One of the simplest ways to explain the Matthew effect (in science)

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A partial view of the Matthew effect in science asserts that the (already) most recognized scientists are those who (more easily) gain greater recognition for their scientific contributions. A full view of that effect naturally adds to the (comparative) advantages of the most recognized scientists, the (comparative) disadvantages of lesser-recognized scientists. The purpose of this report is to present one of the simplest explanations of the Matthew effect in science, which, as it is also very general, can explain the existence of that effect in other areas where inequality is manifested.

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Keywords
Matthew effect — Comparative advantage — Comparative disadvantage — Virtuous circle — Vicious circle

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> For to every one who has will more be given, and he will have abundance; but from him who has not, even what he has will be taken away.
>
> Matthew XXV: 29

> To whoever already has, more will be given, but whoever doesn't have will have what little they have taken away from them.
>
> Mark IV: 25

> I tell you, that to whoever that has, it will be given; but from whoever does not have, even what they have shall be taken away.
>
> Luke XIX: 26

1. Introduction

The effect of Matthew in science is usually associated with the seminal article of Merton (1968) and its sequel in Merton (1988). In these, a recurrent situation in science is analyzed, in which the scientists most recognized by the scientific community are those who, more easily, receive greater recognition for their scientific contributions. Because of the similarities, this situation is then associated with the (first part of the) gospel of Matthew XXV: 29.

As acknowledged immediately in Merton (1968: 57), this pattern of recognition happens in two situations: i) collaboration of scientists with different degrees of recognition in scientific works (in co-authorship); ii) multiple discoveries, i.e. independent works leading to the same innovative result.[1]

At the heart of the Matthew effect there are basically two elements: (scientific) performance (or achievement) and reward (for example, recognition) of this performance. These two elements interact dynamically, giving rise to a comparative advantage/virtuous circle – the rich(er) get richer – or to a comparative disadvantage/vicious circle – the poor(er) get poorer – being sure that the starting position, ie the initial conditions will also be relevant. It is this process that one intends to explain, using one of the simplest forms, as will be seen next.

2. The explanation

Let us assume that performance, at moment t, say P_t, is a function of past performance, P_{t-1}, as well as of past reward, say R_{t-1}, in accordance to the following expression:

$$P_t = \alpha P_{t-1} + \beta R_{t-1}, \tag{1}$$

[1] Taking this second situation into account, it is ironic to realize that, the very effect of Matthew seems (possible) to be characterized by the existence, in itself, of that effect, inasmuch as in the gospels of Mark IV: 25 and Luke XIX: 26 the same statement is presented. Thus it may be said that, in reality, the Matthew effect corresponds to a parallel passage of the three gospels (Lucas, Mark, and Matthew), i.e. corresponds to the so-called "triple tradition" (Honoré, 1968).

where both α and β are non-negative (constant) parameters.[2] Reward, at moment t, R_t, is assumed to be a function of past performance, P_{t-1}, in accordance to the following expression:

$$R_t = \gamma P_{t-1}, \tag{2}$$

where γ is a non-negative (constant) parameter.[3]

Substituting expression (2), for $t-1$, into expression (1) yields

$$P_t = \alpha P_{t-1} + \beta\gamma P_{t-2}, \tag{3}$$

which is equivalent to

$$P_{t+2} - \alpha P_{t+1} - \beta\gamma P_t = 0. \tag{4}$$

Plainly, expression (4) is a homogeneous linear second-order difference equation (with constant coefficients), whose solution is

$$P_t = a_1 m_1^t + a_2 m_2^t, \tag{5}$$

where a_1 and a_2 are parameters to be determined from the initial conditions, P_0 and R_0, whereas m_1 and m_2 are the roots of the characteristic polynomial

$$m^2 - \alpha m - \beta\gamma = 0. \tag{6}$$

Leaving aside the mathematical details, it is easy to show that

$$m_1 = \tfrac{1}{2}\alpha + \tfrac{1}{2}\sqrt{\alpha^2 + 4\beta\gamma},$$
$$m_2 = \tfrac{1}{2}\alpha - \tfrac{1}{2}\sqrt{\alpha^2 + 4\beta\gamma},$$

and that

$$a_1 = \frac{\sqrt{\alpha^2+4\beta\gamma}+\alpha}{2\sqrt{\alpha^2+4\beta\gamma}} P_0 + \frac{\beta}{\sqrt{\alpha^2+4\beta\gamma}} R_0,$$
$$a_2 = \frac{\sqrt{\alpha^2+4\beta\gamma}-\alpha}{2\sqrt{\alpha^2+4\beta\gamma}} P_0 - \frac{\beta}{\sqrt{\alpha^2+4\beta\gamma}} R_0.$$

[2] Note that, for the sake of illustration, we are considering that α *or* β may be zero. Plainly, both parameters being zero will make the case uninteresting.

[3] Note that, not only for the sake of illustration, we are considering that γ may be zero. This may be the case when, for example, an article is published that proves that seasonality is relevant to explain the number of births occurring in Portugal (Caleiro, 2010), but this result is (unsurprisingly or, indeed, not) ignored by public authorities, which insist on spending – in this case being synonymous with waste – public money, through recourse to measures of alleged demographic policy based, for instance, on payments by newborns, whose effectiveness is known to be dubious. (Rego et al., 2012).

Considering these solutions for m_1, m_2, a_1, and a_2 in expression (5) it is then possible to simulate the evolution of the performance, P_t – and, by way of expression (2), of the reward/recognition, R_t – over time. Clearly, in these simulated temporal trajectories, the initial conditions play a relevant role.[4] Thus, consider two cases where the initial performance is more favorable in one case. Figure 1 shows the evolution of performance for the following two cases:

- Case 1: Initial conditions: $P_0 = 2$; $R_0 = 0$; $\alpha = 0.6$; $\beta = 1.1$; $\gamma = 0.4$.
- Case 2: Initial conditions: $P_0 = 3$; $R_0 = 0$; $\alpha = 0.6$; $\beta = 1.1$; $\gamma = 0.4$.

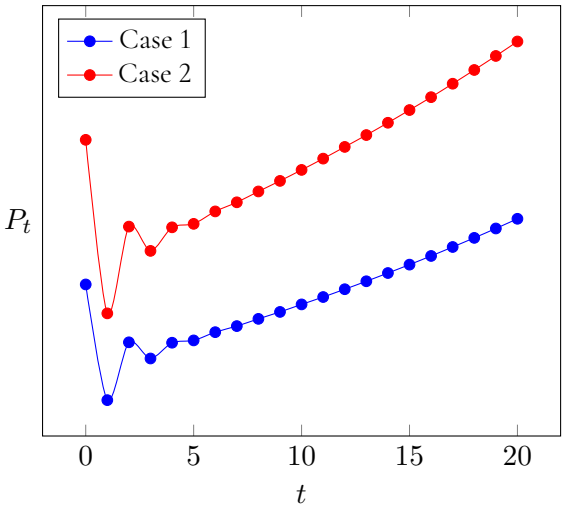

Figure 1. On the importance of the initial conditions

Figure 1 thus illustrate the case where performance increases over time but, due to a higher initial performance, this increase is higher (in case 2).

Let us now show how comparative advantages or disadvantages may occur, for instance because of distinct γ values. Figure 2 shows the evolution of performance for the following two cases:

[4] In fact, initial conditions play a crucial role in a particular area where the Matthew effect appears to be present, namely that of education (Walberg & Tsai, 1993), in particular the acquisition of reading skills. Thus, it seems to be valid that the early acquisition of reading skills brings comparative advantages later on in these subjects. On the other side of the question, as the acquisition of reading skills has an obvious influence on the literacy, the eventual difficulties in acquiring those competences end up being reflected in (later) problems in many other areas of cognitive development (Stanovich, 1986). It is very interesting to note that this is also the position taken by the OECD, which demonstrates the practical or political usefulness of this result. In OECD (2017: 11) we can read: "The first years of life lay the foundations for future skills development, well-being and learning."

- Case 1: Initial conditions: $P_0 = 3$; $R_0 = 0$; $\alpha = 0.6$; $\beta = 1.1$; $\gamma = 0.3$.
- Case 2: Initial conditions: $P_0 = 3$; $R_0 = 0$; $\alpha = 0.6$; $\beta = 1.1$; $\gamma = 0.4$.

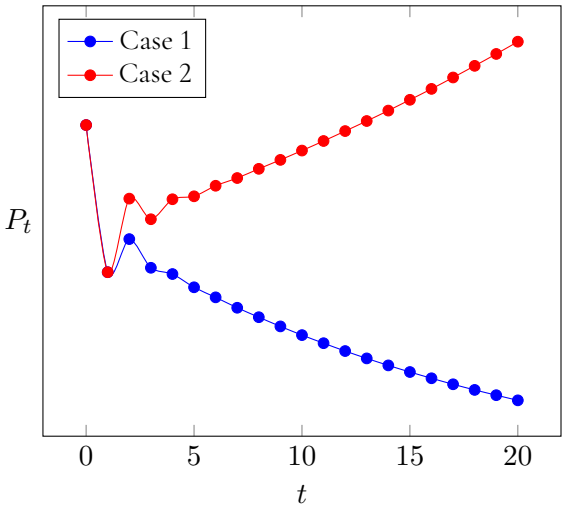

Figure 2. The two sides of the Matthew effect

As expected, for the same initial conditions and the same values of α and β, a sufficiently high (resp. low) value of γ leads to the occurrence of a comparative (resp. disadvantage).

3. On the use of γ

Expression (2) states that the reward (or recognition) is proportional to the performance (or achievement) through the γ parameter, which was considered being constant. Clearly, the smaller the value of γ the greater the possibility of a comparative disadvantage. Thus, if the value of γ can be reduced by another person(s), to whom this is beneficial, the constancy of γ can be called into question.[5]

In order to exemplify the above, consider the following anecdotal episode. Suppose someone has a publication in a journal where (at least) 4 Nobel prizes (from her/his area) have also been published.[6] Because, apparently, that publication should be highly valued, there seems to be evidence of something (ethically or morally) wrong if the γ value associated with it is considered by another person(s) as (almost) nil.[7]

4. Conclusion

Using a quite straightforward approach, we provided one of the simplest ways to explain the Matthew effect (in science).

In recognizing that, in the essence of Matthew (total) effect, there is a situation of comparative advantage, as well as one of comparative disadvantage, – Using the old saying: the rich(er) get richer and the poor(er) get poorer – it is obviously possible to generalize the Matthew effect to other areas (beyond science). In fact, the Matthew effect is present whenever there are virtuous/vicious circles (or spirals), which is a recurrent situation in many (other) areas.[8] These areas are all those where inequality is an issue. In this sense, the Matthew effect is a fact more present than acknowledged, even in itself.[9]

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[5] Moreover, this can be seen as an example of toxic behavior, which is phenomenon that seems to characterize the academic environment (Caleiro, 2017;2018).

[6] For instance, Heckman, James J. (2000). Policies to foster human capital, *Research in Economics*, 54: 1, 3-56; Krugman, Paul R. (2017). Avinash and Joe's excellent engine. *Research in Economics*, 71: 4, 643-644; Pissarides, Christopher A. (2015). Dale Mortensen: An appreciation. *Research in Economics*, 69: 1, 1-6; Stiglitz, Joseph E. (2017). Monopolistic competition, the Dixit–Stiglitz model, and economic analysis. *Research in Economics*, 71: 4, 798-802.

[7] Obviously, ignorance may also explain this (unintentional but still toxic) behavior. This would raise other issues, such as mediocrity, that we intend to address later.

[8] For example, while not explicitly acknowledging the existence of the Matthew effect, Caleiro (2009) simulated the cumulative process of material and human enrichment/impoverishment of the regions or territories, *in light of the logic of that effect*.

[9] For instance, even in science, where some gender bias seems to exist (Rossiter, 1993)

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