Francesco Sylos Labini

Science and the Economic Crisis

Impact on Science, Lessons from Science

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ISBN 978-3-319-29527-5 ISBN 978-3-319-29528-2 (eBook)
DOI 10.1007/978-3-319-29528-2

Library of Congress Control Number: 2016931354

Printed on acid-free paper

This Springer imprint is published by SpringerNature
The registered company is Springer International Publishing AG Switzerland

Foreword

The world is in the grip of the biggest economic crisis for more than 80 years. Nearly all nations are affected, though, of course, some are more affected than others. The key political question of today is: “What should be done to bring this crisis to an end?”

In this book, Francesco Sylos Labini, who is a researcher in physics, takes an unusual approach to the crisis by relating it to the situation in science. How is this economic crisis related to scientific research? A little reflection shows that this link is in fact very close. The neoliberal economic policies, which have dominated for the past 30 or so years, are based on neoclassical economics. This looks very much like a science such as physics, since it consists of equations and mathematical models. But is it really scientific? Should we trust the predictions of neoclassical economics in the same way that we trust those of physics? Sylos Labini gives good reasons for thinking that we should not, and that neoclassical economics is more of a pseudo-science, like astrology, than a genuine science, like astronomy.

Sylos Labini begins his argument by analyzing predictions in the natural sciences. In some areas, such as the future positions of planets and comets, predictions can be made with extraordinary accuracy; but this is not always the case. Predictions of tomorrows’ weather, or of when volcanic eruptions or earthquakes will occur, are much less certain. Let us consider meteorology. Here the laws governing the behavior of the atmosphere are precise and well established, but there is a difficulty—the so-called butterfly effect. A small disturbance, such a butterfly flapping its wings in Brazil, can be magnified and cause a hurricane in the United States. This leads to what is called chaotic behavior—a subject which has been studied mathematically, and in which Sylos Labini is an expert. Despite the difficulties caused by chaos, weather forecasting can be, and has been, improved by better collection of observations, better mathematical models, and the use of more powerful computers.

If we turn from this to neoclassical economics, we see that the situation is completely different. As Sylos Labini points out, we do not know the laws of economic development in the way that we know the laws governing the atmosphere.

The butterfly effect seems to apply to the world economy, however, since the failure of a few sub-prime mortgages in a region of the United States led to a worldwide economic recession. Yet neoclassical economists take no account of the mathematics of chaos whose use is now standard in the natural sciences. Although weather forecasts can be trusted up to a point, little credence should be given to those of neoclassical economics, and yet, as Sylos Labini points out, neoclassical economics has nonetheless achieved a cultural hegemony. In order to explain how this has been possible, Sylos Labini turns to a consideration of the organization of research, and, more generally, of the universities.

What is interesting is that neoliberal policies have the same general effect in the universities as they do in society as a whole. In society, their tendency has been to concentrate wealth in fewer and fewer hands. The richest 1 % has grown richer and richer at the expense not only of the working class but also of the old middle class. Similarly, in the university sector, more and more funding is going to a few privileged universities and their researchers at the expense of the others. This is justified on the grounds that these universities and researchers are better than the others, so that it more efficient to concentrate funding on them. To find out which universities and researchers are better, regular research assessments are conducted, and they are used to guide the allocation of funds. But how accurate are these research assessments in picking out the researchers who are better from those who are not so good? Sylos Labini gives us good reasons for thinking that these research assessments, far from being accurate, are highly misleading.

One striking result, which he mentions, is known as the Queen's question. Lehman Brothers collapsed in September 2008 and started the great recession. By chance, Queen Elizabeth visited the London School of Economics to inaugurate a new building in November 2008, and here she asked her famous question: "why did no one see the economic crisis coming?" Of course the neoclassical economists of the London School of Economics not only did not foresee the crisis, but they had been advocating the very neoliberal policies that led to it. In December 2008, the UK's research assessment exercise reported its results. These showed that the field that had obtained the highest score of any in the country was none other than economics, which in the UK had by then become almost exclusively neoclassical economics. If the results of this assessment were to be believed, then economics was the field in which the best research in the UK had been done in the preceding 5 years—better than the research in physics, computer science, or the biomedical sciences. Obviously this shows that something had gone very wrong with research assessment.

Sylos Labini is an active member of Return on Academic Research (Roars.it), an organization that is active in opposing the attempts of the Italian government to introduce a research organization modeled on the UK into Italy. His book explains the failings of such research assessment systems. One interesting argument he uses concerns some of the major discoveries in physics and mathematics made in the last few decades. In physics he discusses high-temperature superconductivity, the scanning tunneling microscope, and graphene; and in mathematics Yitang Zhang's proof of an important theorem in prime number theory. Unknown individuals, working in low-rated institutions, made all these discoveries that is to say, researchers who would have had their research funding cut by the rigorous implementation of research assessment exercises. The point is that scientific discovery is unpredictable, and one has a better chance of increasing important discoveries by spreading funds more evenly rather than by concentrating them in the hands of a small elite.

In the final part of his book, Sylos Labini points out that the same neoliberal push towards inequality is to be found in throughout Europe. Research funds are being concentrated more in Northern Europe and less in Southern Europe. Sylos Labini argues not only for a more egalitarian distribution of research funds, but also for an overall increase in the funding for research and development. This is the strategy that will produce innovations capable of revitalizing the economies and putting them once more on a growth path. Sylos Labini makes a very strong case for his point of view. Let us hope that a new generation of politicians will be willing and able to implement his ideas. Meantime his book is to be strongly recommended to anyone seeking to understand the current crisis and its ramifications.

July 2015

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Acknowledgments

I am grateful to Angelo Vulpiani, one of my mentors in physics. In addition to our countless interesting discussions on the role of forecasts in science, I thank him for painstakingly commenting on a preliminary version of this work. I am also thankful for his unwavering encouragement.

Several friends and colleagues, who have read early versions of this work, or specific chapters, have given me valuable advice and suggestions. In particular I thank Lavinia Azzone, Antonio Banfi, David Benhaiem, Andrea Cavagna, Guido Chiarotti, Francesco Coniglione, Stefano Demichelis, Luca Enriques, Donald Gillies, Grazia Ietto-Gillies, Michael Joyce, Martin Lopez Corredoira, Laura Margottini, Enzo Marinari, Maurizio Paglia, Daniela Palma, Roberto Petrini, Francesco Sinopoli, Giorgio Sirilli, Fabio Speranza, and Marco Viola.

Many ideas presented in this work come from the blog Return On Academic ReSearch (Roars.it), which has given me a privileged observation point on several issues. I am therefore grateful to all its editors for our extensive daily discussions ever since we embarked on the Roars.it adventure in 2011, and for sharing my commitment to be both a researcher and a citizen. Each one of them has taught me a lot and has influenced my ideas on some of the issues raised in this work, especially, but not exclusively, with regard to research and higher education issues. My Roars friends and colleagues include the following: Alberto Baccini, Antonio Banfi, Michele Dantini, Francesco Coniglione, Giuseppe de Nicolao, Paola Galimberti, Daniela Palma, Mario Ricciardi, Vito Velluzzi and Marco Viola.

I thank Luciano Pietronero, Andrea Gabrielli, and Guido Chiarotti for our numerous discussions on many topics touched upon in this work, and specifically for their collaboration in the study on the diversification of national research systems, as well as for sharing with me their results on “economic complexity” that I will discuss in Chaps. 2 and 4. I had fruitful discussions with Giulio Cimini and Matthieu Cristelli on the use of big data in economics. I also thank Mauro Gallegati for pointing out several references that have allowed me to deepen various concepts regarding neoclassical economics.

I am grateful to Donald Gillies and Grazia Ietto-Gillies for many interesting exchanges of views; their comments have helped me to clarify my views on different issues, from the problem of research evaluation (Chap. 3) to the criticism of neoclassical economics (Chap. 2) to the relation between basic research, innovation and technical progress (Chap. 4). In particular, Donald's writings have greatly influenced my outlook on research evaluation and neoclassical economics.

Fabio Cecconi, Massimo Cencini, and Angelo Vulpiani were my co-organizers of the meeting on *Can we predict the future? Role and limits of science,* that prompted me to investigate the role of forecasts in the different scientific fields discussed in Chap. 1.

I have had the good fortune of sharing with José Mariano Gago—who alas is no longer with us—Amaya Moro Martin, Gilles Mirambeau, Rosario Mauritti, Alain Trauttman, and Varvara Trachana many discussions, arguments and science initiatives in Europe, which have made me think about the central role of research and the dramatic nature of the crisis of the European Union which I discuss in Chap. 4.

Lastly, I am grateful to my wife Valeria, who has stood by my side throughout this endeavor and encouraged me with loving intelligence and patience.

Despite having had the good fortune to receive comments and suggestions from many distinguished friends and colleagues, everything written in this book is my sole responsibility.

Rome
November 2015

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Introduction

I have the privilege of devoting most of my time to trying to solve problems of theoretical physics that are quite distant from everyday life. However, living in Italy—a country mired in a series of crises that affect me closely both as a scientist and as a citizen—has prompted me to bring into the public debate a number of issues pertaining to the world of scientific research. I firmly believe that this is a crucial imperative in times like these, when ideology and economic interests not only drive public agendas and government policies, but have also seeped into schools, universities and culture at large.

We are faced with an economic crisis that has brought the world economy to its knees and is combined with an economic crisis pertaining specifically to Italy. This situation overlaps with, and is a consequence of, a political crisis with distinctive characteristics, causes, and developments at the international, European, and Italian levels. First and foremost, however, this is a cultural crisis on a global scale. The grand utopias that dominated our recent and immediate past seem to have vanished. Equality, brotherhood, freedom seem to be words that today have nothing to do with our reality, where inequalities have never been so great, freedom is being reduced gradually in favor of security and solidarity is overwhelmed by arrogance and indifference. Furthermore, because of insurmountable inequalities, the possibility of a change for the better of any individual's situation is currently in a regressive stage in many countries, and also what has regressed is the role of higher education as the driving force of social mobility.

Hence, what we are currently facing is essentially a political and cultural crisis that affects our society as a whole, and not merely an economic and social crisis. Scientific research is far from immune: on the contrary, it is particularly hard-hit by this crisis. On the one hand, the scarcity of research funds has become a structural problem in many countries, particularly in Southern Europe, where many young scientists are faced with very limited opportunities for pursuing their research activities on a permanent basis. On the other hand, fierce competition is distressing and distorting the very nature of research work. It seems that scientific research is thus completely taken off track as a result of this pressure.

The fact that the economic crisis has been tackled primarily through austerity policies in the very countries exposed to the greatest financial distress has further stifled scientific research and sparked a vicious cycle that prevents scientists from undertaking innovative research projects that could actually contribute to ending the crisis. Indeed, the very intellectual forces capable of producing new ideas and energies have been marginalized and gridlocked in a limbo of uncertainty for which there is no clear exit. Due to the absence of catalysts, subsequent generations may now be isolated and deprived of prospects, both individually and collectively.

Science can provide crucial tools that could be instrumental both in comprehending the problems of our time and in outlining perspectives that might constitute a solid and viable alternative to the rampant jungle law—a misconstrued Social Darwinism—that is currently very widespread. The present work ponders the interface between science dissemination and scientific policy—with some digressions into history and the philosophy of science. It therefore aims to show how the ideas developed over the past century in natural sciences (both in general and specifically in meteorology, biology, geology, and theoretical physics—much neglected in the public debate), actually play a major role in understanding the seemingly diverse and unrelated problems lying at the heart of the current crisis and may suggest plausible and original solutions. As we advance on this voyage across modern science, one of the main threads will be finding an answer to this crucial question: what are the practical, economic and cultural benefits of basic research? We will be focusing mostly on the so-called hard sciences as they have a more immediate impact on technology. Nevertheless, several arguments developed in the course of this work apply also to science in the widest sense, including social sciences and the humanities. Culture, of which science is a significant albeit small part, is the cornerstone of our society.

Abstract

The economic crisis is changing the structure of our society, introducing insurmountable inequalities, marginalizing younger energies, stifling scientific research and so inhibiting the possibility to develop the new ideas and innovations that could help to guide us out of the crisis. Science can provide crucial tools that could be instrumental both in comprehending the problems of our time and in outlining perspectives that might constitute a solid and viable alternative to the rampant jungle law—a misconstrued Social Darwinism—that is currently very widespread. The present work ponders the interface between science dissemination and scientific policy and it aims to show how the ideas developed over the past century in natural sciences actually play a major role in understanding the seemingly diverse and unrelated problems lying at the heart of the current crisis and thus suggesting plausible and original solutions.

Chapter 1
Forecast

The Scientific Method

Richard Feynman, who once referred to himself as a "Nobel physicist, teacher, storyteller, and bongos player", was an original and eccentric character. He is remembered as one of the most famous theoretical physicists of the last century, the unforgettable author of the "*Feynman Lectures on Physics*",[1] among the most studied physics textbooks in the world, and the brilliant speaker who, during a memorable lecture, explained how does scientific research work as follows[2]:

> Let me explain how we look for new laws. In general we look for new laws through the following process: first we guess it. Then we calculate the consequences of this guess, to see what this law would imply if it were right. Then, we compare the computation results to nature, to experimental experience to see if it works. If the theoretical results do not agree with experiment, the guess is wrong. In this simple statement is the key of science. It does not matter how beautiful your hypothesis is, it does not matter how smart is who has formulated this hypothesis, or what is his name. If it does not agree with the experiments, the hypothesis is wrong. […] In this way we can show that a theory capable of making predictions is wrong. We cannot, however, show that it is correct, but we can only show that it is not wrong. This is because in the future there could be a greater availability of experimental data that you can compare with a larger set of consequences of the theory so that we can perhaps find that the theory is wrong. We can never be sure that we have the correct theory, but just do not have the wrong theory.

In a simple and effective way, Feynman explained the concept of a scientific theory's falsifiability, formulated in a more organic way by Austrian philosopher and naturalized British citizen, Karl Popper.[3] According to Popper, experimental observations in favor of a theory can never prove it definitively, but they can only

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[1] Feynman et al. [1].

[2] See the original video on YouTube http://www.youtube.com/watch?v=EYPapE-3FRw.

[3] Popper [2].

F. Sylos Labini, *Science and the Economic Crisis*,
DOI 10.1007/978-3-319-29528-2_1

show that it is wrong. In fact, a single experiment with contradictory results is enough for its refutation.

Popper's criterion was however refined by 20th century philosophers of science because, when considering a scientific theory within a mature field in which the observed phenomena are far from theoretical predictions, various inferential steps may mediate them, so that the rejection of a single conjecture may not imply the refutation of the theory itself.[4] As physicist and science historian Pierre Duhem first noted at beginning of the 20th century, for a very advanced discipline, such as physics, one cannot test a single hypothesis in isolation, because to derive empirical consequences it is necessary to assume also a number of auxiliary hypotheses. For this reason, a very elaborate and high-level theory may be overturned only gradually by a series of experimental defeats, rather than from a single wrong experimental prediction.[5] A good criterion is the following: a theory is scientific if, and only if, it is experimentally confirmable—that is, if the theory is able to acquire a degree of empirical support by comparing its predictions with experiments. To be confirmable, a theory must be expressed in a logical and deductive manner, such as to obtain from a universal statement, in a rigidly linked way, one or more particular consequences that are empirically verifiable.

Traditionally, therefore, the scientist's work is to guess the theoretical hypotheses, seeking to build a coherent logical framework that is capable of interpreting experimental observations. These propositions are naturally expressed in the "language of nature" mathematics, as Galileo Galilei first claimed in his 1623 book "*Il Saggiatore*". Precision and mathematical rigor in the theoretical description and accuracy of experimental measurements are two sides of the same coin. In physics we can, in fact, distinguish correct theories from incorrect ones in a simple way: the former are more and more distinct with increasing experimental accuracy. Moreover, as we will see later, as one proceeds to more accurate measurements, one has access to an increasing amount of information that enables an ever-deeper understanding of the physical phenomena.

Since the laws of nature are by definition universal and unchanging, in other words are the same in any place at any time and space, the knowledge of these laws makes it possible to formulate testable predictions with experiments conducted under controlled conditions, in order to eliminate or minimize the effects of external factors not considered by the theory. The result of these experiments is, given the same conditions, universal, i.e. repeatable in any other place or time. The corroboration of a theory through predictions confirmed by reproducible experiments is therefore one of the pillars of the scientific method. A physical theory, through a mathematical formulation, provides the value of some parameters that characterize a given system and that can be measured. If the parameters values derived from the theory agree with the observed ones, within the limits of experimental errors, then

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[4] Gillies [3].

[5] The American logician Willard Van Orman Quine then further developed this idea, and now philosophers of science refer to it as the Duhem-Quine thesis.

the theory provides an explanation of the phenomenon. Let us consider a few historical examples to illustrate the use of previsions as a test of scientific theory correctness.

Anomalies and Crisis

Mercury, Venus, Mars, Jupiter and Saturn are the only planets visible by the naked eye in the sky. Until the late 1700s, it was thought that no others existed, but, in 1781, the British astronomer William Herschel, during an observational campaign of double stars (that is stars orbiting around each other), accidentally discovered a body, which would have then proved to be the planet Uranus. Observing the body's orbital motion around the Sun, he found anomalies with respect to the previsions of Newton's law of gravity. At that time, these anomalies represented a major scientific problem. In fact, in the 19th century, astronomy was a reference science, which aimed to measure with great accuracy the positions of celestial bodies and to interpret the observations by Newton's theory of gravity: these measurements and the corresponding theoretical calculations were at that time more accurate than in any other scientific discipline. Indeed, the regularities of the motions of heavenly bodies were known since ancient times, but only in the Renaissance, thanks to the work of Tycho Brahe, Johannes Kepler and Galileo Galilei, were a large amount of very accurate observations recorded. Isaac Newton used this knowledge to identify the mathematical laws that can precisely explain the different observations. Newton's laws of motion were shown to be so precise that any other observation in any other scientific field that did not prove compatible with them could not be considered correct. Indeed, these laws were also applied to chemistry and engineering problems and provided the rationale for the entire technological progress that had occurred since their discovery. In addition Newton, thanks to the introduction of the other hypothesis that the force of gravity weakens in a certain way with distance, was able to find a comprehensive explanation of planetary orbits, comets and tides. In particular, the Newton's law of gravitation assumes that the force of gravity decreases as a power law[6] as a function of the distance between two bodies: doubling the distance between two bodies weakens the gravitational force between them by a factor of four.

To interpret the anomalies in the trajectory of Uranus, rather than to question the correctness of the law of gravitation of Newton, it was hypothesized that they were due to the gravitational effects of an eighth planet that had still not been observed. This hypothesis corresponded to the introduction, for the first time in astronomy, of "dark matter": dark matter was therefore hypothesized to explain some differences

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[6] A power law is described by a function of the type $f(x) = a * x^b$, where a and b are two constants; particularly b is called the exponent of the power law. In the case of the force of gravity, the variable x corresponds to the distance between two bodies, the exponent is $b = -2$, and the constant a is equal to the product of the masses of the two bodies and the gravitational constant.

between observations and theoretical predictions through its gravitational effects on the position of an already known planet. The problem was then to find other independent evidences of the existence of this object. In current times, a conceptually similar situation is found in the cosmological model that is generally accepted: to explain some observations, which would not be in agreement with the predictions of the model, it is necessary to introduce dark matter (and now also dark energy). We will discuss later about the role of dark matter in modern astrophysics; in 1846 the search for an explanation of the anomalous motion of Uranus would have led to the discovery of the eighth planet, Neptune. In that case, therefore, the hypothesis of the existence of dark matter through its gravitational effects was verified by direct observations led by the calculations done in the framework of Newtonian gravity.

The calculations of the mass, distance and other orbital characteristics of the new planet were carried out by French astronomer Urbain-Jean-Joseph Le Verrier and British astronomer John C. Adams. Technically they had to solve, for the first time, the inverse perturbations problem, that is instead of calculating the orbital parameters of a certain object determined by the presence of another planet with known characteristics, the properties of the object were calculated from the knowledge of the orbital anomalies of Uranus. The planet thus hypothesized, named Neptune, was then observed for the first time less than a degree from the position predicted by Le Verrier: for theoretical astronomy, it was really a remarkable triumph as Newton's gravitation law was spectacularly confirmed.[7]

A similar, but in a way opposite, situation to that of Uranus occurred again in the 19th century in the case of Mercury. Indeed, small irregularities in its trajectory were observed; to interpret them it was assumed, as for Uranus, the existence of another planet within its orbit. This hypothetical planet was named Vulcan, and was held responsible, through its gravitational effects, for the observed anomalies of Mercury's orbit. However, in this case "dark matter" was found not be the correct explanation and Vulcan, in fact, was never observed.[8]

According to the Kepler's first law, derived from Newton's law of gravity, the planets revolve around the Sun along elliptical orbits with the Sun at one of the two focal points.[9] This law is derived neglecting the gravitational action of the other planets, which, however, are responsible for small perturbations caused by the planets' relatively small masses. These perturbations generate the precession of the point where the planet is closest to the Sun (perihelion): this means that the planet's trajectory does not lie in a single ellipse. In fact the orbit does not close, with the resulting effect that the ellipse does not remain the same but "moves", having as the Sun as one of the foci, and therefore makes a rosette motion. In this way, the

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[7] Morton [4].

[8] Baum and Sheehan [5].

[9] Differently from a circle, defined as the curve for which the distance from the centre is a constant, the ellipse is characterized by two special points called foci: an ellipse is the curve for which the sum of distances from the foci stays constant.

perihelion changes position in time. During the 19th century, the precession of Mercury's perihelion was measured as equal to 5600 s of arc for century.[10] The motion of the Mercury's perihelion was calculated using Newton's theory, considering the sum of the gravitational effects of the Sun and of the other planets. The value derived from the theory, however, was different, although by a small amount, from the observed one.

American astronomer Simon Newcomb in 1898 provided the value of this difference as 41.24 arc seconds per century,[11] with a measurement error of only 2 arc seconds per century. Newcomb considered several causes to explain this anomaly: the fact that the Sun is non-spherical, the presence of a ring or a group of planets inside the orbit of Mercury, a great expanse of diffuse matter similar to that reflecting zodiacal light, and, finally, a ring of asteroids located between Mercury and Venus. By making the calculations for the different cases, in the same framework of Newton's theory, Newcomb however concluded that none of these possible causes could explain the observations.

The hypothesized planet Vulcan was never observed, and Albert Einstein instead explained the anomalies of Mercury, in his famous work of 1915 when in which he introduced the theory of general relativity. In particular, Einstein presented calculations providing a value for the precession of the abnormal Mercury's perihelion of 42.89 arc seconds per century, well within the measurement error reported by Newcomb.[12] The Mercury's perihelion precession became very quickly one of the three main observational confirmations of general relativity, together with the deflection of light passing close to the Sun and the redshift of the light[13] emitted from a type of very compact star called a white dwarf. Einstein's new theory of gravitation completely changed astrophysics and modern cosmology, providing a new conceptual framework for relating the effects of gravity, space and time.

In fact, general relativity describes gravitational force no longer as the action between distant mass bodies that occurs in the ordinary three-dimensional space, as happened in the Newtonian theory, but as the effect of a physical law that binds the distribution of mass and energy with the geometry of space-time itself.[14] The equations formulated by Einstein that describe the force of gravity are similar to those that characterize the properties of an elastic medium. In this description, the gravitational effects are due to the distortion of this medium caused by presence of a large enough mass—like a star. For example, the Sun locally deforms the elastic medium in which it is embedded, that is space-time: the force of gravity is thus interpreted as a local curvature of space-time. As a result of this deformation, light

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[10] This measurement refers to the angular position in the sky and it is expressed in arc seconds. One degree corresponds to 3600 arc seconds.

[11] That is, less than 1/80 of a degree per century.

[12] Roseveare [6].

[13] The shift towards red (redshift) is the phenomenon in which the frequency of the light, when observed in certain circumstances, is lower than the frequency it had when it was emitted.

[14] Richard et al. [7]. For a brilliant and simple introduction to General Relativity see: Ferreira [8].