Do Pharmaceutical Sales Respond to Scientific Evidence?

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I investigate how different sources of information influence the diffusion of pharmaceutical innovations. In prescription-drug markets, both advertising and scientific information stemming from clinical trials can affect physicians' prescription choices. Using novel indices of clinical-research output, I find that both marketing and scientific evidence directly influence the diffusion process in the antiulcer-drug market, with marketing having a more pronounced influence. I also find evidence that clinical outputs are important drivers of firms' marketing efforts, affecting sales indirectly. Taken together, the direct and indirect effects of science on demand imply strong private incentives for clinical research. I conclude that product-market competition in the pharmaceutical industry is shaped by both advertising rivalries and scientific rivalries. Moreover, drug advertising may perform an important informative function.

1. Introduction

How do different types of information influence the diffusion of pharmaceutical innovation? The spread of technological advances is limited by the extent to which relevant information is available among potential adopters. Furthermore, the information necessary for the diffusion of pioneer products may be different from that required for the market penetration of subsequent innovations.

In most industries, one would expect underinvestment in the production of knowledge to limit the availability of objective sources of information about product characteristics, safety, and efficacy (Arrow, 1962). However, in prescription-drug markets, two features of the institutional environment—extensive, government-mandated

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In what follows, I make the identifying assumption that clinical-research outputs and (SCIENCE1 and SCIENCE2) are uncorrelated with month-to-month *changes* to these unobserved characteristics ($\Delta\xi$).[16]

4.4 RESULTS

This section reports the empirical results on the *direct* competitive effects of advertising and science (Section 5 below estimates the magnitude of the *indirect* effect of scientific information on demand—through the promotion efforts induced by scientific activity). The findings suggest that the levels of both variables drive diffusion and performance on the product market, with marketing activities having a more pronounced effect. Because of the semilog functional form of the logit model, coefficient estimates are not immediately interpretable as elasticities.

Turning to the results of Table IV, model (1) presents OLS estimates of the diffusion equation ignoring the effect of scientific information ($\beta_8 = \beta_9 = 0$). The coefficient on STKDETAILING and STKJOURNAL are positive and significant, and the demand curve is downward sloping, as anticipated. Other product characteristics contribute significantly to the model fit, with signs conforming to priors, except for DOSAGE and INTERACTIONS.[17]

Model (2) adds the effect of science. In this specification, β_5 decreases by about 10%, and both SCIENCE1 and SCIENCE2 obtain positive and significant coefficients. A likelihood-ratio test between models (1) and (2) easily rejects the former (LR $= 62.334$, df $= 2$). Interestingly, including the SCIENCE measures causes the DOSAGE coefficient to flip sign, while the coefficient on INTERACTIONS is not statistically significant.

Model (3) addresses the issue of endogeneity by presenting 2SLS estimates. The results are similar, except that the STKDETAILING coefficient drops substantially.[18] Because serial correlation is present

16. I gain additional insight into this issue by examining whether variation in the flow of scientific information can be explained by differences in the characteristics of the firms selling these drugs. I report the results of specifications that regress FLOW (and also the count of published clinical studies) on a constant, the log of the US revenues of the firm outside the gastrointestinal therapeutic area, its stock of detailing minutes on all its other products, and its stock of journal advertising expenditures on all its other products. I observe no systematic relationship between these variables. See Azoulay (2001) for further details.

17. One would expect consumers to prefer drugs with the lowest dosage frequency, *ceteris paribus*. Tagamet entered the market with a requirement of four daily doses, but was able to match Zantac's twice-a-day dosage within a year of the new drug's entry.

Because advertising does not jam all other information channels available to reach the population of prescribing physicians, pharmaceutical firms face strong private incentives to perform clinical research.

6. Concluding Remarks

The results presented here demonstrate that product-market competition in the H_2-antagonist therapeutic class was shaped by rival firms' advertising efforts and the quality of the scientific information concerning the four drugs. The paper provides an original methodology for computing indices of quality-adjusted scientific outputs. I find that marketing had a more pronounced direct effect on demand than science, but the latter was still statistically and economically significant. I introduce the distinction between market-expanding and comparative science, demonstrating that the second type was a particularly effective business-stealing weapon for the second mover Zantac. In addition, I find evidence that clinical-research outputs were important drivers of firms' promotion efforts, although detailing and journal-advertising expenditures also responded positively to the intensity of competitors' marketing campaigns. Taken together, these results suggest that pharmaceutical advertising does not perform a purely persuasive function, nor does it jam professionally sanctioned information channels by preventing scientific results to get through to prescribing physicians.

I take into account both the direct and the indirect effect of science on demand to compute the appropriate elasticities. The sum of the direct and indirect effects yields a level for the total market-expanding science elasticities of demand around 0.4 for the pioneer drug and its challenger, and positive and significantly above zero for the two later entrants. These results imply strong private incentives for performing clinical research and suggest that controlled clinical trials do not accomplish the sole function of securing regulatory approval, but also represent investments whose effects on the product market are both substantial and long-lived. The results are consistent with long-run trends noted by industry practitioners (Carr, 1998). A growing number of drugs go into postapproval, so-called Phase IV trials. These are designed to extend the range of conditions for which a drug can be used, thereby making it more profitable. Such trials also satisfy the need to accumulate evidence for use in persuading physicians to favor new drugs over older ones.

The results of this paper are also of significant interest in the