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The technological capabilities of nations: The state of the art of synthetic indicators

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ABSTRACT

Composite synthetic indicators of the technological capabilities of nations have been used more frequently over the last years becoming a sort of Olympic medal table of the innovation race. The European Commission, specialised United Nations Agencies, the World Bank, the World Economic Forum, and individual scholars have developed several of these measurement tools at macroeconomic level. All these indicators are based on a variety of statistical sources in order to capture the multidimensional nature of technological change. This paper reviews these various exercises and: i) it brings into light the explicit and implicit assumptions on the nature of technological change; ii) it discusses their pros and cons; and iii) it explores the consistency among the results achieved. Most of the final rankings at the country level are fairly consistent, but significant discrepancies for some nations emerge. The value of synthetic indicators of technological capabilities for public policy, company strategies and economic studies is finally discussed.

1. Introduction

There are at least three good reasons which justify the efforts to collect systematic statistical data on national technological capabilities [1]:

1. *Theoretical analysis:* innovation indicators can be used to increase and broaden our knowledge of technological change and to test innovation theories. There is a large consensus within economic and social theories about the fact that technological change represents the engine of development and even of progress. More specifically, innovation is considered the determinant of economic growth, productivity, competitiveness, and employment. Appropriate measurement tools are needed to test and quantify these hypotheses.
2. *Source of information for public policies:* policy makers need to locate their country position in the global landscape to identify national strengths and weaknesses, to secure technological opportunities, and to assess the effectiveness of the policies adopted [2,3]. Reading and interpreting statistics of technological change provides a fundamental source of information to design and carry out an effective innovation policy.
3. *Input for firms' strategies:* managers use innovation studies to have a deeper understanding about technological advance, especially in a period of fierce internal and international competition. Data on the technological capability of different countries allow a better understanding of the geographical contexts in which firms can develop and establish their innovative activities.

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We will focus on a specific instrument for measuring innovation: synthetic indicators at the country level. The production of innovation indicators has recently been spreading both at micro and macroeconomic levels: data collection and surveys are systematically developed at firm, industry, technological field and country level (for reviews, see [4,5]). Within this renovated effort of measuring innovation, a larger attention has been paid to compare the technological activities of different nations. Various United Nations specialised agencies, including the World Bank, UNDP, UNIDO and UNCTAD, business associations, like the World Economic Forum, and individual scholars have collected data about technological capabilities at national level. Also the European Commission has provided appropriate tools such as the European Innovation Scoreboard and the Global Innovation Scoreboard, in particular for evaluating the progresses of the Lisbon Strategy, focusing on a smaller and less diverse group of countries (see European Commission [6–8]).

What are the features of these synthetic indicators? They take into account the various aspects which constitute the technological capability of a country and aggregate them into a single figure. They are typical macroeconomic indicators aiming at comparing the positions of different countries and their changes. Their merit is to provide a clear and immediate image of a country's ranking, while the drawback is to sacrifice the inherent complexity of the process of knowledge production and distribution.

Mass media, economists, politicians and managers are the main users of these indicators. The media use them since the public opinion is captured by the direct ranking of countries: these rankings are often seen as a sort of technological Olympic medal table which ignites the spirits of supporters. Economists use them to scrutinize the relationship between innovation and other economic phenomena such as competitiveness, trade, growth and productivity. Policy makers and managers are also keen to read and comment on these data, but they are less eager to guide their actions on the ground of these indicators, perhaps because they realize that they are far too aggregate to be connected to specific policies and strategies.

The objectives of this paper are:

a. to provide a comprehensive exposition of the main exercises of innovation measurement based on composite indicators;
b. to gather evidence about the results of these exercises; and
c. to test the consistency of the results achieved by these exercises and to assess their usefulness and limits.

The next section discusses the theoretical assumptions on which the synthetic indicators of technological capabilities are grounded. Section 3 describes the data sources, methodologies, and statistics used by each approach. We then analyse in Section 4 the results obtained, comparing the positions of different countries according to each synthetic indicator, seeking and discussing the causes of any significant difference. Section 5 contains a comparison between the ranking provided by the various composite indicators and the most widely used simple indicator, namely the ratio R&D to GDP Section 6 concludes.

2. In search of the theory underlying the measurement of technological capabilities

2.1. Uncovering the implicit assumptions

The theoretical assumptions underlying these macroeconomic measures of technological capabilities are not always explicit. What are the implicit assumptions encountered in the majority of the exercises here reviewed?

The first methodological assumption is related to entrusting the use of “countries” as unit of analysis: countries are made of differentiated areas and regions and they are far from being homogeneous. Using one single figure to capture the overall technological capabilities of such different entities hides several simplifications. Macroeconomic analysis is used to this type of simplifications: the GDP is used daily even if its real economic meaning is often questioned because it aggregates very heterogeneous phenomena. When we consider the aggregate rate of unemployment, we disregard the fact that in some regions there can be full employment, while in others unemployment rate can be far higher than the national average. Similar problems are encountered when technological capabilities are measured: there are important differences across regions, industries and companies within the same country. The possibility of inter-country comparisons is based on the implicit assumption that a national system of innovation is somehow capable to distribute knowledge across the whole country [9,10].

The second assumption regards the usefulness of international comparisons. Differences in technological capabilities are very broad [2,11]. Thus one can doubt about the usefulness to comparing such different countries like Sweden and India, United States and Ghana because each of these countries is characterized by technological capabilities that are so different to be often disparate. James [12] stresses that the selection of data to calculate composite indicators is often biased and it does not reflect adequately national differences in development stages. Comparisons became more significant if they are carried out between more similar national systems of innovation, like Sweden and Denmark, Ghana and Togo.[2] These international comparisons also allow us to identify convergences or divergences across countries. The analysis of convergence is of particular interest for the European Union: in a moment in which the member states intend to strengthen their cohesion and to adopt a common strategy for innovation, it gains relevance to identify the contribution provided by each member state.

The two assumptions above are related to both simple and composite technological capability indicators. Composite indicators raise a third additional problem: they present a typical problem of aggregation between apples and oranges. When a composite indicator is obtained as the arithmetic mean of single statistics, we are assuming that a unit of an indicator can be substituted by a

[2] For an exercise regarding Africa, and using a more appropriate set of indicators, see [13].