R&D and regional competitiveness: a study of global entrepreneurial firms

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Abstract:

We quantify, using data from the World Bank's Enterprise Surveys and the World Economic Forum's Global Competitiveness Index, the empirical relationship between global competitiveness and R&D investment activity as well as the independent relationship between global competitiveness and R&D investments across geographic regions of economic development. We also explore alternative measures of the effectiveness of R&D investments. Our findings suggest that R&D investments are a possible policy target variable in high-income regions for policy makers to consider for increasing firms' global competitiveness.

Keywords: R&D | global competitiveness | entrepreneurship | regional growth | program management

Article:

Introduction

The research question asked in this paper is, in general terms: What is the impact on a country's overall economic development when more firms within the country invest in R&D? Stated more succinctly: What is the relationship between a country's R&D intensity and its global competitiveness? These are important questions for policy makers to consider for increasing the level of economic development of their country, and answers to these questions might identify a policy target variable to accomplish this goal.

The Global Competitive Index, constructed and maintained by the World Economic Forum (2019, p.5), "… is an annual yardstick for policy-makers to look beyond short-term and reactionary measures and to instead assess their progress against the full set of factors that determine productivity." The Index is based on 103 competitiveness criteria that fall within 12 pillars: institutions, infrastructure, ICT (information communication technology) adoption, macroeconomic stability, health, skills, product market, labor market, financial system, market size, business dynamism, and innovation capability. These 12 pillars fall within four broadly defined groups: a county's enabling environment, its human capital base, its market infrastructure,

and its innovative ecosystem. An increase in a country's global competitiveness represents an increase in the country's overall economic development and hence its overall standard of living.Footnote1

There is overwhelming evidence that investments in R&D have an impact on the economic growth of industrialized economies tracing to at least the pioneering research of Mansfield (1972) as well as to later researchers. These later researchers have focused over the decades—which is a testament to the importance of the research questions—on various countries; examples include the scholarship of Romer (1980), who emphasized that R&D contributes to endogenous technological advancements in response to market conditions; Stokey (1995), who modeled, for the purpose of our paper, non-appropriability characteristics of R&D-based economic growth;Footnote2 Jones (1995), who for the purpose of our paper, emphasized that there are exogenous factors that affect economic growth that are not R&D related;Footnote3 Guellec and de la Potterie (2001), whose empirical work is a springboard for our sampling population including lesser developed countries; and Önder et al. (2021) whose modeling emphasized the need for dynamic considerations of the role of R&D on economic growth (see footnote 2).

R&D is clearly a target variable subject to governmental incentives for countries to use to pursue economic development through increased global competitiveness (Cunningham & Link, 2021, 2022). However, the impact of R&D on competitiveness and economic growth has not been studied for countries that fall along the spectrum of levels of economic development. This paper contributes to filling that void through it emphasis on regional differences, as proxied by the development status (e.g., low to high income) of groups of countries, in competitiveness and the attendant influence of R&D especially in entrepreneurial firms within non-industrialized countries. In addition, other have looked at the returns from patents to entrepreneurship (e.g., Goel & Saunoris, 2017); this paper looks at a broader, and perhaps more policy-oriented perspective by examining the returns from R&D to competitiveness.

The remainder of this paper is organized as follows. In Section "Empirical model and data", we offer an empirical model to address across-country differences in their global competitive index (GCI) as a function of their R&D intensity, and we discuss the data used to estimate the model.

Our empirical findings are presented in Section "Empirical findings".

The paper concludes in Section "Discussion of the findings" with a summary of our findings and a suggested roadmap for future research.

Empirical model and data

The structure of our across-country empirical model is:

$$\text{global competitiveness} = f(\text{technical capital, human capital})$$

where the technical capital of a country is measured in terms of the intensity of firms engaged in R&D activity (R&D), and the human capital of a country is measured in two ways: by the mean number of firms with 100 or more employees (Employees) and by the mean years of top managers' working experience in the sector in which the firm currently operates (Experience).

Each of the variables used to estimate Eq. (1) is defined in Table 1. As noted in the table, the data used to quantify the global competitiveness (GCI) come from editions of the Global Competitive Index Report; the variables R&D, Innovation, Employees, and Experience come from the World Bank's Enterprise Surveys; and regional income metrics are also defined by the

Table 1. Definition of the Variables

Variable	Definition	Source
GCI	Country specific global competitive index for the year following the year of the data on the other variables. The index is based on 103 competitiveness criteria that fall within 12 pillars. The index serves as an annual yardstick for assessing a country's progress against factors that determine productivity.	Global Competitive Index Report: https://tcdata360.worldbank.org/indicators/gci?country=BRA&indicator=631&viz=line_chart&years=2007,2017
R&D	Percent of all firms in a country that reported currently or previously being active in research and development (R&D) activity. For some countries and for some years, the survey question is: "During the last three years, did this establishment spend on formal research and development activities, either in-house or contracted with other companies?" The other form of question is: "During last fiscal year, did this establishment spend on research and development activities, either in-house or contracted with other companies, excluding market research surveys?"	World Bank Enterprise Data: https://www.enterprisesurveys.org/en/data
Innovation	Percent of all firms in a country that were innovative. The Enterprise Survey question: "During the last three years, has this establishment introduced new or significantly improved product or services?"	World Bank Enterprise Data: https://www.enterprisesurveys.org/en/data
Employees	Percent of all firms in a country with 100 or more employees in the survey year. The Enterprise Survey question contains sampling size of the firms. A firm is micro if employee size < 5, small if employee size > = 5 and < = 19, medium if employee size > = 20 and < = 99, and large if employee size > = 100. A binary variable = 1 was created if the firm had more or equal to 100 employees in the survey year; 0 otherwise.	World Bank Enterprise Data: https://www.enterprisesurveys.org/en/data
Experience	Mean value across all firms that reported the number of years of top management experience in the current sector of operations in the survey year. The Enterprise Survey question is: "How many years of experience working in this sector does the Top Manager have?"	World Bank Enterprise Data: https://www.enterprisesurveys.org/en/data
HighIncome	= 1 if a country is in the middle east or in North Africa; 0 otherwise. The World Bank classifies these countries as high-income economies.	World Bank: https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html
UpperMiddleIncome	= 1 if a country is in Latin America or in the Caribbean; 0 otherwise. The World Bank classifies these countries as upper-middle-income economies.	World Bank: https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html
LowerMiddleIncome	= 1 if a country is in Europe or Central Asia; 0 otherwise. The World Bank classifies these countries as lower-middle-income economies.	World Bank: https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html
LowIncome	= 1 if a country is in East Asia or the Pacific; 0 otherwise. The World Bank classifies these countries as low-income economies.	World Bank: https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html

*Countries in the four broad grouping of HighIncome, UpperMiddleIncome, LowerMiddleIncome, and LowIncome are not homogeneous in many dimensions. For example, several countries in western Europe are more developed than several countries in eastern Europe. However, our sampling population (see Table 2) does not include some of the more developed counties such as Germany, France, Switzerland, or England

Table 2. Sampling Population of Countries (n = 89)

Description	Number of Countries
Population of countries in the World Bank Enterprise Data	156
Less 37 countries for which comparable R&D, Employment, and Experience information was missing	119
Less 30 countries for which the GCI was missing. In some instances, the World Economic Forum did not consider all countries for their analysis, and in some cases some countries were excluded due to data constraints for a specific year.	89

A list of the 89 countries in the sampling population, in total and by regional cluster (see below), is available on request from the authors

Table 3. Descriptive Statistics on the Variables

Variable	Mean	Standard Deviation	Range
GCI	58.25	9.44	35.5–82.4
R&D	31.38	19.94	4.1– 74.0
Innovation	38.15	17.40	4.0–77.7
Employees	22.98	7.34	5.1–37.7
Experience	19.59	4.56	11.03–30.01
Product	1189.54	947.82	22.1–4615.9
Correlation	0.19	0.13	-0.25–0.53
*HighIncome**	0.22	0.42	0/1
*UpperMiddleIncome**	0.29	0.46	0/1
*LowerMiddleIncome**	0.28	0.45	0/1
*LowIncome**	0.20	0.40	0/1

*The countries in each region are defined at: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups

World Bank. Table 2 describes the sampling population of 89 countries derived from the data sources listed in Table 1, and descriptive statistics on all of the variables are in Table 3. Several of the variables in Tables 1 and 3 enter an estimatable version of Eq. (1) to control for regional effects on GCI.

There are nuances about the Enterprise Survey questions that delimit the extent that certain variables can be used in the estimation of Eq. (1). For example, the literature has shown that investments in R&D are an input to innovation, where innovation refers to bringing a new product or technology to the market (e.g., Audretsch & Link, 2019; Cunningham & Link, 2021).Footnote4 However, the structure of the Enterprise Survey questions on R&D and Innovation does not allow for such behavior to be jointly modeled. For example, with reference to the structure of the survey questions on R&D and Innovation in Table 1, it might be that R&D in year (t-3) leads to innovation in year (t-2), but innovation in year (t-2) could then lead to greater R&D in year (t-1), and the greater R&D in year (t-1) could result in greater innovation in year t. Thus, the use of variables R&D and Innovation creates an endogeneity problem if both enter Eq. (1).Footnote5

Also, the Enterprise Survey question about the number of employees in the survey year, which is not only a measure of human capital but also a proxy of firm size, is asked in a manner (see Table 1) that does not allow for Employees being a continuous variable across firms within a country. As shown in Table 3, the mean value of Employees is 22.98 meaning that on average nearly 23 percent of the countries in the sampling population have an average firm size of 100 or more employees. Our sampling population of countries is dominated by small-sized firms.

To emphasize our use of the word entrepreneurial in the subtitle to this paper, the correlation between Employees and Innovation is -0.20 ($p = 0.06$). Not only is our sampling population of countries dominated by small-sized firms (see also the range of Employees in Table 3), those countries that are relatively more innovative are also dominated by small-sized firms.

Empirical findings

The least-squares results from a parsimonious specification of Eq. (1) are in column (1) of Table 4.

There are several notable findings from the results reported in Table 4. First, R&D activity in a country is positively related to the measured competitiveness of a country. The coefficient on R&D is positive and significant. The estimated coefficient suggests that on average a 10 percentage point increase in the number of R&D-active firms in a country is related to a 1.9 point increase in a country's competitive index. From Table 3, the mean value of GCI is 58.25, thus a 10 percentage point increase in the R&D-active population of a country has, on average, a modest yet positive impact on measured competitiveness.

Second, the dimension of human capital that is positively related to the measured competitiveness of a country is its managerial experience rather than its number of employees (Hamel, 2006; Birkinshaw et al., 2008). The estimated coefficient on Experience is positive and significant. On average, an increase in managerial experience of 10 years (a 2 standard deviation increase in Experience; see Table 3) is related to a 6.4 point increase in a country's competitive index.

The results in column (1) in Table 4 do not take into account any regional differences in the R&D-to-competitiveness relationship. Using the specification in Eq. (1) and controlling for high income countries (HighIncome), upper-middle income countries (UpperMiddleIncome), and lower middle income countries (LowerMiddleIncome), as fixed effects changes the algebraic sign

on the coefficient of R&D from positive to negative although the coefficient remains significant. Each of these regional binary variables is positive and significant (not shown in Table 4). These findings suggest that R&D is significantly correlated with each of the regional variables.Footnote6 Thus, perhaps a more appropriate specification is one that controls for regional effects in the relationship between R&D and CGI.Footnote7

The regression results in column (2) of Table 4 suggest that R&D is a meaningful target variable for increasing a country's competitiveness but only in high-income countries. The coefficient on the interaction variable HighIncome*R&D is positive and significant. On average, a 10 percentage point increase in the number of R&D-active firms in a high-income country is related to a 2.1 point increase in a country's competitive index. Using R&D as a target variable in the upper-middle income and lower middle income countries has a statistically zero impact on competitiveness, and the impact is even negative in low-income countries.Footnote8

Table 4. Least-Squares Regression Results, Dependent Variable is GCI
(standard errors in parentheses, n = 89)

Variables	**(1)**	**(2)**
R&D	0.19*** (0.04)	--
Employees	0.14 (0.11)	0.14 (0.11)
Experience	0.64*** (0.19)	0.19 (0.19)
*HighIncome*R&D*	--	0.21*** (0.04)
*UpperMiddleIncome*R&D*	--	0.07 (0.05)
*LowerMiddleIncome*R&D*	--	-0.05 (0.08)
*LowIncome*R&D*	--	-0.43*** (0.15)
Intercept	36.50*** (3.79)	49.66*** (4.22)
R2	0.40	0.55
F-level	18.97***	16.72***

***Significant at .01-level or better; no Variance Inflation Factor (VIF) was greater than 1.9

While the findings from Table (4) do inform the literature about a policy for increasing the level of R&D activity in a country as a vehicle to affect its competitiveness, the findings do not address how policy makers might affect the effectiveness of any level of R&D activity. Unfortunately, such information about R&D effectiveness is not available in the Enterprise Survey, or in any other public domain database. However, there is information from the Enterprise Survey that allow for some exploratory investigations.

We considered two measures that might have an intuitive appeal to proxy R&D effectiveness, although we have no means to test for their construct validity. The first such variable

is constructed as the product of the aggregate variables R&D and Innovation; Product. The second such variable is the correlation coefficient between R&D and innovation using the primary data on a country-by-country basis; Correlation.

Two specifications using these exploratory variables interacted with the World Bank regional variables are shown in Table 5. Across the board, assuming that our effectiveness of R&D exploratory proxies have some interpretative value, the estimated coefficients relevant to high-income countries are positive and significant.

Table 5. Least-Squares Regression Results Using Proxies for the Effectiveness of R&D, Dependent Variable is GCI (standard errors in parentheses, n = 89)

Variables	**(1)**	**(2)**
Employees	14.52 (10.94	0.20* (0.11)
Experience	0.23 (0.19)	0.26 (0.19)
*HighIncome*Product*	0.004*** (0.0008)	--
*UpperMiddleIncome*Product*	0.0004 (0.001)	--
*LowerMiddleIncome*Product*	-0.003 (0.002)	--
*LowIncome*Product*	-0.01*** (31.36)	--
*HighIncome*Correlation*	--	39.80*** (8.37)
*UpperMiddleIncome*Correlation*	--	5.19 (7.91)
*LowerMiddleIncome*Correlation*	--	-11.35* (6.77)
*LowIncome*Correlation*	--	-37.87*** (8.70)
Intercept	50.08*** (4.24)	49.15*** (4.02)
R2	0.54	0.56
F-level	15.79***	17.51***

*Significant at .10 level; no Variance Inflation Factor (VIF) was greater than 1.5
***Significant at .01-level or better

Thus, policy makers in non-high income countries who desire to increase a country's global competitiveness should consider target variables other than R&D.

Discussion of the findings

To re-emphasize, the innovation process is based on a time-dependent two-way relationship between R&D investments and innovative outputs (i.e., new products to the market). Unfortunately, we are unable to quantify this process with the international data available in the World Bank's Enterprise Survey. What we are able to quantify is the independent relationship

between global competitiveness and R&D investment activity as well as the independent relationship between global competitiveness and R&D in alternative regions. Our findings should be interpreted cautiously although there is empirical evidence that increased investments in R&D are related with increased global competition among high-income countries.

As we discussed, there are limitations to the scope of R&D and innovative activities addressed in the Enterprise Surveys; however, the data are sufficiently robust to explore the construction of new variables that possibly capture across-country differences in the innovation effectiveness of R&D investments. While these exploratory findings complement our findings on the use of R&D investments to enhance competitiveness, there is some evidence that policies related to the enhancement of top management in firms might be a second route to follow.

We conclude with the suggestion that other researchers might use our exploratory analysis to pursue future work that discriminates between per se investments in R&D and investments in activities that quantify the effectiveness of R&D. In addition, as we pointed out above with reference to the extant literature, future research should consider a dynamic approach to understanding the aggregate relationship between investments in R&D an competitiveness. Such an approach should also consider the aggregate (i.e., country-level) time-based endogenous relationship between R&D and competitiveness, which might be viewed in light of the endogenous relationship between firm R&D and firm innovation discussed above. Through dynamic empirics, policy makers will gain a better understanding of the use of R&D as a competitiveness-related target variable as well as the timing that is involved in realizing related social benefits.

Notes

1. A recent example of a study demonstrating this relationship using the Global Competitiveness Index (GCI) is by Rajnoha and Lesnikova (2022).

2. Our paper does not discuss the spillover consequences in a period 2 from competitiveness gains through R&D in a period 1.

3. As we discuss below, our empirical model so considers the aggregate income level of each country.

4. As a point of emphasis, our analysis focuses on product innovation and not process innovation. For a discussion of the latter, see Goel and Nelson (2018).

5. Lagging one or the other is not a possibility given how the R&D and innovation variables are measured in the Enterprise Survey. And, this interactive process might take less than one year or more than one year.

6. These results are available on request from the authors.

7. Our emphasis is on regional effects as measured by a country's income level. One could include in a specification a country-by-country level of income, but it, like an innovation variable would be colinear with R&D activity.

8. An alternative set of regional controls was also considered. The continent in which a survey country resides was considered. The results suggest that R&D is a statistically meaningful target variable only among European and Asian countries. These results are available on request from the authors.

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