

Supplementary box S1 | What is R&D productivity?

One of the challenges of writing about R&D productivity is that the term itself often connotes different meanings to different people. In our analysis, we have defined a productivity relationship by further adapting Little’s Law or Throughput = WIP/C as described by Hopp and Spearman¹ and we will adhere to the terminology that has long been used in the pharmaceutical industry. However, for readers from other disciplines, we further elaborate our definition and productivity relationship especially as it might be considered by economists.

As shown in supplementary Figure S1, R&D management strives to improve R&D’s contribution to firm performance by increasing the volume of innovation and its value, while reducing cost. For the industry, this simply amounts to raising R&D productivity by improving both R&D efficiency and R&D effectiveness. This can be made more operational by observing that the volume of innovation depends upon the number of new molecular entities (NMEs) in development, which we call ‘work in process’ (or *WIP*); the probability that they will be approved by the US FDA, which we call ‘probability of technical success’ (or $p(TS)$); and the number of years it takes on average to steer a compound through R&D, which we call ‘cycle time’ (or *CT*). The right side of the equation at the centre of the figure displays how these variables combine and can be handled to achieve the desired outcome of greater productivity.

For economists however, management endeavours to raise R&D performance by enhancing both R&D productivity (number of NMEs per year) and value (medical usefulness and commercial value of NMEs), while improving R&D efficiency (lowering cost-per-NME).

References

Hopp W. J. & Spearman M. L. *Factory Physics: Foundations of Manufacturing Management*. (Irwin/McGraw-Hill, Boston, 1996).

