

## The diffusion path of seminal economic papers. A tool for improving university staff management

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***Abstrat.** Universities that employ individuals with highly cited papers ('seminal' papers) captivate a large number of students, being able to charge above-average fees. In order to evaluate the diffusion process of new papers, we focus on widely cited papers, that is, 'seminal' papers. The 'seminal' papers included in our analysis are those produced in the period 1960-1989, which were cited more than 500 times up to 2004. We investigate the diffusion path of seminal papers concluding that Universities are able to predict from the first years of a paper publication whether it will be 'seminal'. Seminal papers in the first years show a remarkably high citation rate, with the upward trend being sustained over time, presenting therefore no signs of ageing.*

### 1. INTRODUCTION

Diffusion in a scientific field would be regarded as the dissemination of knowledge, channeled through citations that are distributed over different periods of time and propagated by means of scientific journals.

Increasingly, the education-related activities, especially at post-graduated level, assume a significant economic importance. Universities that employ individuals with highly cited papers ('seminal' papers) captivate a large number of students, being able to charge above-average fees.

University ranking, which measures staff's scientific production, is more than ever a determinant factor for obtaining public funds. Seeing university as an organization that aims to maximize its budget, the papers produced by its staff might be interpreted as 'new products', some involving radical improvements and others incremental ones. As the citation process evolves during a long span of time (lengthy diffusion process), each new paper can be modeled as a stochastic rent, where each citation corresponds to a given amount of money.

In order to evaluate the diffusion process of new scientific ideas, we focus on widely cited papers, that is, 'seminal' papers. The

'seminal' papers included in our analysis are those produced in the period 1960-1989, which were cited more than 500 times up to 2004 (data used is drawn from top ranking economic journal downloaded from ISI Web of Knowledge database).

We seek to investigate the diffusion path of seminal papers, analyzing their life cycle. This investigation would permit universities to forecast papers' potential and thus providing guidance for hiring, with a long-term contract, authors that are likely to become highly profitable.

## **2. SCIENTIFIC KNOWLEDGE INNOVATIONS ('SEMINAL PAPERS') AND DIFFUSION**

Thirty years ago Rosenberg (1976: 191) made the following observation about the diffusion of innovations: "in the history of diffusion of many innovations, one cannot help being struck by two characteristics of the diffusion process: its apparent overall slowness on the one hand, and the wide variations in the rates of acceptance of different inventions, on the other."

Without diffusion, innovation would have little social or economic impact. In the study of innovation, the word diffusion is commonly used to describe the process by which individuals and firms in a society/economy adopt a new technology, or replace an older technology with a newer. But diffusion is not only the means by which innovations become useful by being spread throughout a population, it is also an intrinsic part of the innovation process, as learning, imitation, and feedback effects which arise during the spread of a new technology enhance the original innovation (Hall, 2004).

Understanding the diffusion process is the key to understanding how conscious innovative activities conducted by firms and governmental institutions, activities such as funding research and development, transferring technology, launching new products or creating new processes, produce the improvements in economic and social welfare that is usually the end goal of these activities.

For entities such as universities diffusion of its authors' papers can be the most important part of the innovative process of scientific production as university ranking, which measures staff's scientific production, is more than ever a determinant factor for obtaining public funds.

One can adapt Rogers' (1995) useful set of five analytic categories that classify the attributes that influence the potential adopters of an innovation, which can be valuable to estimate the impact of authors' scientific papers:

- 1) The relative contribution of the paper ('innovation');
- 2) Its compatibility, with the potential adopter's current path of investigation;
- 3) The complexity of the paper;
- 4) Trialability, the ease with which paper's contribution can be tested by a potential adopter;
- 5) Observability, the ease with which the paper can be evaluated after trial.

Rogers (1995) implicitly assumes that neither the new innovation ('seminal paper') nor the technology it replaces ('older scientific ideas') changes during the diffusion process and that the new is better than the old. These assumptions have been challenged strongly by Rosenberg (1972, 1982), who argued that not only was the new technology improved as user experience and feedback accumulated, but also that frequently the replaced technology experienced a "last gasp" improvement due to competitive pressure and that this fact could slow the diffusion of the new. In the case of 'seminal papers' diffusion process, one may argue that both Rogers' and Rosenberg's assumptions have a point, in the sense that, on the one side, once papers are published they cannot be changed; on the other side, new scientific knowledge conveyed by seminal papers can lead to new interpretations and stimulate the appearance of 'replies' and new research, which might be seen as new eventual seminal paper.

### **3. MODELING 'SEMINAL PAPERS' DIFFUSION PATH**

It is a well-known fact that when the number of users of a new product or invention is plotted versus time, the resulting curve is typically an S-shaped or ogive distribution. The not very surprising implication is that adoption proceeds slowly at first, accelerates as it spreads throughout the potential adopting population, and then slows down as the relevant population becomes saturated. In fact, the S-shape is a natural implication of the observation that adoption is usually an absorbing state.

One of the leading models explaining the dispersion in adoption times uses the mechanism of ‘consumer learning’ and is widely known as the epidemic model.

Adapting it to the ‘seminal papers’ diffusion process, in this model, authors from papers that cite seminal papers (‘consumers’) can have identical tastes (same investigation path) and the cost of the new technology (‘seminal paper’) can be constant over time (the number of papers that a paper cites is limited, which translates a cost of inclusion), but not all consumers are informed about the new technology at the same time.

Because each author learns about the seminal paper from his or her scientific neighbor, as time passes, more and more authors cite the seminal paper during any period, leading to an increasing rate of adoption.

However, hypothetically new papers emerge and predate the existing one, and in this case the rate decreases. This will generate an S-shaped curve for the diffusion rate. However, in the case of scientific knowledge diffusion, predation is a rare phenomenon. Most cases are characterized by ever increasing impact, which translates the fact that new papers incrementally improve on existing ones.

Regardless of the details of the mechanism generating the probability distribution of adoption times, the question which is likely to concern Universities that try to hire authors of potential seminal papers is whether from the observation of the first years citations one can conclude about its seminal potential.

An important factor in explaining the slowness of technology adoption is the fact that the relative advantage of new technologies is frequently rather small when they are first introduced. As many authors have emphasized, as diffusion proceeds learning about the technology takes place, the innovation is improved and adapted to different environments, thus making it more attractive to a wider set of adopters (Rosenberg, 1976; Nelson et al., 2002).

The implication is that the benefits to adoption generally increase over time; if they increase faster than costs, diffusion will appear to be delayed (because the number of potential adopters will increase over time, expanding the size of the adopting population). These theoretical explanations seem to suit the examples of the set of ‘seminal papers’ selected below (Figures 1 to 4).

#### 4. ILLUSTRATING ‘SEMINAL PAPERS’ DIFFUSION PATH

In specific case of scientific papers, the value of some new technology (‘seminal papers’, for instance) to the readers/authors depends on partly on the extent to which it is adopted by other readers/authors, either because the paper is used to communicate with others or because its applicability depends on the existence of a large scientific community working in the related field. Goods of this type are usually termed network goods by economists: their chief characteristic is that they rely on standards to ensure that they can communicate either directly or indirectly. For these goods, which papers in general and ‘seminal’ papers in particular are good examples, an important determinant of the benefit of adoption is therefore the current or expected network size.

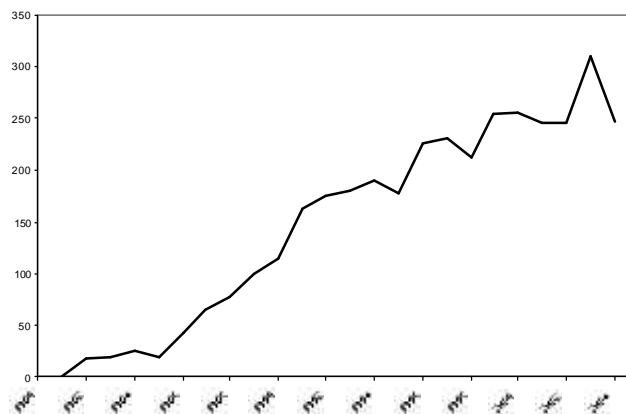


Figure 1- H. White's seminal paper: "A heteroskedasticity-consistent covariance-matrix estimator and a direct test for heteroskedasticity", *Econometrica*.

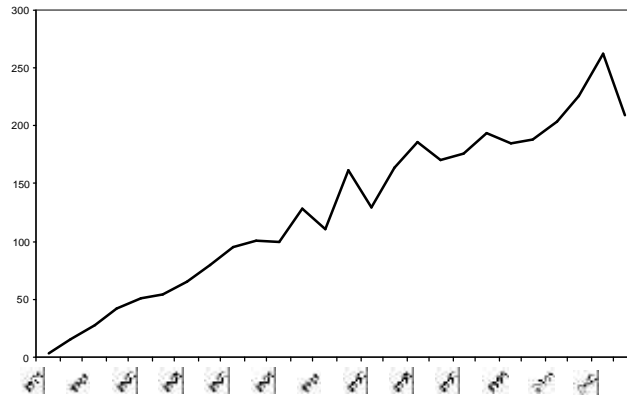


Figure 2 – D. Kahneman and A. Tversky's seminal paper: "A prospect theory – analysis of decision under risk", *Econometrica*.

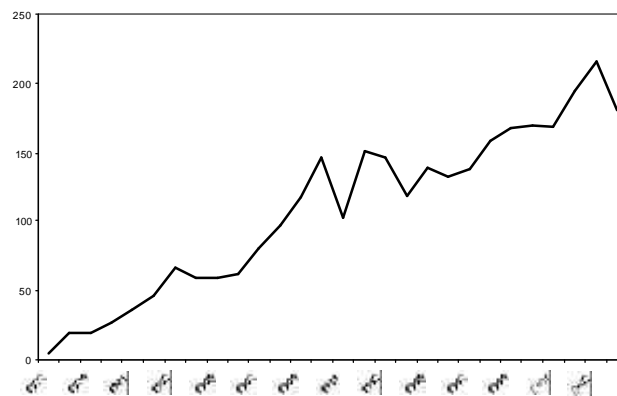


Figure 3 – M. C. Jensen and W. Meckling, "Theory of firm – managerial behaviour, agency costs and ownership structure", *Journal of Financial Economics*.

Figure 1 up to 3 depicts the general path of diffusion of seminal papers. It is straightforward to observe that the number of citations increases over time evidencing no signs of ageing. This reveals that scientific knowledge, regarding the field, accumulates over time. An exception to this general path is Engle and Granger's paper, which outdated by the emergence of Johansen's seminal paper (see Figure 4).

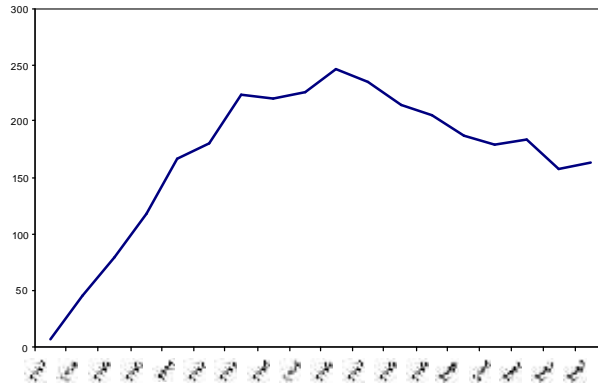


Figure 4 – R.F. Engle and C. W. Granger, “Cointegration and error correction – representation, estimating, and testing”, *Econometrica*.

In the next figure, we illustrated the evolution of the sixteen most cited seminal papers among those included in our analysis (i.e., cited more than 500 times) and produced in the period 1960-1989.

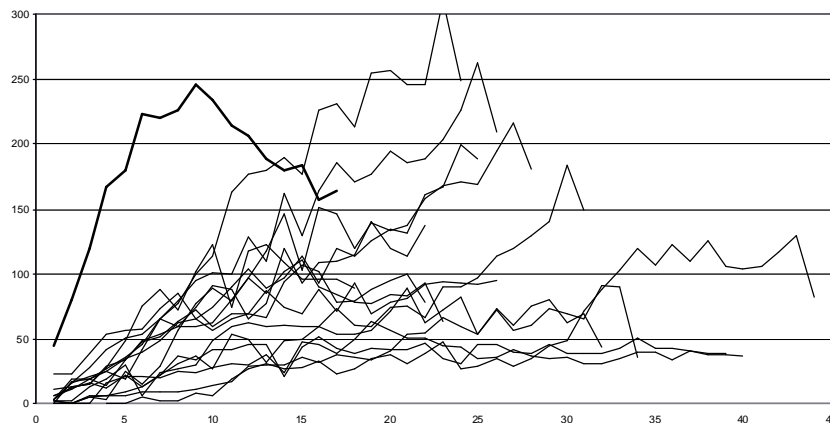


Figure 5 – The diffusion path of the sixteen most cited economic ‘seminal papers’

### 5. CONCLUSIONS

From observing the diffusion path of the selected economics ‘seminal papers’, we might argue that Universities are able to predict from the first years (three up to five years) of a paper publication whether it will be ‘seminal’ or not. In fact, ‘seminal’ papers are those, which in

the first years show a remarkably high citation rate, with the upward trend being sustained over time. In general, scientific knowledge conveyed in a seminal paper shows no depreciation during time. Only one ‘seminal’ paper presented a decrease in citation rates after ten years from its publication. This illustrates a well-known case of methodological ‘predation’ in econometrics – the replacement of Grangers’ tests by Johnsen’s.

The outcome of this investigation would permit universities to forecast papers’ potential and thus providing guidance for hiring, with a long-term contract, authors that are likely to become highly profitable.

#### 4. REFERENCES

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