Language Structure and its Effects on Behavior: A Study Evaluating the Association of Structural Differentiation of Languages and Innovation

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Abstract

In this project we seek to evaluate the role of differences within languages' grammatical structures in people propensity and capacity to innovate. The project utilizes the scientific notion that "the imprint of inherited cultural values in a language's grammar is rooted in the impact of language on cognition, forcing speakers to encode selectively, and shaping their mental representation of social reality (Chen, 2013). We attempt to extend the existing literature on linguistic-based influences on cognition by assessing the effect of structural variation within languages on the global quantitative and qualitative output of innovation. A number of previous studies evaluate a role of culture in regard to various forms of socio-economic behaviors, but the specific association of language-based cultural attributes and innovation-related productivity remains ambiguous and vague. In order to measure the effect of the linguistic diversity on people's propensity and capacity to innovate, we created language indices that reflect (1) gender distinctions, (2) individualistic and collectivistic emphases, and (3) hierarchy differentiation. The preliminary findings from our analysis of global patenting activity indicate that there may indeed be an association between these linguistic structural differences and innovative productivity. This project is relevant to the on-going literature in International Business, Strategic Management, and Linguistic and Culture studies. Outline of Literature Review & introduction of Hypotheses: In this project we expect to utilize assertions form linguistic and culture literature, such as the publication by Whorf (1956), as well as findings and propositions in the study of Applied Economics and International Business Management, such as the publications by Santacreu-Vasut et al (2013), ESantacreu-Vasut et al (2014), and Chen (2013). These studies evaluate scientific propositions, within the linguistic filed, that relate to the subject matter and exemplify how the cognition-related impacts of language structure lead to differentiated outcomes, and effect global economic behaviors and policies. Hypothesis 1a: Higher level of Female/Male distinction in a countries' dominant language will have a negative effect on this countries innovative output. Hypothesis 1b: Higher level of Female/Male distinction in a countries' dominant language will have a negative effect on female participation in innovation activities. Hypothesis 2: Higher level of individualism in a countries' dominant language structure will have a positive effect on this countries innovative output. Hypothesis 3: Higher level of formal hierarchy in a countries' dominant language structure will have a negative effect on this countries innovative output. Data: In order to measure the effect of the linguistic diversity on people's propensity and capacity to innovate, we created language indices that reflect (1) gender distinctions, (2) individualistic and collectivistic emphases, and

(3) hierarchy differentiation. The data regarding languages was imported from the World Atlas of Linguistic Structures (WALS).We intend to also utilize the USPTO database to compile country-specific and company-specific patent and citation information. Finally, we intend to create a primary database of inventor-level patenting information segmented by the gender of individual inventors. Going-Forward Study Design and Method: In order to test our hypotheses in a controlled and representative manner, we intend to implement a "top-down / bottom-up" approach, where a large-sample empirical study will be conducted at both country and industry levels. We will also supplement our preliminary dependent variable (per-capital volume of patents) with the associated patent-specific citations, in order to construct a "quality-adjusted measure of innovative output". Country-level empirical study & control mechanisms: In an effort to infer the effect of language structure on innovation we intend to conduct regression analysis of our linguistic-based structural differentiation indices against our data on quality-adjusted per-capita patent output. The utilization of a panel data analysis (i.e. our database consolidates patent output for a twenty-year period from 1992 to 2012) will allow us to control for the time-fixed effect in the regression, whereas the previously outlined use of per-capita distribution of patents will provide a control mechanism for the differences in countries' population sizes. We will also include a number of control variables in an effort to isolate the effect of language structure on innovation. Industry-level empirical analysis and a company-level case study: In order to test our hypothesis which examines the effect of gender-related language structure on female participation in innovation-oriented activity (hypothesis 1b), we intend to conduct an industry-level study of patenting activity by gender. Specifically, we plan to choose an industry that exhibits comparatively global distribution of patents (such as pharmaceutical or medical device) and select a time frame that that will limit the number of total patents to no more than ~ 3,000. We will then evaluate inventor-specific information (i.e. names of inventors are available at USPTO) and conduct additional research in order to determine the gender of each individual inventor. We will then analyze our previously described gender-differentiating language indices against the resulting database of patenting activity segmented by the gender of inventors. References: Chen, M. K. 2013. The effect of language on economic behavior: Evidence from savings rates, health behaviors, and retirement assets. American Economic Review, 103(2): 690-731. Santacreu-Vasut, E., Shoham, A. and Gay, V., 2013. Do female/male distinctions in language matter? Evidence from gender political quotas. Applied Economics Letters, 20(5):495-498. Santacreu-Vasut. E, Shenkar, O., & Shoham, A. 2014. Linguistic gender-marking and its international business ramifications. Journal of International Business Studies, 45: 1170-1178. Whorf, 1956. Language, thought and reality: Selected writings of Benjamin Lee Whorf. Cambridge, MA: The MIT Press

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Abstract

Recent studies in a wide range of fields have related language to a number of characteristics including trust, cognition, perception and sense-making. Language is a key aspect of international business, but thus far it has been studied mainly from a cross-cultural perspective. In this paper, we argue that the effects of language run much deeper and can affect real aspects of national competitive advantage. In particular, we demonstrate that language structure affects a nation's innovation performance. This insight is novel and relevant for both theoretical and practical aspects of international business, with particular significance for enterprise-oriented global innovation strategies as well as tailoring government policies and regulations.

Introduction

In this paper we evaluate three distinct categories of grammatical language structure and seek to assess the role of these differences in regard to people's propensity and capacity to innovate. The understanding of the different levels of innovative output among nations has been a major source of attraction for academics, practitioners, and policy makers alike. What factors allow certain nations to attain and maintain competitive edge and to position themselves as global innovation leaders? Proposed retorts in regard to this question enacted a wide range of policies as government agencies, world-wide, seek to stimulate their domestic economies, enhance military strength, and attain global influence and independence. Similarly, multinational corporations and other global business actors continuously evaluate nations' relative capacity and positioning vis-à-vis innovation. These business players actively utilize this knowledge as they develop strategies to source and cultivate new technologies and ideas, locate research and

development infrastructure, procure human capital and intellectual property assets, and optimize international networks of cooperative alliances and joint ventures. On a more conceptual track, academic researchers have evaluated a wide-range of innovation-related stimuli and developed a number of related constructs and theories. The complexity and multidimensionality of this stream of research, in combination with its apparent relevance to practitioners and policymakers, presents both challenges and prospects for academics. Accordingly, innovation research continues to gain relevance and popularity among scholars across various Management and International Business disciplines, fostering and cultivating new relevant insights and propositions.

There is presently an established and well-documented association between innovation productivity and countries' institutional environment, political structure, geographic locus, and the relative level of economic development (Abramovitz (1986), Grossman and Helpman (1993), Mudambi and Navarra (2002), Utterback (1987), Almeida and Phene (2004), Boschma (2005), Keith and Pavitt (2000), Dowrick and Nguyen (1989)). The empirical evidence clearly indicates that the worldwide output of knowledge-intensive technologies and processes concentrates in select geographies, which is reflected in the comparative level of R&D investment, patenting activity, as well as the configuration of global network of corporate alliances and other cross-border cooperative ventures. A general observation indicates that that the most innovative countries tend to be wealthier and economically developed, such as the United States, Japan, or Germany. The closer look, however, reveals that there is a great level of heterogeneity in regard to innovative productivity among nations with comparable socioeconomic measures. For example, why did Malaysia generate 3.4 times more patenting activity than Poland, over the past several years, despite its smaller population size and lower estimated level of GDP per capita?

Similarly, why did Finland generate 3.6 times more patenting activity than Norway, over the past several years, despite the much lower estimated level of GDP per capita, as well as generally comparable population size, location, and socio-economic structures? Therefore, a close analysis indicates that nations' relative level of innovative productivity is much more complex than being merely a reflection of the differences in population size, institutional environment, political structure, geography, or the level of economic development. Accordingly, although a significant progress has been accomplished, to date, in this area of research, there remain meaningful gaps in the related theoretical construct and in our understanding of the overall subject matter.

What else contributes to the topology of global innovation? There is a number of prospective paths that we can explore in the effort of answering this question. In this publication we attempt to evaluate one intriguing factor that may be of relevance. Specifically, we assess whether there is a connection between the concentration of knowledge-intensive development efforts and the cultural attributes derived from the linguistic-based influence on cognition. A number of previous studies evaluate a role of culture in regard to various forms of socio-economic behaviors, but the specific association of language-based cultural attributes and innovation-related productivity remains ambiguous and vague. The preliminary findings from our analysis of global patenting activity indicate that there may indeed be an association between these variables.

According to the cognitive science research, grammatical syntax and linguistic structures are embedded within peoples' ancestry, influencing their cognitive framework and effecting their social perceptions and behaviors (Whorf (1956), Boroditsky, Schmidt, and Phillips, (2003), Kashima and Kashima (1998), Corbett (2011). We evaluate three distinct categories of grammatical language structure (gender distinctions, individualistic/collectivistic emphases, and

hierarchy/power distance variation) and seek to assess the role of these differences in regard to people's propensity and capacity to innovate. Our study has relevance to both theoretic and practical aspects of International Business subjects, with a particular significance to enterprise-oriented global innovation strategies as well as innovation-tailored government policies and regulations.

Literature Review

Language is an integral part of any human culture, tracing cultural elements and characteristics to our distant ancestor. When the GLOBE study (House et al.2004) created a definition for "societal culture," the authors claimed that culture consists of common experiences, and the first such experience that they have emphasized is the language. Charles Darwin is among those enlisted to bolster the view that language is a form of memory that stores information in a genome-like mode:

"If we possessed a perfect pedigree of mankind, a genealogical arrangement of the races of man would afford the best classification of the languages now spoken around the world; and if all extinct languages, and all intermediate and slowly changing dialect, were to be included, such *an arrangement would be the only possible one. (Darwin, 1859, p. 422)"*.

Past literature in sociology, anthropology, economics, and management sciences provides fertile background connecting cultural attributes with various forms of social and economic activity. Hall's 1976 book is one of the earlier attempts to evaluate relationships between members of a large number of dissimilar cultures. He segmented culture into "situational frames" that contain linguistic, kinesic, proxemic, temporal, social, material, personality, and other components, and used this framework to differentiate between "low-context and high-context" cultural settings

(Hall, 1976). Several years later, in his seminal presentation of the "cultural dimensions" framework, Hofstede outlined the role of **national culture** in cross-cultural business communication and behaviors (Hofstede, 1983). In subsequent scholarly works, authors evaluated various aspects of this relationship, developing a number of theoretical constructs and testing related associations empirically. One particular stream of such research evaluates how the cognition-related impact of language structure leads to differentiated outcomes, thus effecting global economic behavior and policies. Hofstede defines culture as a "collective mental programming" to behave in a particular manner, and identifies **language** as a key contributor to the mental programming that differentiates national cultures (Hofstede, 1983). The role of languages in formation of societies and societal behaviors has been documented in different fields of scholarly studies and in practice. This idea evolved from the descriptive method used by linguists to evaluate the impacts of languages on a societies. It was originally inspired by the "father of American anthropology" Franz Boas, who discovered an enormous diversity of linguistic structures and categories when studying new languages. From that point forward, many scholars, including sociolinguists, supported the view that languages cause considerable impact on individual and societal behaviors. Languages differ widely in the way they separate genders, encode time, address hierarchy (age or status related), and differentiate individualistic and collectivistic emphases. Researchers documented the relevance of this structural differentiation to the wide range of socio-economic developments and outcomes. For example, Chen finds that languages that grammatically associate the future and the present influence future-oriented societal behaviors such as savings, retirement planning, smoking, practicing of safe sex, and avoiding obesity (Chen, 2013). Other empirical studies recognize that countries where language structure emphasize gender have lower female participation in senior

management occupations, and are more likely to regulate women's involvement in politics (Santacreu-Vasut, Shenkar, and Shoham, 2014; Santacreu-Vasut, Shoham, and Gay, 2013). Furthermore, Hicks, Santacreu-Vasut, and Shoham analyze a sample of U.S immigrants to demonstrate that linguistically differentiated gender roles are acquired early in life and persist regardless of peoples' subsequent immigration patterns. Their study establishes that households with individuals whose native language emphasizes gender are significantly more likely to allocate household tasks on the basis of sex (Hicks, Santacreu-Vasut, and Shoham, 2014). Although a significant progress has been accomplished, to date, in this area of research, there remain meaningful gaps in the related theoretical construct and in our understanding of the overall subject matter. We attempt to address some of these limitations by assessing the effect of structural variation within languages on peoples' propensity and capacity to innovate. Connecting these two major areas of research, linguistics and innovation, which are integral to international business activities and relations, presents an opportunity for an interesting and managerially relevant study. More specifically, we attempt to evaluate a potential association between language-based cultural attributes, measured by the differentiated linguistic structures, and innovation-related productivity, measured by the per capita quantity of registered patents.

Linguistic indices and Patent Data

In order to measure the effect of the linguistic diversity on people's propensity and capacity to innovate, we created language indices that reflect (1) gender distinctions (index "GII V2"), (2) individualistic and collectivistic emphases (index: "Pronoun Drop"), and (3) hierarchy differentiation (index: "Politeness"). Higher score in the "gender" index indicates that the related language structure is more gender discriminative. Higher score in "Individualism/Collectivism" index reflects a greater emphasis on individualism. Finally, higher

scale score in the "hierarchy" index indicates a greater emphasis on a formal hierarchy within language structures. The linguistic data was imported from the World Atlas of Linguistic Structures (WALS; Haspelmath, Dryer, Gil, Comrie, 2007). Aggregate country-specific patenting information for a five year period from 2008 to 2012 was obtained from the USPTO database. We have also collected population size information for all countries in our database and used this data to calculate "per-capita" output of patents for each country for the selected five year period.

Preliminary Analysis and Takeaways:

The rapport of our linguistic records in regard to the global distribution of patents indicates that there is indeed a strong connection between language structure and innovation. Specifically, the data suggests that gender-related differentiation (GII v2 index) has a strong association with innovative output. Correlation between GII v2 index and the per-capita distribution of patents is -0.20, **indicating that innovative output is lower in countries where language structures are more gender discriminative.** Figure 1 exemplify this association. Notably, if we exclude Israel from analysis, the suggested associated becomes meaningfully stronger with correlation between GII v2 index and the per-capita distribution of patents of -0.28 (i.e. Israel is a large outlier, with very high per capita patent output and highly discriminative language structure with respect to gender). These results suggest that a greater level of sex-based grammatical discrimination has a negative effect on the speakers' capacity for innovation. We believe that this association may be driven by the way such language structures influence peoples' cognition, thus effecting societal norms and behaviors in a manner that restricts female participation in various socio-economic activities, including those that contribute to innovation.

The per-capital patent analysis against the "Individualism/Collectivism" index ("**Pronoun Drop")** indicates that **residents of countries with individualistic language structure tend to innovate more than those from countries where language structure reflects greater emphasis on collectivism.** Correlation between Pronoun Drop index and the per-capita distribution of patents is 0.34. Once again, if we exclude Israel from analysis, the suggested associated becomes meaningfully stronger with correlation between Pronoun Drop index and the per-capita distribution of patents of 0.40 (i.e. Israel is a large outlier, with high patent output and index values of Pronoun Drop=1). Figure 1 exemplifies this association. These results point to a possibility that individualism/collectivism differentiation within languages effects societal norms and behaviors in a manner that influences knowledge-intensive development activities. Specifically, these results indicate that individualistic language structures potentially assert a favorable effect on creativity and innovation.

Finally, the hierarchy index category (i.e. Politeness) has a 0.23 correlation with per-capita patent output, indicating that **countries with more hierarchical language structures associate with higher output of innovation.** Figure 1 exemplify this association. The results suggest that that languages with higher structural hierarchy have a favorable effect on innovation.
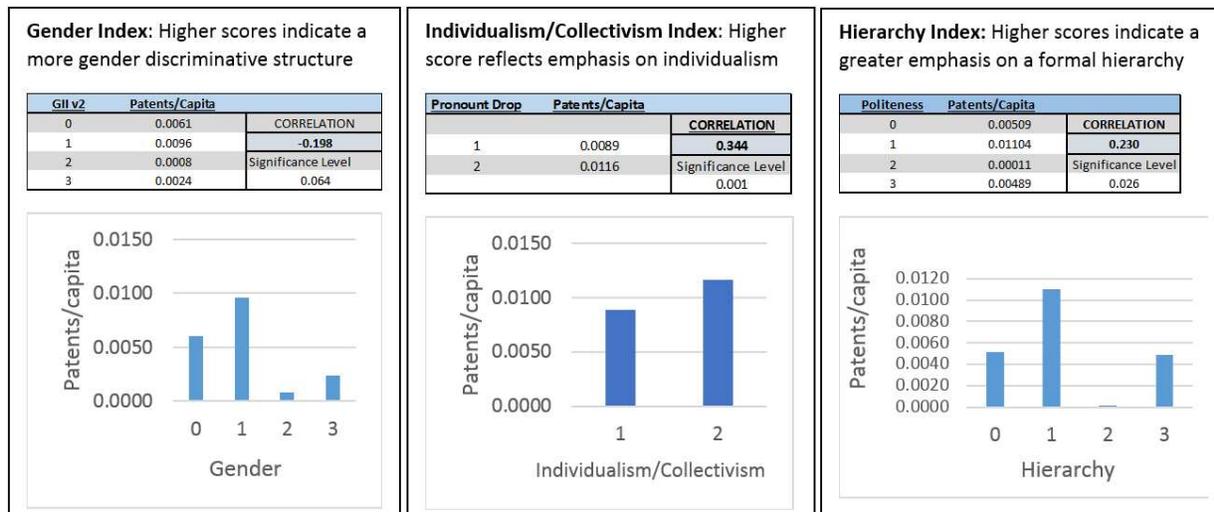
Gender Index: Higher scores indicate a more gender discriminative structure

GII v2	Patents/Capita	
0	0.0061	CORRELATION
1	0.0096	-0.198
2	0.0008	Significance Level
3	0.0024	0.064

Individualism/Collectivism Index: Higher score reflects emphasis on individualism

Pronoun Drop	Patents/Capita	
		CORRELATION
1	0.0089	0.344
2	0.0116	Significance Level
		0.001

Hierarchy Index: Higher scores indicate a greater emphasis on a formal hierarchy

Politeness	Patents/Capita	
0	0.00509	CORRELATION
1	0.01104	0.230
2	0.00011	Significance Level
3	0.00489	0.026

Figure 1 Histograms of patents per capita for linguistic categories of gender, individualism, and hierarchy

Theory and Hypotheses:

We utilize the previously outlined research on cognition that stipulates that "the imprint of inherited cultural values in a language's grammar is rooted in the impact of language on cognition, forcing speakers to encode selectively, and shaping their mental representation of social reality" (Chen, 2013)**. We combine this notion with our preliminary analysis of global patenting activity and linguistics to theorize that structural variation within languages influences peoples' propensity and capacity to innovate**. We evaluate three distinct categories of grammatical language structure (gender distinctions, individualistic/collectivistic emphases, and hierarchy/power distance variation) and seek to assess the role of these differences in regard to innovation. More specifically, we propose that a greater level of sex-based grammatical discrimination will have a negative effect on the speakers' capacity for innovation. This position is based on our view that such language structure effects peoples' cognition, thus effecting

societal norms and behaviors in a manner that restricts female participation in various socio-economic activities, including those that contribute to innovation. Therefore:

Hypothesis 1a: *Higher level of Female/Male distinction in a countries' dominant language will* have a negative effect on this countries innovative output.

Hypothesis 1b: Higher level of Female/Male distinction in a *countries' dominant language will* have a negative effect on female **participation** in innovation activities.

Additionally we adapt the assertion that languages that exclude the use of pronouns (such as "I" in english) decrease the prominence of the speakers' eccentricity, thus disemphasizing individualism within the linguistic structure (Kashima, Kashima (1998). We utilize this position to propose that individualism/collectivism differentiation within languages effects societal norms and behaviors in a manner that influences knowledge-intensive development activities. We specifically theorize that individualistic language structures assert a favorable effect on creativity and innovation. Therefore:

Hypothesis 2: Higher level of individualism in a countri*es' dominant language structure will* have a positive effect on this countries innovative output.

Finally, we propose that hierarchical differentiation within languages (i.e. formal/informal hierarchy) effects societal norms and behaviors in a manner that influences innovative output. Similarly to our position in regard to individualistic language structures, we assert that languages with lower structural hierarchy have a favorable effect on peoples' creativity and innovation. Therefore:

Hypothesis 3: High*er level of formal hierarchy in a countries' dominant language structure will* have a negative effect on this countries innovative output. (Notably, the results of our previously outlined preliminary analysis conflict with this particular hypothesis).

Going-Forward Study Design:

In order to test our hypotheses in a controlled and representative manner, we intend to implement a "top-down / bottom-up" approach, where a large-sample empirical study will be conducted at both country and industry levels. We will also supplement our preliminary dependent variable (per-capital volume of patents) with the associated patent-specific citations, in order to construct a "**quality-adjusted measure of innovative output".** This information is publically available at the USPTO, and our use of patent-related information for the 2008-2012 time frame allows at least 60 months for accumulation of citations even for the most recent patents in our database.

Country-level analysis: In an effort to infer the effect of language structure on innovation we intend to conduct regression analysis of our linguistic-based structural differentiation indices against our data on quality-adjusted per-capita patent output. The utilization of a **panel data** analysis (i.e. our database consolidates patent output for a five-year period from 2008 to 2012) will allow us to control for the time-fixed effect in the regression, whereas the previously outlined use of per-capita distribution of patents will provide a control mechanism for the differences in countries' population sizes. Additionally, we have already segmented patenting data by industries, which allows us to control for the industry-level fixed effects in the regression. Furthermore, we intend to collect country-level economic development statistics (GDP, GDP per capita, and Human Development Index) in order to control for the differences in size of national economies and the related human development measures. We intend to

supplement our database with a country-level information in regard to (a) political structure differences, (b) colonial past, (c) communism past, and (d) religion, in order to control for the potential association of these variables with the output of innovation. Finally, we will exclude US patent data from our analysis. Since USPTO database reflects global patenting activity in the United States, excluding US domiciled patents from analysis will control for the prospective endogeneity issue. In addition, excluding US patents from analysis should control the effects of discriminatory patenting practices and the related biases (this relates to the US patent office treating domestic patent applicants more favorably than it does foreign applicants). The effect of discriminatory patenting practices by the US, as well as other industrial nations, have been argued and analyzed in several international studies of business practices and international law (Kotabe (1991), Kotabe (1992), Kotabe (2010)).

Industry-level analysis: In order to test our hypothesis which examines the effect of gender-related language structure on female participation in innovation-oriented activity (hypothesis 1b), we intend to conduct an industry-level study of patenting activity by gender. Specifically, we plan to choose an industry that exhibits comparatively global distribution of patents (such as pharmaceutical or medical device) and select a time frame that that will limit the number of total patents to no more than ~ 3,000. We will then evaluate inventor-specific information (i.e. names of inventors are available at USPTO) and conduct additional research in order to determine the gender of each individual inventor. We will then analyze our previously described gender-differentiating language indices against the resulting database of patenting activity segmented by the gender of inventors.

Summary and Conclusion:

We evaluate the effect of the differentiation in linguistic structures on nation's capacity and propensity to innovate, based on findings from previous research on cognition that stipulates, "the imprint of inherited cultural values in a language's grammar is rooted in the impact of language on cognition, forcing speakers to encode selectively, and shaping their mental representation of social reality" (Chen, 2013**).** We combine this notion with our preliminary analysis of global patenting activity and linguistics to theorize that structural variation between languages effects human behavior, and specifically influences people's propensity and capacity to innovate. In order to measure the effect of linguistic diversity on innovation, we use language indices that reflect gender distinctions, emphasis on individualism/collectivism, and hierarchy differentiation. We then analyzed these indices against the aggregate country-specific data on patents per capita for the five year period from 2008 to 2012. The preliminary findings from our analysis indicate that there may indeed be an association between languages' structures and innovation.

We believe that this type of future research is relevant for both theoretical and practical aspects of international business, with particular significance for enterprise-oriented global innovation strategies as well as tailoring government policies and regulations to encourage innovation.

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