# Accelerating Innovation in a Post-COVID World - Evidence from Global Innovation Index

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Prior to the onset of the COVID-19 crisis, average innovation expenditures worldwide had been growing faster than GDP. According to the Global Innovation Index (GII), in 2017 and 2018, research and development (R&D) grew by 5.0% and 5.2% respectively—in line with the strong growth of the pre-Global Financial crisis period (of 2008-2009) and significantly stronger than global GDP growth for 2017 (3.14%) and 2018 (3.1%). This growth in R&D expenditure—the highest over a six-year period—was sustained by growth in key emerging markets, such as China and India, and by leaders in high-income economies. China's R&D expenditure grew 8.6% in 2018, higher than the prior year. India's R&D spending growth in 2018 was estimated at 5.5%. In high-income economies, real R&D expenditure grew 3.8% in 2018. Expenditures grew 8.3% in the Republic of Korea, 3.4% in the United States of America (U.S.), 3.7% in Germany, and 2.4% in Japan. Private sector funding drove much of this growth in innovation expenditure. The top 2,500 R&D companies invested 823 billion Euros in R&D in 2018, an increase of 8.9% with respect to the previous period.

The onset of the COVID-19 crisis has unexpectedly shocked the world and has had a significant negative impact on global growth. According to the IMF, the COVID-19 pandemic has had a more negative impact on activity in the first half of 2020 than anticipated, and the recovery is projected to be more gradual than previously forecast. The IMF projects global growth at –3.5 percent in 2020 (some 5½ percentage points lower than in the pre-COVID-19 projections of January 2020) and at 5.5 percent in 2021. Further the IMF notes that the adverse impact on low-income households is particularly acute, imperiling the significant progress made in reducing extreme poverty in the world since the 1990s.

Many governments have set up emergency relief packages to cushion the impact of the lockdown and face the ongoing recession. Understandably the initial focus of these packages has been on injecting liquidity, supporting businesses via loan guarantees and helping households and workers via unemployment benefits. As the COVID vaccines are starting to be deployed, countries need to start anticipating the transition from containment to recovery measures.

France has pledged to give 5 billion euros, a 25 % increase in its original R&D budget. Germany has unveiled a second stimulus package of 50 billion euros on future-focused technologies. The U.S. and China are considering spending large additional amounts of stimulus money geared to building infrastructure and boosting innovation. China, for example, intends to focus on new fields of innovation and new forms of soft infrastructure, such as big data centers, 5G infrastructure, and new energy vehicles (NEVs).

While the impact of the COVID crisis varies across sectors, key sectors have increased their emphasis on innovation as is the case for the information and communications technology sector, which, across hardware, software and services accounts for nearly 38 percent of total R&D spending by firms in 2018–19. The pharmaceuticals and biotechnology sector — another top R&D spender accounting for nearly 19 percent of global R&D spending by firms in 2018–19 – has also increased its spending on innovation and R&D over the last months.

Despite the short-term shocks, the importance of innovation in a post-COVID world has only increased. Crises are often a source of creativity and innovation, and, at times, industrial renewal. The COVID-19 crisis has catalyzed innovation and might accelerate progress and industrial renewal more broadly. The opportunities for breakthrough technologies and innovation continue to abound.

In such a context, this paper uses data from the Global Innovation Index (GII) research to evaluate the conditions required for accelerating innovation in nations. The GII [ˆ1] is focused on metrics and methods for capturing the richness of innovation in nations. The dataset used for this research covers 129 countries/economies from 2011 to 2019, representing 91.8% of the world's population and 96.8% of the world's GDP. The wide range of countries and time periods allows us to conduct both horizontal and vertical analyses.

## Accelerating Innovation

In addition to the traditional measures of innovation, such as R&D expenditures, the number of research articles, etc., the GII framework uses a holistic measurement of innovation based on a variety of dimensions, mainly relying on two sub-indices, *Innovation Inputs*, and *Innovation Outputs*. *Innovation Inputs* capture five elements of the national economy which enable innovative activities, including institutions, human capital and research, infrastructure, market sophistication, and business sophistication. *Innovation Outputs* refers to the result of innovative activities resulting in the economy, including knowledge outputs and creative sector outputs.

Each pillar is further divided into three sub-pillars: the five **input** pillars (1) **Institutions** is gauged on three dimensions, including *Political Environment, Regulatory Environment,* and *Business Environment;* (2) **Human capital and research** is based on *Education, Tertiary Education,* and *Research & Development (R&D);* (3) **Infrastructure** is divided into *Information and Communication Technologies (ICTs), General Infrastructure* and *Ecological Sustainability;*

(4) **Market sophistication** is made up of *Credit, Investment,* and *Trade, Competition, and Market Scale;* (5) **Business sophistication** includes *Knowledge Workers, Innovation Linkages,* and *Knowledge Absorption;* and the two **output** pillars: (6) **Knowledge and technology outputs** contains *Knowledge Creation, Knowledge Impact,* and *Knowledge Diffusion;* (7) **Creative outputs** consist of *Intangible Assets, Creative Goods and Services,* and *Online Creativity.* Each of these sub-pillars are measured by four to five specific variables. For example, the sub-pillar *Knowledge Workers* is measured by the following five variables: knowledge-intensive employment, % of firms offering formal training, GERD performed by business, GERD financed by business and Females employed with advanced degrees.

Technological progress frequently leads to an acceleration of innovation in nations, such as what we have witnessed with the rapid deployment of remote learning and work-from-home in many countries during the COVID crisis. Of particular significance are countries which have succeeding in accelerating their innovation relative to their peers as this can lead to enhanced competitiveness and rapid creation of wealth. Some related research exists on the concept of leapfrogging, primarily from the perspective of technological leapfrogging (Sharif, 1989; Wang, 1991; UNESCO, 1996; Sussman, 1997; UNCSTD, 1997; Van Dijk, 1999). "Leapfrogging" was originally described by Gerschenkron (1962, 1963) who emphasized the advantages of the catching-up countries, such as economy of scale in plant sizes in steel and semiconductor industries, since these countries started to use the technology only after it became sufficiently matured to have the standardized capital goods suitable for mass production. Along with Gerschenkron's (1962, 1963) study, subsequent researchers also define "leapfrogging" within a technology framework. Sauter and Watson (2008) argue that "leapfrogging" can be considered as either the early adoption and use of new technologies or the development and manufacture of new technologies within less developed countries.

Due to the lack of qualified quantitative data over an extended period, most studies on leapfrogging are qualitative in nature (International Telecommunication Union, 2004; Alzouma, 2005; OECD, 2005, 2006; Prakash, 2005; Sinha, 2005; Raji et al., 2006; Ensley, 2009). In addition, they rarely make distinctions on the different development paths of high-income and low-income countries (Lee & Kim, 2009).

The GII provides a rich dataset for analyzing innovation acceleration for more than a decade. The GII framework includes a holistic framework for innovation allowing us to analyze the results beyond the narrow bounds of technological progress. We can provide a quantitative basis for understanding the conditions that allow for innovation acceleration amongst nations. Further, the global scope (more than 120 countries covered each year) of the GII dataset allows us to explore heterogeneity across different income groups.

## Analysis

We use the GII dataset over a 9 year period (2011-2019) to answer three questions:

1. Are there some countries which have been able to significantly accelerate their development by investing in innovation?
2. If yes, then which factors explain the ability of these countries successfully innovate?
3. What lessons can we draw for nations to accelerate their investment in innovation in the post-COVID environment?

Note that the GII computes a relative rank for each country based on its overall innovation score computed using the GII framework.

## Innovation Accelerators

The GII computes an *Innovation Output* score and rank for each country by computing the average scores of the economy on the two output pillars – **Knowledge and Technology Outputs** and **Creative Outputs**. Following the methodology of the GII, we identify a set of countries as Innovation Accelerators by regressing the *Innovation Output* scores against GDP per capita in natural logs of PPP US$. First, we calculate an underlying trend line by using cubic spline with five knots determined by Harrell's default percentiles for each year, respectively. Then, for each country, we calculate the 1.1 times of the underlying *Innovation Output* scores given the trend line. Countries above the 1.1 times of the underlying scores are considered as Innovation Accelerators.

**Table 1** lists the countries identified as Innovation Accelerators one or more times during the time-period 2011-2019, grouped by income category. We note that the distribution of countries across geography is as follows: North America (1), Europe (22), Asia (17), Latin America (1) and Africa (13) and across income groups is as follows: high income (21), upper middle-income (14), lower middle-income (9) and low-income (10). We can compare the average % GDP PPP per capita growth rates (over 2011-2019) for the Innovation Accelerators as compared to other countries in the respective income groups for the same period: high-income (49.0% vs 27.9%), upper middle-income (103.5% vs 39.0%), lower middle-income (127.6% vs 44.8%) and low-income (87.7% vs 32.3%). We note that the wealth creation rates (as measured by GDP PPP per capita) are significantly higher for all innovation accelerators. Using GDP nominal for the same comparison, we get: high-income (12.7% vs 7.2%), upper middle-income (18.0% vs 25.1%), lower middle-income (33.7% vs 27.3%) and low-income (16.6% vs 0.8%). Thus the wealth creation rates are higher for all innovation accelerators in GDP nominal per capita also except for those in the upper middle-income group. The reasons for this difference need further research. It could be due to time lags in the impact of innovation acceleration showing up in GDP growth rates or possibly the complexity of navigating a successful path out of the classical middle-income trap. For example, Gill and Kharas (2007) point out the main challenges in east Asia are congestion, conflict, and corruption, while Foxley and Stallings (2016) find inequality is the main problem in Latin America.

**Table 1: Innovation Accelerators and Economic Growth Rate**

## Innovation Enablers

For the next phase of analysis, we observed how the five Input pillars of the GII Innovation Framework (namely **Institutions**, **Human Capital and Research**, **Infrastructure**, **Market Sophistication**, and **Business Sophistication**) influence the overall *Innovation Output* score (which is the average of the two output pillar, **Knowledge and Technology Outputs** and **Creative Outputs**) for the nations identified as *Innovation Accelerators*. We compared both the actual scores and the relative ranks of the nations for this analysis over the 2001-2019 time period. Multiple regression analyses were also run with Innovation Output as the dependent variable and different innovation input pillars and sub-pillars as independent variables.

A comparison of both the relative ranks and the absolute scores of the *Innovation Outputs* of the total sample of innovation accelerators show that they perform better in **Business Sophistication** as compared to their peers. The importance of this input pillar is also confirmed by a regression analysis (significance at 1% level) of the **Innovation Output** score across the five innovation input pillars. After dividing countries into different income-level groups, we find that this finding still holds in the high-income group and low-income group, but not necessarily in the lower-middle income group. Additionally, innovation accelerators in the high-income group also show a better performance in Institutions (significance at 5% in a regression), while those in the low-income group also perform better in **Market Sophistication**. A summary of the results is presented in **Table 2**.

**Table 2: Summary Table for Overall Innovation Outputs for Accelerators**

We conduct the same comparisons of *knowledge and technology outputs accelerators* and *creative outputs accelerators*. The summaries of the results are in **Table 3** and **Table 4**, respectively. In the total sample, both knowledge and technology outputs accelerators and creative outputs *accelerators* perform better in Business Sophistication as well. After looking into different income groups, we find innovation *accelerators* in the high-income group also perform better in **Human Capital and Research**. Other results are similar to the findings shown of the *Innovation Outputs*. The patterns are also consistent with regression results.

To investigate the above dimensions further in detail, we analyze which specific sub-pillars of **Business Sophistication**, **Institutions**, **Human Capital and Research**, and **Market Sophistication** are most impactful in high-income and low-income countries, respectively. Using the same measurement of relative average score and rank we find that innovation accelerators in the high-income group perform better in the *Knowledge Worker*, *Political Institutions*, and *Research and Development (R&D)* sub-pillars while those in the low-income group perform better in Innovation *Linkages*, and *Trade*, *Competition*, and *Market Scale*.

**Table 3: Table for Knowledge and Technology Outputs Accelerators**

**Table 4: Table for Creative Outputs Accelerators**

## Discussion and Conclusions

Investing in innovation is important for fueling growth and development, especially to emerge out of the economic crisis caused by COVID-19. This study is unique in using the decade long rich data set of the GII to understand the characteristics of nations that are able to accelerate their innovation success. Moreover, our findings provide macro-level evidence for development paths and heterogeneity among different income groups, consistent with the micro-level findings.

We find that some nations are indeed able to invest more successfully in innovation and benefit from faster development as measured by higher GDP per capita growth rates. Innovation accelerators have an overall better performance in **Business Sophistication**. This finding is consistent with previous literature focusing on absorptive ability and labor force quality (e.g. Dahlman and Nelson, 1995; Steinmueller, 2001). Moreover, we find that there is heterogeneity between low-income countries and high-income countries: besides **Business Sophistication**, innovation accelerators in the low-income group also perform well in **Market Sophistication**, while those in the high-income group perform well in **Institutions** as well as **Human Capital and Research**. We further investigate the detailed dimensions of the four aspects above. Our findings show that *Innovation Linkages*, and *Trade, Competition, and Market Scale* are outstanding in low-income countries, while the aspects of *Knowledge Worker, Political Institutions*, and *R&D* stand out in high-income countries. These findings are consistent with recent research findings in the micro-level that less developed countries should focus more on trading, while developed countries should invest more in R&D (Bloom et al., 2016; Bloom et al., 2019).

The research results are interesting for policymakers in both less developed and developed countries to focus their actions so as to develop efficiently in the post-COVID-19. For example, the COVID-19 crisis has greatly increased the importance of digitization in every aspect of society and the economy. This has created a huge opportunity for all countries to make significant breakthroughs in technological innovation and make progress in social and economic development. However, the lessons from this analysis shows that investment in technology alone will not result in appropriate innovation acceleration. Important aspects related to the factors identified above need to be focused on and strengthened.

Academic researchers and policymakers aspire to identify patterns of economic development, which are meaningful to both theoretical research and practical policymaking. Although that goal has attracted much attention, often it has lacked worldwide comparable determinants and various detailed dimensions of potential factors to adequately provide supporting evidence. This study examines these questions both vertically and horizontally with quantitative support from the rich decade long GII dataset. Reviewing this important issue in the post-COVID-19 world, the findings in this study provide evidence of successful development experience in innovation accelerators for the world to learn from.

Though the evidence is not definitive about the causal inference, the extant patterns suggest that low-income countries are can take different paths for innovation acceleration as compared to high income nations. Our findings offer another perspective different from earlier articles, but consistent with a number of theoretical concepts, such as “New Structural Economics” (Lin, 2012).

Our results motivate some questions about upgrading in developing countries. For example, at what point should developing countries change their focus from external linkage to internal independent technology (R&D)? What model explains the causal inference between those possible innovation inputs factors and outputs results? What should those less developed countries do after successful “leapfrogging”?