Market Size and Innovation: The Role of Technology Licensing

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1. Research Question

Motivated by prior work on market size spurring innovation, we study the role of increased downstream demand in facilitating inter-firm cooperation in the pharmaceutical industry, where licensing is a common form of collaboration between upstream innovators and downstream commercializers. We propose a simple model of licensing with heterogeneous match quality which predicts that positive demand shocks will increase the likelihood of licensing and improve match quality by reducing the relative importance of transaction costs. We then use the differential impacts of the introduction of Medicare Part D across drug categories targeting different ages of consumers as a source of variation in demand to empirically examine these predictions.

The innovation of new technologies is regarded as a primary source of improvements to economic welfare and growth (Arrow, 1962). This is particularly palpable for medical innovation, where the availability of new treatments can be directly linked to higher longevity, better clinical outcomes, and overall health improvements (Murphy and Topel, 2003, 2006; Lichtenberg, 1996, 2010). A leading force propelling the innovation of new technologies is firms' aspiration to rip the monetary rewards derived from commercialization, implying that larger market sizes enable higher rates of innovation (Nordhaus, 1969). This has been well documented in the context of the pharmaceutical industry by a sizable literature that identifies causal relationships between larger market sizes and higher innovation rates.

We argue that, by facilitating productivity-enhancing cooperation between upstream innovators and downstream commercializers, market size also intermediates the relationship between inputs and outputs of the process of technological innovation. It has long been argued that inter-firm collaboration creates gains by pooling firms' complementary capabilities (Teece, 1986; Gans et al., 2002; Spulber, 2014) and thus increasing the overall returns to R&D expenditure. In the pharmaceutical industry, where clinical development requires the application of a wide range of skills and there are important returns to experience and diversification (Cockburn and Henderson, 2001; Dranove and Meltzer, 1994), this type of agreements is believed to increase innovative productivity by allowing entrepreneurial upstream biotech innovators to access such skills through partnerships with experienced large downstream pharmaceutical firms (Danzon et al., 2005), increasing the probability that a developing compound will reach the market and/or do so in a shorter time period. Taken together, these observations imply that, by facilitating inter-firm cooperation, a larger market size could generate an increase in the amounts of output obtained from the process (i.e., the number of new technologies that become available to consumers) even if inputs (R&D expenditure) remained constant.

2. Empirical Strategy

Our empirical evidence exploits the impacts of the 2003 passage of Medicare Part D on the patterns of licensing-based cooperation in the pharmaceutical industry. This program constituted a significant expansion of prescription drug expenditure coverage for Medicare enrollees, therefore increasing the expected market size for treatments targeting conditions that are more prevalent among the enrolled population (65 years and older). Immediately following the program's enactment, there was a significant increase in the number of licensing deals oriented at the

development and commercialization of therapies targeting the conditions that are more prevalent among Medicare enrollees.

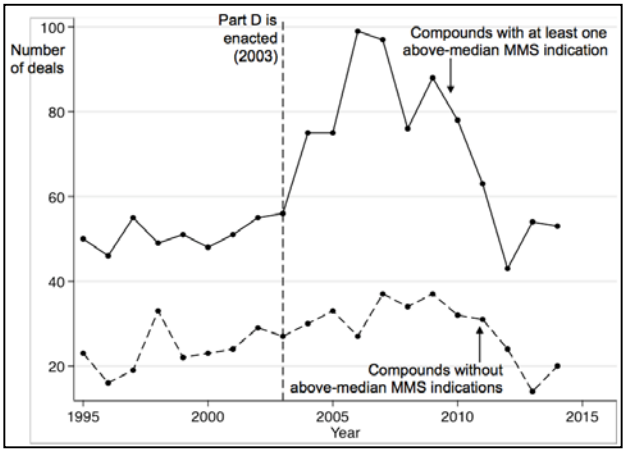
To measure the magnitude of the demand shock from Part D across therapeutical categories, we follow previous studies (Duggan and Scott-Morton, 2010; Blume-Kohut and Sood, 2013; Dranove et al., 2014) and construct a "Medicare Market Share" (MMS) measure. Using Medical Expenditure Panel Survey data in 2003, we derive MMS at the indication or medical condition level as the fraction of individuals suffering that condition who are enrolled in Medicare.

We use data on drug pipeline and licensing deals from Thompson Reuters Cortellis "Competitive Intelligence" [1], which tracks pharmaceutical drug pipelines from a wide variety of sources. [2] While an absolute claim cannot be made, the data are thought to account for virtually all compounds that reach pre-clinical development. This is reflected by the large number of compounds covered by the sample, over 55,000 by late 2014. For each compound we observe the list of indications tested in preclinical development and the set of clinical trials associated to each. We also observe the identity of the originator firm (i.e., the firm responsible for the compound's discovery) and whether the compound has been the subject of a cooperation agreement in the form of a "development and commercialization" or "commercialization" licensing agreement.

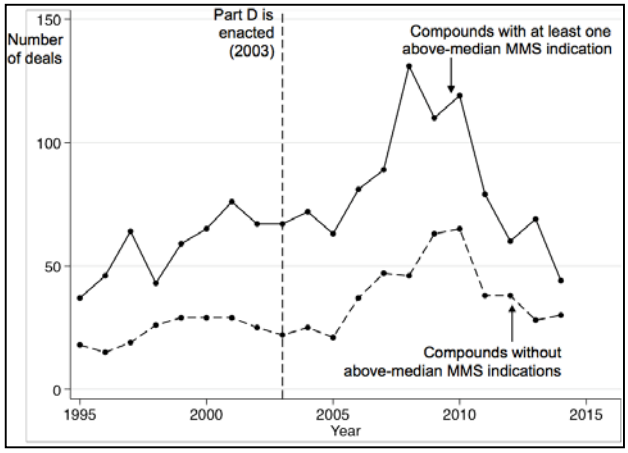
We first investigate how the probability of licensing changes upon the shock, differentially for high and low MMS drugs. As motivating empirical evidence, Figure 1 shows how the numbers of compounds in-licensed by US firms (in the left panel) and non-US firms (in the right panel) change over time, separately for compounds with high (above-median) MMS indications and those with low-MMS indications.

Figure 1: Number of deals by US and non-US in-licensors, 1995-2014

US in-licensors



non-US in-licensors



For US firms, there was a strong and short-termed surge in licensing deals for the development and commercialization of elderly-oriented compounds relative to other compounds. Reassuringly, for non US licensees

[1] We thank Pierre Azoulay and Josh Krieger for generously sharing this data.

[2] The sources include ClinicalTrials.gov and international counterparts, press releases, scientific articles, conference reports, company websites, industry newsletters, grant making bodies, among others.

arguably not affected by Medicare Part D, there was no differential change in the number of licensing deals upon the shock for high- and low-MMS drugs. These results confirm that positive downstream demand shocks facilitate collaboration by reducing the relative importance of transaction costs.

We plan to estimate a linear probability model of licensing in response to the demand shock as follows, before moving on to nonlinear models and also hazard models. Here j denotes drug innovation, and t denotes year. We adopt a triple-difference estimation strategy. Besides intensity of demand shock (MMS) and the post-2003 dummy, we also consider heterogeneous impacts based on the importance of complementary assets. As in Hermosilla and Qian (2013), we measure this by counting the number of physicians a compound would have to be detailed to and the number of patients (NPP) enrolled on average on clinical trials specific to each condition.

$$Prob(Licensed)_{\mathrm{jt}} = \alpha_t + \beta * \mathrm{MMS}_j * 1\{t > 2003\} + \gamma * \mathrm{MMS}_j * NPP_j * 1\{t > 2003\} + e_{\mathrm{jt}}$$

Besides probability of licensing, we also plan to examine how the quality of match is affected, by running the same regression with match quality as the outcome variable. We use Cortellis data to measure 1) whether the licensee has marketed drugs one targeting the same disease or therapeutic area; 2) whether the licensee has sponsored a clinical trial of a drug targeted in the same disease or in the same therapeutic area; 3) whether the licensee has previously attempted to develop a drug using the same technologies; and 4) whether clinical trials were successful after the partnership started.

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