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Article

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Measuring Innovation

Ryan Born and Yuchen Guo[1]

The developed world thrives on new technology. Better forms of communication, farming, and manufacturing are often considered to be drivers of long-term growth. Yet innovation is difficult to grasp and has many fuzzy definitions. Thus there is no real consensus on this topic, but merely the insight that innovation is a complex, multi-faceted process that is difficult to measure adequately.[2] In this article, we focus on two measures of innovation, expenditure on research and development (R&D) and the Knowledge Economy Index (KEI). These two measures emphasize different aspects of innovation activity in a country.

Expenditure on research and development

Eurostat provides data on research and development expenditure as a percentage of GDP described as a very rough, but simple measure of innovation that captures the intensity of research and development.[3]

Figure 1 shows that R&D spending varied across countries in 2012. Most of the selected countries spent at least one percent or more of their GDP on research and development. Greece, Poland and the Slovak Republic were the only countries below this threshold. But beyond that, countries differed strongly in terms of their R&D spending. Roughly, R&D expenditure varied by geographic and economic region. Furthermore, the Scandinavian countries of Sweden, Finland and Denmark spent three percent or more of their GDP on the R&D sector. A lower share of R&D spending of 2–3 percent was found in the US and most Western European countries, including Austria, Belgium, France and Germany. Ireland and the UK, by contrast, spent a share of 1.5 percent of GDP on R&D, which is half of the amount spent in Germany or France. Furthermore, it is interesting to note that Slovenia was the only Eastern European country with R&D spending above 2.5 percent, which is close to that of Germany and the US. The average expenditure is 1.96 percent, which is met or exceeded by 11 out of 22 countries.

As seen in Figure 2, there appears to be a positive correlation between R&D expenditure as a percentage of total GDP and real GDP per capita.[4] Greece, Poland and the Slovak Republic are at the bottom of the income distribution ranking of sample countries. At the same time, these countries exhibit the lowest R&D expenditure. Conversely, the Scandinavian countries that spent the highest share of GDP on R&D in the sample also exhibit high levels of GDP per capita.

The Knowledge Economy Index

The Knowledge Economy Index (KEI) aims to measure whether the environment is conducive for knowledge to be used for economic development. It is an aggregate index that represents the overall level of development of a country or region towards the so-called knowledge econ-

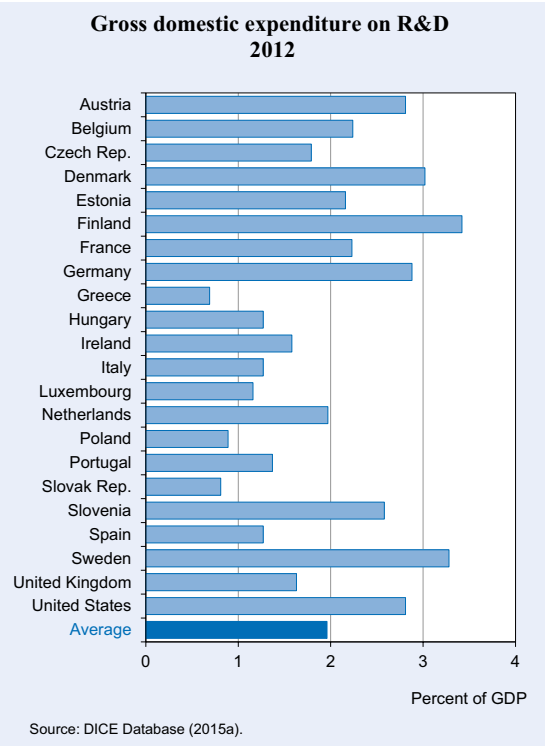
[1] Ifo Institute (both).

[2] There have been several attempts in the literature on this topic to define innovation. Manuylenko et al. (2015), for example, define innovation as an act of creating something new, and argue that innovation and invention are often equated, although there is also the fundamentally opposite opinion that innovation and invention are separate. Baregheh, Rowley and Sambrook (2009) suppose that innovation can be represented as a process of creation, generation, implementation, development and adoption.

[3] The World Bank lists several other indicators that measure innovation: researchers per million people, patent applications, charges for use of intellectual property, and hi-tech exports as a percentage of manufactured exports (World Bank 2016). In the following, 2012 numbers are used as they constitute the most complete data set.

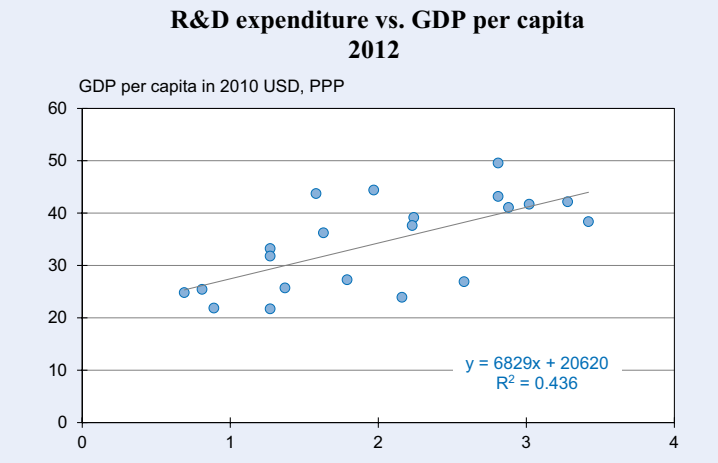
[4] This figure excludes Luxembourg as an outlier.

Figure 1



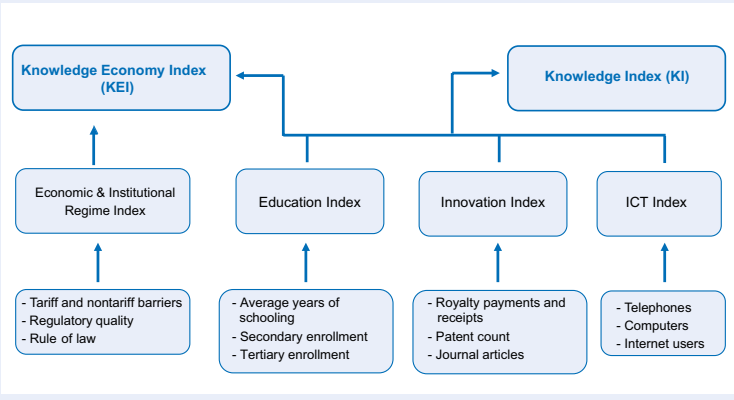
Source: DICE Database (2015a).

Figure 2



Source: DICE Database (2015a,b).

Figure 3



Source: World Bank (2007).

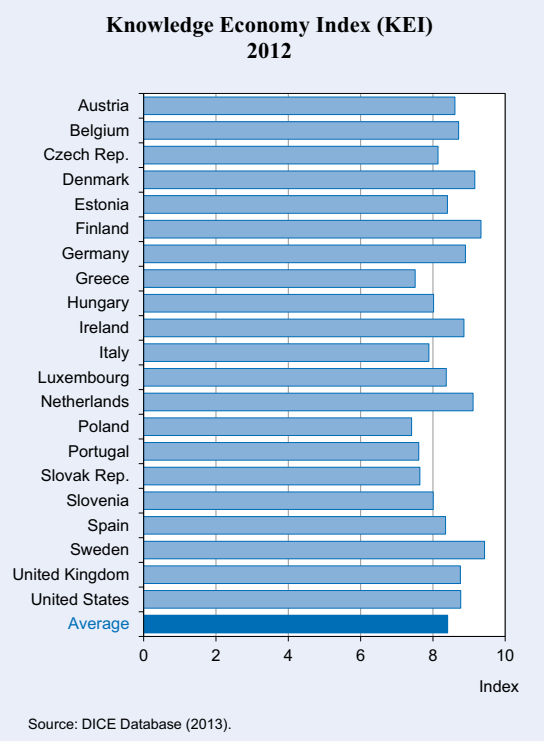
omy. The characteristics of a knowledge based economy include high levels of human capital and a prominent role played by information and communication technologies in production (Lucas-Model (Lucas 1988), Romer-Model (Romer 1990)). The KEI is calculated based on the average of the normalized scores (on a scale of 0 to 10 relative to other countries in the comparison group; with 10 as the top score for the top performers and 0 as the worst score for the laggards) of the country or region on four pillars related to the knowledge economy – economic incentive and institutional regime, education and human resources, innovation and Information and Communication Technologies (ICT). For the purposes of calculating KEI, each pillar is represented by three key variables (see Figure 3). Specifically, institutions are captured by measures of rule of law and institutional quality. Education and human capital are accounted for by standard measures used in the human capital literature: average years of schooling and enrolment rates in secondary and tertiary schools. The Innovation Pillar is comprised of Royalty and License Fees Payments and Receipts, Patent Applications Granted by the US Patent and Trademark Office, and Scientific and Technical Journal Articles. Lastly, information and communication technologies feature in the KEI with the number of telephones, computers and internet users.

Figure 4 depicts scores on the KEI for OECD countries. At first sight, there are some similarities between the KEI and R&D spending (Figure 1). As with R&D spending, Denmark, Finland and Sweden rank highest on the KEI. Greece, Poland and Portugal rank lowest on the KEI, which falls into line with their low levels of R&D spending. However, for a number of countries, the KEI provides a different picture to that of the comparison of R&D expenditure/GDP ratios. Ireland and the United Kingdom, for instance, spend a lower fraction of GDP on R&D than Slovenia. However, both countries rank higher on the KEI than Slovenia. Moreover, the Netherlands exhibits the lowest R&D spending among Western European OECD countries, but ranks higher on the KEI than Germany, a country with high R&D spending among Western European OECD members.

Comparing the measures

How can the differences between the two measures of innovation be explained? Of course, R&D spending is only a very rough input measure of innovation. However, the KEI as any index also bears weaknesses in the measurement of its sophisticated components. For instance, human capital enters the index only through numbers of average schooling and enrolment rates. It

Figure 4



Source: DICE Database (2013).

is worth noting that this does not account for the quality of education, which can vary strongly among countries (see, for example, Hanushek and Kimko 2000). Including not only the quantity, but also the quality of education (e.g. PISA scores) would capture differences in human capital to a fuller extent. The KEI nevertheless offers a holistic measure that considers a broad range of determinants for innovation.

In particular, KEI includes a range of factors that influence innovations, whereas R&D/GDP merely captures monetary efforts to invest in the R&D sector. For instance, Slovenia ranks relatively low on the KEI, but its R&D expenditure in 2012 was among the highest of all OECD members and exceeded Ireland's share of GDP spent on R&D by approximately 50 percent. At the same time, Ireland ranks higher than Slovenia on the KEI by one unit. This discrepancy between the two measures may be because the KEI is influenced by a number of institutional and infrastructural factors, such as a country's level of ICT. Looking at the ICT Development Index (UN 2015), Ireland ranks 22 globally and Slovenia ranks 33. This difference in the level of ICT may be one reason why Ireland still performs better than Slovenia on the KEI, despite lower R&D spending.

Furthermore, R&D spending/GDP is prone to variation in time, as it only measures R&D expenditure in a given year. The KEI, on the other hand, is influenced by long-term institutional factors and other stock variables, such as the average years of schooling or total number of telephones. This may be another reason why KEI and R&D expenditure yield different rankings.

To sum up, the KEI and R&D spending/GDP measure two different aspects of innovation. R&D spending measures the efforts of a country to invest in the R&D sector in a given year. The KEI, by contrast, measures the *productivity* of the R&D sector, i.e. how will investments in the R&D sector be translated into innovation activity.

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