Is Fahrbach right in thinking theory change is coming to an end?

By Silvina Maestro

Ludwig Fahrbach puts forward a defense of realism in the form of the argument of the exponential growth of science. This view takes into account the quantity of scientific work done by scientist since around the 18th century and proposes that we focus on the increment of the amount of such work in time. In this essay I shall assess Fahrbach's view that theory change is coming to an end. I begin with an explanation of the exponential growth of science approach he uses to support realism against the pessimistic meta-induction argument. I will then assess his refutation of the pessimistic meta-induction and finally I shall follow with a critical assessment of such views. I shall conclude that he fails to show compelling evidence for his argument, that higher degrees of success at best might be associated with a period of theory stability but is not enough to prove the end of theory change. Furthermore, I shall attempt to show that a more critical assessment of figures reveals that the growth of science has not been exponential.

1. Introduction. Fahrbach defense of realism is based on his argument of an exponential growth of science. He observes that the majority of all scientific work ever done, at least 80%, has happened since 1950. Within this work Fahrbach includes activities such as the making of observations, the conduction of experiments and the creation and testing of theories. His considerations are based upon two criteria, namely the number of journal articles published and the number of people working as scientists in any given period. Taking into account the quantity of scientific work done by scientist since around the 18th century he suggests we notice that the amount of scientific work has exponentially increased with time. Using figures coming from bibliometrics, he concludes that the exponential growth in the number of journal articles published has resulted in a doubling of the rate of publishing to 15-20 for the last 300 years. He does, however, concede that this exponential curve does not align itself with all scientific disciplines but believes that it has certainly done so for some.

In regard to his second criterion, the amount of scientists, he cites Derek de Solla Price when he claimed in 1963 that said amount had doubled every 15 years in the last 300 years and that 90% of scientists that ever lived where alive at that time (de Solla Price 1963, p. 141). Fahrbach wonders if that statement is still correct. After considering a slow down in the number of scientists in Europe and America in the 1970's, but also considering the results of an increase in rate in Asia and the number of research doctorates twice doubling in the US from the 1960's to the 2000's he concludes that de Solla Price's claim must also be correct for today. With this in mind, he claims that such a strong increment in both scientists and scientific activities means that the last 15-20 years has seen half of all the scientific work ever done, with three quarters of all such work being done in the last 30-40 years. He will use these doubling rates as the basis for his view of theory change coming to an end and his refutation of the pessimistic meta-induction argument.

2. The pessimistic meta-induction refutation. Before Putnam and Laudan, Henri Poincaré might be seen as laying the groundwork for the pessimistic induction argument when he talks about science and its ruins piled upon ruins (Poincaré 1905/1952, p. 160). In support of anti-realism, the pessimistic meta-induction argument appeals to the history of science and the fact that we find many of the successful theories of the past superseded by new ones. The inductive inference to approximate truth that realists attach to empirically successful theories is undermined by the anti-realists who invite us to accept our current successful theories as candidates for the same destiny of those refuted in the past. Thus, the anti-realists will advise to either disbelieve or remain agnostic about current theories, lest they be proven false in the future.

Those supporting the pessimistic meta-induction, Fahrbach claims, are not considering the exponential growth of science. To further his point he introduces a graded notion of success of theories, according to which our current successful theories benefit from a much higher degree of success than those that having enjoyed success in the past were ultimately refuted. Using this graded notion of success, he attempts to show that by correctly modifying the realist view, it must not be in discordance with the history of science (Fahrbach 2011a, p. 1285).

The increase in scientific work, he claims, has lead to an increase in the opportunities for our current theories to be refuted. For him this has not been the case and suggests that a period of theory stability has arrived. The exponential growth of computer and manpower resulted in a steady improvement in the amount and precision of data. At the same time the production of better methods and instruments has resulted in better observations. Thus, the degrees of success of the theories have greatly increased, compared to those refuted in the past when scientist did not have such amount and precision of resources available. Predictions from the past, Fahrbach claims, were comparatively fewer and less precise.

By increasing the degrees of success of our theories he brings them closer to approximate truth and by doing so he creates a form of modified realism (Fahrbach, 2011a, p. 1291) reconcilable with the history of science and saved - or so he thinks - from the perils of the pessimistic meta-induction

3. Critical assessment. It cannot be denied that since the first editions of the Philosophical Transactions of the Royal Society or the Journal des sçavans the number of scientific publications has increased. However, could this observation be enough to substantiate an argument such as that of Fahrbach? That most scientific activity has taken place in the last 60 years and that in said period most of our best theories have remained unchallenged is not sufficient an argument to justify a claim such as the end of theory change. Fahrbach's resourceful proposition only manages to illuminate the way towards higher degrees of success, an insufficient path to arrive at the justification of the end of theory change - his desired destination. Such higher degrees of theory success at best show a slow down in the process of theory refutation or a period of theory stability. Considering the time frames we are given to compare, theories only seem to enjoy a longer-lasting shelf life. This phase of stability is what people like John M. Ziman call the steady-state dynamics of modern science; a phenomenon, he says, followed the exponential growth Fahrbach refers to. Ziman points out that if the exponential growth of science were not to recede at some stage

it wouldn't be long before every man, woman and child would be engaged in research and writing scientific papers (Ziman, 1994 p. 10).

In this period of stability, namely since the 1960's, some claim the age of cited material has risen, with scientist referencing material with a longer life cycle - an increasingly old body of literature. For Larivière et al, bibliometric data from macro-level patterns of usage of scientific literature over the last 100 years show that the exponential growth started to level off at the end of the 1970's; the advent of both world wars and the consequent decrease in publishing resulted in an increase in periods where scientists had to rely in older literature. Interestingly he points out that, for subfields such as nuclear and particle physics and astronomy, after the creation of e-print servers like arXiv the trend shows an increase in new material being cited. Fahrbach leaves physics outside of his considerations, as it appears to him to need special treatment. All things considered, this increase in use of new material, Larivière claims, only averages to a period of kuhnian normal science*,* even with some countries like China still enjoying an exponential growth rate, the majority of countries display low rate growth or stagnation (Larivière et al, 2008, p.291). The increase in quantity and precision in observations that Fahrbach talks about can thus be seen to be counteracted.

A more critical assessment of the figures might show that the growth of science in the 20th century was neither exponential nor constant. Mabe and Amin describe a split in three phases with the first (1900–1944) and the last (1978–1996) having identical slower rates, for them showing a tendency of the scientific activity - not unlike organisms - towards equilibrium (Mabe and Amin 2001, p. 157).
They perform a filtration of the data found in the Ulrich's International Periodicals Directory, Summer 2001 Edition, based on a number of criteria, namely that the journals must be a serial publication, classified as academic/scholarly, that the journal is still publishing at present and hence classified as active and most importantly that they are refereed as stipulated by the Ulrich's classification scheme – a scheme recently amended and allowing for more realistic calculations. Once this filtrations has been done the number of journals amounts to 14,694 for 2001. This figure is markedly different from the previous estimations performed by de Solla Price, who considered that the number of periodical titles published by the end of the 20th century would exceed the million (Mabe, 2003, p. 192).

When the calculation is repeated for every year in the Ulrich's database since 1665 a growth curve resulting of the number of scholarly and scientific journals created and still active for the 338 years studied can be built. It shows, using a logarithmic scale, a calculation of the average increase that states an almost consistent growth of 3.46% per annum. Growth rates then, are shown to have been strikingly consistent in time from the 1800 to present day, with 3.25% growth from 1860/1900 to 1940 and 1976 to today, including a middle period from 1945 to 1975 with a higher growth.

Also not considered by Fahrbach is the influence that world events such as wars and the fluctuating willingness from governments and institutions to apportion funds to research has in scientific undertakings. For Mabe, the period since 1977 is a period of conservative growth where the science and technology investments of the past failed to match what was anticipated and overly enthusiastic expectations of a more naïve era result in dissatisfaction, disenchantment and scepticism (Mabe, 2003, p. 194).

Fahrbach is right in pointing out that the acquisition of data has benefited greatly from a steady improvement in precision as well as diversity, and that automation has resulted in huge amounts of data being generated. Laborious number crunching activities can now be performed at great speeds by increasingly more powerful computers that double their capacity almost every two years (Fahrbach, 2011a, p. 1290). However, this is not enough to support his view. That better and more observations, instruments and data assist in the substantiation of better theories is not enough to rescue them from eventual refutations. Moreover, some claim that important data in the conduction of research is not deemed important or valuable enough to be kept; such data, however precise, is inaccessible to the larger scientific community (Wynholds et al, 2012 P.22). Fahrbach fails to establish a significant difference between those theories created in the initial 20% of the history of science to those in the 80% he holds as evidence to the end of theory change. If this is then only a matter of degree Laudan's argument about approximate truth and success still follows (Laudan, 1981, p.33). Even if in possession of more empirical success, our current best theories are not completely immune to future obsolescence.

There are other reservations one might have when assessing Fahrbach's view. His approach of utilizing rough estimates (Fahrbach, 2011b, p.146) might have lead him into generalizations that could have the power to wound his argument fatally. By not exploring in more depth the figures he fails to notice the difference between "real" and "artificial" growth in science. Michels and Schmoch, for example, point out that even though there seems to be a growth of roughly 34% in article numbers in the period of 2000–2008, at least 17% is accounted for the inclusion of older literature that had not previously been included in databases (Michels and Schmoch, 2012, p.845). Using data from the number of articles on the Web of Science (WoS) in the period of 2000-2008, they assert that the growth in the amount of papers might be linked to simply the additional coverage by this database source of journals that already existed.

They conclude that the number of publications cannot be interpreted as an increase in scientific activities or the growth of science itself but as a separate growth in the structures of a particular field, for example the enlarging of databases. The increase arises from the addition of old journals already published some time ago but that have not yet been incorporated in the database. They also cite as a reason for the growth of number of publications the updating of databases by including amended features for citing author's names by including their full first name rather than just their initials.

There seems to be no way of differentiating between new, additional and recurring journal categories, and hence no differentiation between an actual growth of science or just journal's policies of enlarging the coverage of their database. This, they say, can account for the increase in numbers and not the growth of science.

Another worry is that of the problem of accurate counting of unique work. In their research Larsen and von Ins have come across technical problems in the counting of papers where different publications use diverse methods; the use of certain methods can lead to the double counting of material. They also conclude that after taking into account co-authored papers, the productivity of unique contributors seems to have decreased from 1 to 0.8. (Larsen, 2010, p.593).

It can also be argued that the nature of scientific publishing has changed over time. Gross & Gross could be said to be the first to point out the overflowing of scientific literature to non-academic sources (Gross & Gross, 1927, p.388), a trend that has continued with the advent of commercial publishers. Mabe thinks that there seems to be a shift, with the publishing system shifting its drive from learned societies to a mixture market composed of commercial and society participants (Mabe, 2003, p.194). One might wonder if commercial or indeed professional considerations have influence over the quantity and quality of the material published. With publications under commercial pressure and with professional reputations to be built, it could seem like a good idea to focus on a quantitative rather than a qualitative approach, something that can stymie a bibliometric assessment of the real growth in science.

4. Conclusion.

Fahrbach fails to show compelling evidence for his argument. That most scientific activity has taken place in the last 60 years and that in said period most of our best theories have remained unchallenged is not sufficient an argument to justify a claim such as the end of theory change. Higher degrees of success at best might be associated with a period of theory stability but are not enough to prove the end of theory change. A more probing assessment of figures suggests that the growth of science has not been exponential and that its fluctuations are dependent on socio-economical and political factors unscrutinized by Fahrbach. I hope I have also advanced the idea that the increase in the number of publications cannot be interpreted as an increase in scientific activities or the growth of science itself since there are fundamental problems with considering the number of publications simpliciter as a measure of growth.

REFERENCES:

de Solla Price, D. (1963). Little science, big science. New York: Columbia University Press.

Fahrbach L. (2011a) Theory Change and Degrees of Success. Philosophy of Science, Vol. 78, No. 5 (December 2011), pp. 1283-1292. The University of Chicago Press on behalf of the Philosophy of Science Association

Fahrbach, L. (2011b). How the growth of science ends theory change. Synthese, 180, 139–155.

Lariviére V, Archambault É, Gingras Y. (2007). Long-Term Variations in the Aging of Scientific Literature: From Exponential Growth to Steady-State Science (1900–2004). Journal of the Association for

Information Science and Technology. Volume 59, Issue 2, 15 January 2008, Pages 288–296.

Larsen, PO, von Ins M. (2010). The rate of growth in scientific publication and the decline in coverage provided by Science Citation Index. *Scientometrics* 84 3 575–603

Laudan L. (1981). A Confutation of Convergent Realism .Philosophy of Science, Vol. 48, No. 1 (Mar., 1981), pp. 19-49Published by: The University of Chicago Press on behalf of the Philosophy of Science Association

Mabe, M. A., & Amin, M. (2001). Growth dynamics of scholarly and scientific journals. Scientometrics, 51,
147–162.

Mabe, M. (2003). The growth and number of journals. Serials, 16(2), 191–197.

Michels C. , Schmoch U. (2012) The growth of science and database coverage. Scientometrics (2012) 93:831–846

Poincaré, H. (1905/1952). Science and hypothesis. New York: Dover Publications, Inc.

Wynholds, L; Wallis, J ; Borgman, C ; Sands, A; Traweek, S. (2012) Data, data use, and scientific inquiry: two case studies of data practices. 8300 defect for UNSW Proceedings of the 12th ACM/IEEE-CS joint conference on digital libraries, 10 June 2012, pp.19-22

Ziman, J.M. (1994). Prometheus bound: Science in a dynamic steady state. Cambridge, England: Cambridge University Press.