FROM THE ANALYST'S COUCH

Drug launch curves in the modern era

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How quickly will a drug in development reach peak revenues after launch? Anyone who builds financial models in the pharmaceutical industry has wrestled with this question — which is to say, every investor, analyst, banker, dealmaker, commercial team, franchise head and senior executive in the sector, not to mention scores of consultants and journalists focused on drug development and commercialization.

The shape of the launch curve can dramatically affect financial models of pre-commercial drugs. Because revenues are discounted to account for the 'time value of money', a fast ramp has an outsized effect on the projected net present value (NPV). Shortening the projected time to peak sales by even 20% — say, from 5 years to 4 — can radically change the apparent attractiveness of an asset to both financial and strategic investors.

Particularly for assets in the early stages of R&D that are many years away from the market, it is often most practical to base the launch trajectory on general heuristics, rather than commercial analogues. The most commonly used launch curve assumptions are based on an econometric model developed by Bauer and Fischer in 2000 (*Int. Bus. Rev.* **9**, 703–725; 2000), which showed that 'pioneer' drugs (first in a therapeutic area or class) have a slower uptake compared with 'followers' — approximately 8 years for the former, versus 3–4 years for the latter.

Bauer and Fischer's work (and a follow-up analysis using similar methodology and data (*Quant. Mark. Econ.* **8**, 429–460; 2010)) was pioneering and mathematically rigorous, but it has several limitations that affect its applicability to forecasting contemporary drug launches. First, the narrow therapeutic and pharmacological spectrum of agents studied — 36 agents in just four classes of cardiovascular drugs — is unrepresentative of the diversity of the industry today. Second, their model encompassed launches in both the United States and five European countries, which may mask underlying geographical differences in the market uptake of new agents. And finally, their analysis of launches from 1982 to 1990 is now several decades old, and may not reflect the evolution of the broader pharmaceutical market and companies' approaches to drug commercialization.

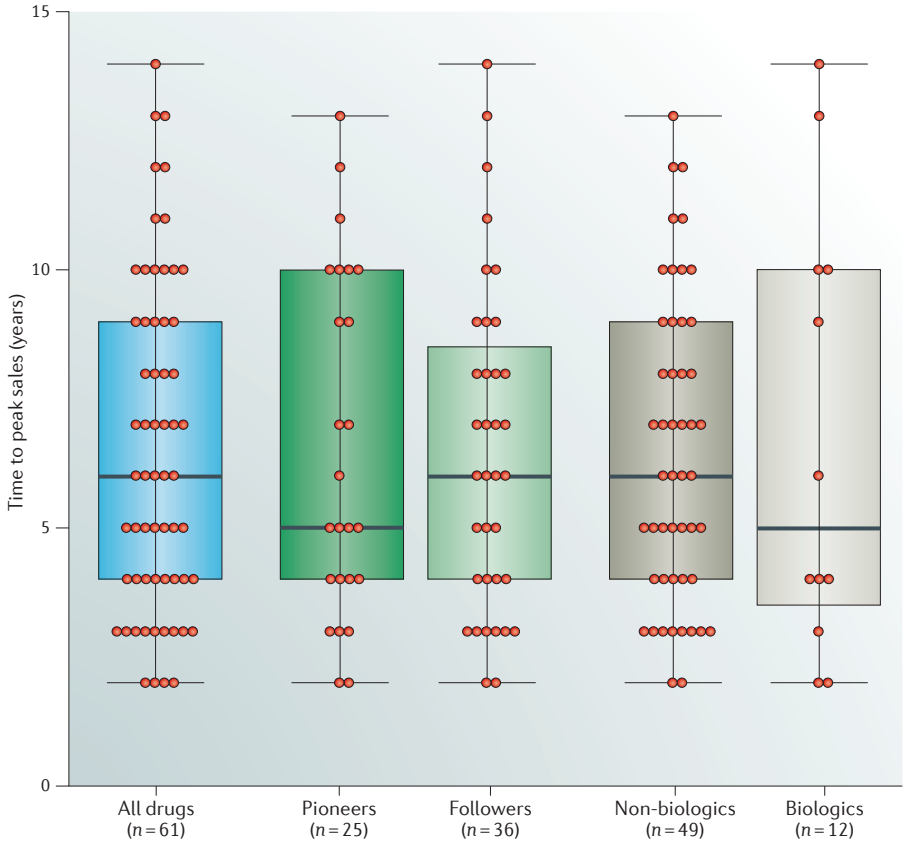

Figure 1 | **Distribution of times to peak sales for drugs launched in the United States, 2000–2002.** The 61 drugs (data points shown as red circles) were also divided into subsets in two ways for comparison: pioneers versus followers and non-biologics versus biologics. Boxes encompass interquartile ranges; whiskers encompass full ranges of data. Differences between the subsets were not statistically significant. See Supplementary information S1 (box) for details.

Developing an updated framework

To develop a set of assumptions more applicable to contemporary pharmaceutical commercial models, we examined US sales trajectories (in extended units) of all 70 prescription drugs approved by the FDA from 2000 to 2002, which we corrected to account for population growth and normalized to peak unit sales. After removing aberrant curves (peaking in the first year after launch or the last year of our data set), we analysed 61 drug launches, encompassing a broad range of pharmacological mechanisms of action and therapeutic areas. We subdivided the drugs into pioneers and followers, based on the assignments of these drugs in a previous study that defined a methodology to classify drugs as 'first in class', 'advance in class' and 'addition to class' (*Health Aff.* **32**, 1433–1439; 2013), considering 'first in class' and 'advance in class' as 'pioneers' and 'addition to class' as 'followers'. We also separately subdivided the drugs into biologics and non-biologics, with biologics defined as those drugs produced by recombinant DNA technology ▶

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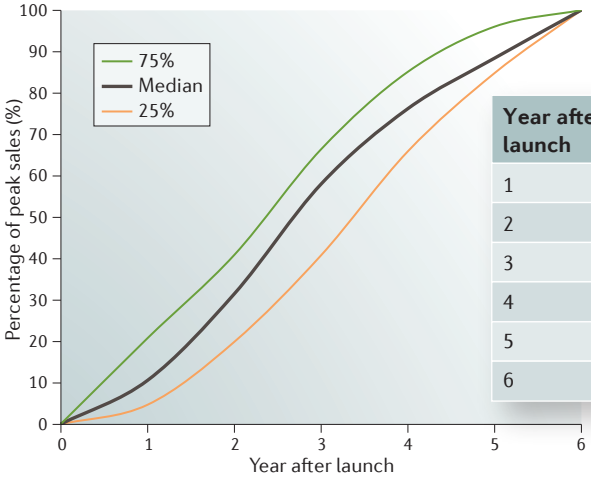
(see Supplementary information S1 (box) for further details of the data set and analysis methods).

For each drug, we identified the year after launch (defining the launch year as $n = 1$) at which sales reached a maximum. To study the trajectory of the growth phase, we first transformed each drug's data to a 6-year curve using the equation $X_i = Y_i \times (6/Y_{peak})$, where X_i is the transformed x-value, Y is year and Y_{peak} is the year in which the drug achieved peak sales. We then interpolated the sales in each integer year (1–5) by assuming that intra-year growth was linear. Finally, we calculated the median value and interquartile range for the percentage of peak sales in each year across the sample.



Year after launch	Median % of peak sales	Interquartile range
1	11	5–21
2	31	20–41
3	58	41–67
4	76	66–85
5	89	85–96
6	100	n/a

Figure 2 | **Shape of a median launch curve for drugs launched in the United States, 2000–2002.** Median and interquartile curves (left) and data (right) by year for a prototypical drug launch with a 6-year time to peak sales. See Supplementary information S1 (box) for details. n/a, not applicable.

Discussion

We had hypothesized that our study would validate Bauer and Fischer's pioneer–follower framework, but perhaps show quicker ramp rates due to advances in commercialization experience, strategies and spending over the past several decades (see the McKinsey report in Further information). However, we did not find this to be the case. Unlike earlier work, we did not identify a statistically significant difference between pioneers and followers; we were also unable to discriminate between biologics and non-biologics (FIG. 1). Overall, the median time to peak sales in our sample was approximately 6 years, roughly in the middle of the range previously defined by Bauer and Fischer — suggesting that pioneers and followers have converged, with the former gaining commercial traction more rapidly than in earlier decades, but the latter peaking later than before.

This finding could affect how some drug developers allocate capital to R&D. For companies that use valuations based on discounted cash flow (DCF) as one input to inform decision-making, shortening the projected time to peak sales for pioneer drugs could make these research programmes more attractive than they would have appeared in models based on Bauer and Fischer's earlier work.

One area of concordance between our work and earlier analyses is our finding that drug launches generally progress along an S-shaped curve (FIG. 2). The century-old idea that new innovations are generally embraced first by 'early adopters', then rapidly by the majority, and finally by the 'laggards' (*Acta Sociol.* **39**, 431–442; 1996) has been validated across many industries, and also appeared to be supported by the complex equations derived in Bauer and Fischer's earlier drug launch analysis. Similarly, we find that recent launch curves are also sigmoidal, albeit slightly left-shifted in terms of the time to 50% of peak sales.

Importantly, our work does not necessarily imply that order of entry has no effect on drug commercialization or financial modelling today. As might be expected from the diverse set of agents we analysed, the interquartile range of the time to peak sales was broad (4–9 years), raising the possibility that the effect of various drug-, indication- and market-specific factors on launch trajectories may mask an underlying effect of launch order. In addition, separate from the consideration of time to peak sales, several prior studies have confirmed that pioneers and followers differ in their peak revenue potential and projected market share (*Nat. Rev. Drug Discov.* **12**, 419–420; 2013; *Nat. Rev. Drug Discov.* **5**, 285–293; 2006).

Like all prior studies of drugs' commercial trajectories, our work has imperfect relevance to current and future agents. By focusing on launches from 15 years ago, we captured the majority of observed market peaks — but the range of indications and competitive landscapes from that period may not reflect those of more recent launches. Furthermore, it is unclear whether priority regulatory pathways in the United States, which have continued to gain popularity in recent years, affect not only the speed of market entry, but also that of market uptake. And finally, the US pricing and reimbursement landscape — as well as drug manufacturers' sales, marketing and market access strategies in response — continues to evolve, and future launches may enter a commercial world that is very different from that of either 15 years ago or today.

These caveats notwithstanding, however, our work suggests that a 6-year, S-shaped curve is a reasonable benchmark for contemporary drug launches, independent of the agent's projected pioneer or follower status. We believe our study provides a meaningful update of earlier work in this area, and that particularly for models of agents currently in early- to mid-stage R&D, the findings are appropriate for pharmaceutical financial projections in the modern era.

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Competing interests statement
The authors declare competing interests: see Web version for details.

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