ECONOMIC FITNESS: CONCEPTS, METHODS AND APPLICATIONS

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What is Economic Fitness and Complexity (EFC)?

Economic Fitness and Complexity is a recent economic discipline and methodology developed in Rome by the group of Luciano Pietronero, together with several international collaborators, first at Sapienza University and ISC-CNR and now at the Enrico Fermi Research Center.
EFC uses and develops modern techniques of data analysis to build economic models based on a scientific methodology inspired by the science of Complex Systems, with special attention to quantitative tests to provide a sound scientific framework. It consists of a data-based and bottom-up approach that considers specific and concrete problems without economic ideologies and it acquires information from the previous growth data of all countries with methods of Complex Networks, Algorithms and Machine Learning. Its main characteristics are scientific rigour, precision in the analysis and forecasting, transparency and adaptability. The Fitness algorithm overcomes the conceptual and practical problems of the early attempts in this field and sets the basis for a testable and successful implementation of the field of Economic Complexity. In particular, it gives the proper relevance to the fundamental concept of diversification.
A new paradigm replaces the ideological debate about the ideal economic theory for economic development. There is no such thing as the ideal theory valid for all situations. As in medicine, one has first to carefully identify the pathology and then implement the appropriate therapy, there is no universal medicine valid for all problems. Similarly for the economic development of a country, one has to analyze its level of competitiveness and identify the possible realistic lines of development.

These concepts have conceptual similarities with the New Structural Economics of Justin Lin, former Chief Economist at the World Bank and now at the University of Peking. In a recent podcast on “Fitness-Growth Mechanisms” within the program “Computational Macroeconomics in the Digital Era” organized by the China Association for Artificial Intelligence with an online audience of 100,000 + : https://www.bilibili.com/video/BV1B84y1s7AF/?vd_source=a0b1bcd72e0af592e24a2124adf07150

Justin Lin states that: “The Economic Fitness (EFC) provides a Metric to the new Structural Economics (NSE) and, on its turn, NSE provides an economic framework to EFC. We dream that this joint effort will lead to sustainable economic growth and a world free of poverty. In particular, it will be essential for many of the 17 UN SDG objectives, especially for the first three: 1. No Poverty; 2. Zero Hunger; 3. Good Health and Well Being”. In this perspective, EFC provides scientifically grounded aware information as a basis for the decisions of governmental policymakers but also for the business and the market. This leads to a novel perspective, modern and objective, for the traditional dilemma between state and market, often characterized by obsolete and ideological positions. The scientific power of the method has been tested in detail for forecasting the growth of many countries with a backtest totally out of the box and far superior to the usual regressions. The results are more accurate and have been compared in detail with the standard IMF forecasting. According to Bloomberg Views: “New research has demonstrated that the "fitness" technique systematically outperforms standard methods, despite requiring much fewer data”

In addition, EFC has provided a detailed understanding and forecasting of the fantastic growth of China in the past thirty years, which has been a significant mystery for most of the standard economic analysts. In particular, Larry Summers argued in 2014 that one should have expected China's growth to go below 2% for the following year. The Fitness analysis clarified why this expectation was unrealistic, as confirmed by the data of the following years. Another paradigm change is that planning and monitoring of growth are not any more described in terms of the obsolete concept of GDP but in terms of Complexity Gain, which represents the microscopic step to increase Fitness and is now adopted by various mainstream Economic Institutions.

Another vital concept in this field is Relatedness, which describes the dynamics in the Product Space. This will be discussed in detail in the Abstract presented by A. Tacchella. The usual approach is often based in the co-occurrence of products in the basket of countries. The problem with this approach is that the products are 5200 while the countries are only about 150. This leads to a severe problem of signal-to-noise that makes this approach not far from a random choice. To obtain concrete and testable results it is necessary to resort to much more sophisticated Machine Learning methods. The validity of these methods has been tested in detail with out-of-the-box approaches. In this way, it is possible to identify the possible trajectories for development, which are characterized by the Feasibility, which describes how easy is to go in that direction and the Complexity Gain, which is essentially the microscopic increase of Fitness of a given

trajectory. This information leads to a scientifically based knowledge which defines the framework for policymakers' decisions.

Concrete and Specific Results

Economic Fitness represents a synthetic measure of the degree of competitivity regarding the capabilities to produce products and services. Mathematically, the Fitness corresponds to the diversification weighted by the complexity of the products. Diversification provides stability and resilience, while the complexity of the products represents exclusivity and relative wealth. From the financial point of view, this approach is also ethical because it suggests investments based on the development of capabilities rather than on pure speculation. One can then define the Fitness specific to each productive sector and evaluate its possible evolution with methods of Machine Learning. Considering the range and completeness of the dataset analyzed scientifically and systematically, one can then reach a level of granularity far superior to the usual methods and analyse competitiveness and possibility of development for each of the 5200 products considered. The same can be done for developing technologies, using the information provided by the patents and the scientific activity through publications. This leads to three platforms: the first based on the products leads to the Economic Fitness, the second to the Technological Fitness and the third to the Scientific Fitness. From the connections between these three platforms, one can then understand the relations between science, technology and products and address in a systematic way problems like innovation and technology transfer.

Who uses EFC?

·The European Commission (Joint Research Center) has recently adopted these methods to study the 27 EU countries. It will be used to evaluate the best planning and the impact of the recovery fund projects (PNRR) to stimulate the economy of the EU in the era post COVID-19
On the Website: https://publications.jrc.ec.europa.eu/repository/handle/JRC124939 one can find a general methodological document with the analysis of each of the 27 countries performed with EFC methods that identify the present situation and the possible paths of evolution in relation to the PNRR projects. With these methods, extending these analyses in various directions and optimising the projects accordingly is also possible.
For a few years, it has been used by the IFC-World Bank Group to define specific economic actions tuned for specific countries, in particular for developing ones. One of the main targets is to identify the products or technologies which will enable to opening of new markets, considering the specific situation of each country. The IFC-WB has also supported the development of this methodology, which is now officially adopted for

planning its interventions. An example for African countries can be found here: https://www.ifc.org/wps/wcm/connect/fb4761f5-809b-4685-8fd7-24bd23bad6d3/EMCompass-Note-88-West-African-Industrial-Development.pdf?MOD=AJPERES&CVID=ngxrg.e

At CREF, we are establishing a joint research group with IFC-WB to study and forecast the international market. A similar collaboration has already started with Sony CSL to study the 17 UN Sustainable Development Goals.
Recently, we have been invited to a meeting in London at the European Bank for Reconstruction Development (EBRD) and we are discussing a concrete collaboration to adopt the Economic Fitness methodology for their projects.
In a recent collaboration with CNEL and ISTAT, we have made a specific analysis for Italy and its regions to define the present level of competitiveness and identify the possible lines of development.
These data are now discussed with various Italian Ministries.
We also have many interactions and collaborations with individual governments. For example, we are considering a possible collaboration with Saudi Arabia, which would consist of an investment analysis for the Public Investment Fund (PIF) associated with the acquisition of the technologies which would be optimal for the country's industrial development.

What can EFC do in practice?

- · **Plan the industrial development on a medium-long range**. Identifying the specific opportunities for industrial development at a national and regional level is possible, enhancing the existing technological capabilities to increase international competitiveness. Also, these methods permit a detailed analysis for developing Smart Cities within a modern and sustainable development.
- · **Economic Growth and Resilience**. These two factors are core elements of the EFC methodology. From the analysis of the various industrial sectors, it is possible to make accurate predictions of the impact that new products or technologies may have on the economic stability and competitiveness of the country. Estimating the growth of the standard GDP, innovation, and creativity is also possible.
- · **Research and Technology Transfer**. By considering the present situation of the research it is possible to identify which technological areas have the most considerable potential to impact the industrial system in the medium term. It is then possible to identify the specific opportunities for a given country to enter new sectors with an excellent perspective to become an essential player in the market.
- · **Green Economy and Sustainability**. The EFC methodology permits a coherent long-term planning towards a stable ecological transition. This implies developing green products and technologies necessary for an economy that is

simultaneously competitive but also green and sustainable. Considering these elements' complexity and interconnected nature, a scientific approach based on complexity science is absolutely necessary. The risk is that even the best intentions, without scientific control, may lead to disappointing results.

- · **Artificial Intelligence and Chat GPT**. These revolutionary developments are expected to radically change the global industrial and economic structure. The first question is on which industrial sectors these developments will impact the most. Another related and extremely challenging question is the job market's associated reorganisation.
- · **Job Market and Education**. Considering the development and growth predictions in various sectors and regions, it is possible to foresee which professional figures and related competencies will be necessary soon. Anticipating the job market's needs is extremely important to orient the education system of future generations.
- · **EFC for Companies**. The EFC analysis leads to original results also for companies. Companies show a block-nested pattern for the matrix of the products, which requires a different analysis for the country matrix, which is fully nested. The Fitness algorithm can be applied within each block to define the Company's Fitness. Then, we can use patents' information to obtain the technological network and introduce the concept of coherency for groups of technologies related to a specific product. The Product Progression identifies the following product or technology that a company may be able to produce and its competitiveness in the various markets. Along these lines, we can derive several results related to the opportunities to enter a specific market or to develop a new product. Also, the analysis and optimization of the Merging and Acquisition process can be done with these methods.