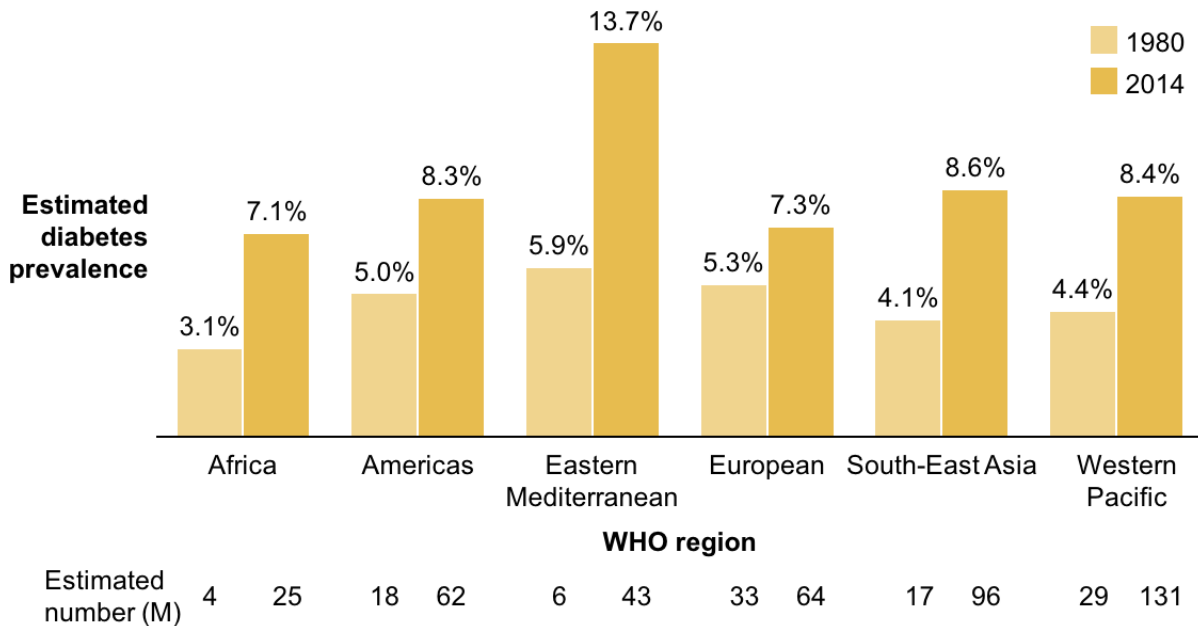
Source: WHO - Global Report on Diabetes (2016)

A bar chart for regions showing indices next to each other. Easy to combine their indices from each county located in the region to look at a glance. This is an example of a bar graph with multiple bars per region.

Amazon Alexa Skill: Alexa, according to the Poloclub…
- Who is the world's most innovative country?
- What region of the world is most innovative?
- What country is happy, healthy, wealthy and wise?
  - Is that same country the most innovative?

Icons in each of the circles that can be pressed to show values of their indices between wealth / education / health / mental health and innovation, each button is the information you turn on or off in the main graph. The main graph could be a map. This is the most interactive graph where all information would be available to the user.