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Innovation and Uncertainty in the Medical Industry: Evidence from the Case of Myriad Genetics, Inc.

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Innovation and Uncertainty in the Medical Industry: Evidence from the Case of Myriad Genetics, Inc.*

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Abstract

We describe the broad range of uncertainties faced by the developers of medical technologies. Empirically, we estimate the asset market incidence of two realizations of uncertainties we classify as within-market policy risks. The events we analyze concern the intellectual property of Myriad Genetics, Inc., an American molecular diagnostics firm. In July 2013, the Supreme Court invalidated several of Myriad's intellectual property claims. Subsequently, the Center for Medicare and Medicaid Services reevaluated the reimbursements it pays for the services at issue in this patent litigation. We estimate that these events substantially moved Myriad's market capitalization, by just under 25 percent in the case of the Supreme Court's decision and nearly 20 percent in the case of CMS's reimbursement rate redetermination. Myriad's exposure to the realization of these intellectual property risks reflects its unusually high reliance on revenues linked to the services at issue. We discuss the implications of these risks for the total volume of medical innovation and for its organization across firms.

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I Introduction

Risk and expected returns shape the aggregate volume and organization of innovative activity. While the theory underlying these linkages has received ample attention, cataloging and quantifying the risks relevant in any particular industry requires empirical documentation and attention to institutional detail. In this paper, we demonstrate the relevance of understudied forms of “within-market policy risks” for the returns to the development of medical technology.

In Section 2 we organize the risks faced by medical innovators into a coherent typology. First among our typology’s broad categories are pre-market risks. This category, which has been widely studied, includes standard risks associated with product development and regulatory approval. Our second broad category encompasses within-market economic risks. These risks, also widely studied, include the introduction of competing products and, more broadly, threats to a product’s demand. A third category involves what we call within-market policy risks. This category includes risks such as patent invalidation and post-approval threats to a product’s reimbursement status within public and private insurers’ payment systems.

In Section 3 we empirically assess the asset market incidence of two distinctive realizations of within-market policy risk. Specifically, we analyze the market capitalization of Myriad Genetics, a company known primarily for its development of the BRCA1 and BRCA2 molecular diagnostic tests for breast and ovarian cancer. As detailed in Section 3, Myriad’s case is remarkable along multiple dimensions. Myriad’s intellectual property was addressed by the Supreme Court, which ultimately invalidated some of its patent claims. Following the Supreme Court’s decision, the Center for Medicare and Medicaid Services (CMS) re-evaluated its reimbursements for the affected services. Further, Myriad’s finances are unusually reliant on the revenues generated by the affected product lines.

The validity of the disputed patent claims and the generosity of Medicare's reimbursements thus had significant implications for Myriad's future profitability.

Section 3's analysis reveals that the resolution of these policy risks significantly affected Myriad's market capitalization. We estimate that the Supreme Court's invalidation of Myriad's intellectual property reduced its valuation by roughly 23 percent, or in excess of \$500 million. Subsequent re-determination of Medicare's reimbursements for Myriad's tests similarly moved Myriad's market capitalization by several hundred million dollars. Further, Myriad's capitalization exhibited high volatility throughout the time period in question. We conclude with a discussion of these policy risks' implications for aggregate levels of medical innovation, for the direction of innovative effort, and for the structure of the firms in which this innovation takes place.

II Characterization of the Risks Faced by Medical Innovators

Innovators face a litany of uncertainties. This section presents a typology of the risks to which those who invest in innovation, and in particular in medical innovation, are exposed. We begin by defining three broad categories of uncertainty. We then discuss the extent to which these uncertainties have been analyzed in prior work and, to the extent that they have, how they have been found to affect innovative activity.

II.a A Broad Typology of Uncertainties

In this section we succinctly define three broad categories of risk faced by medical innovators and their investors.

Pre-Market Risks: Pre-market risks encompass all risks realized prior to a product's introduction to the market. Such risks occur over the course of the development and regulatory approval processes.

Within-Market Economic Risks: Within-market economic risks encompass all standard economic threats to the demand for an innovator's product. Such risks include the in-

roduction of superior or lower-cost substitutes. Demand may also be affected by changes in the prevalence of the medical condition at which a given innovation is targeted.

Within-Market Policy Risks: Within-market policy risks encompass post-approval, policy-driven threats to an innovation’s profitability. By nature, such risks depend on the specifics of the markets under consideration. Examples include reassessments of the validity of intellectual property claims and reassessments of a technology’s efficacy and side effects. They also include changes in the generosity of public insurers’ reimbursements, both in aggregate and for specific products.

II.b Implications for the Volume and Organization of Medical Innovation

Uncertainties have implications for both the volume and organization of innovative activity. In general, due to the costs of financial distress and the asymmetric outcomes associated with downward and upward variability, they reduce expected returns and will tend to reduce innovative effort. Uncertainty has further been found to stall both investment and overall economic activity *conditional* upon expected returns (Bloom, 2009; Shoag and Veuger, 2014). To the extent that the associated risks can be diversified across product lines, they will tend to increase the scale of the organizations within which innovative activity takes place. In the remainder of this section we illustrate the uncertainties at work in the context of medical innovation and discuss the state of the evidence on their relevance.

II.b.1 Pre-Market Risks

Pre-market risks include the uncertainties of the product development and regulatory approval processes. The scientific difficulty of discovery and the stringency of regulatory approval shape medical innovation’s expected returns. Because some aspects of the uncertainty they introduce can be smoothed through scale, these uncertainties have direct implications for innovation’s organization.

Research on pre-market risks has focused primarily on the pharmaceutical sector.

Broad descriptions of pharmaceutical development find that roughly 1 in 5,000 to 10,000 molecules investigated by basic researchers ultimately make their way to market (Lipsky and Sharp, 2001). With expected total costs between pre-clinical and clinical development approaching \$1 billion (DiMasi et al., 2003), it should not be surprising that pharmaceutical development has historically been concentrated among firms of substantial scale. That said, biotechnology's rise has been associated with a proliferation of smaller players (Cockburn, 2004).

Recent evidence from cancer trials shows that the expected length of the approval process shapes the direction and volume of innovative activity (Budish et al., 2013). Because firms patent potential cancer treatments early in the approval process, for example, the process's length reduces a firm's period of patent exclusivity. And because it is easier to demonstrate the efficacy of drugs targeted at cancers that kill quickly, Budish et al. (2013) find that firms invest relatively little in the development of treatments for cancers with low rates of short-term mortality.

II.b.2 Within-Market Economic Risks

Within-market economic risks include a variety of standard, post-approval uncertainties involving a product's profitability. Such uncertainties can involve either the size of the pool of a product's potential purchasers or changes in the state of competition. As detailed in the following paragraph, the demand-side drivers of potential market size have received significant attention in the relevant literature. The introduction of competing products has received detailed attention in the growth literature, in particular in the context of "creative destruction" models of growth and innovation (Aghion and Howitt, 1992).

Within-market risks are perhaps the most widely studied in the empirical literature, which typically finds medical innovation to be highly responsive to the relevant incentives. For example, research has found both drug and medical equipment innovation to exhibit

significant responsiveness to the market contractions and expansions implied by shifting demographics, coverage regimes, and public health requirements. Acemoglu and Linn (2004), for example, find that investments in pharmaceutical developments closely tracked the evolution of market size as implied by the baby boom's population bulge. Clemens (2013) finds that the market expansion implied by the introduction of Medicare resulted in a substantial expansion in U.S.-based patenting in medical equipment and devices. Finally, Finkelstein (2004) finds that changes in inoculation policy significantly altered the course of vaccine development.

II.b.3 Within-Market Policy Risks

Within-market policy risks involve legal uncertainties that influence a product's market standing. The political economy and public choice literatures focus most of their attention in this context on regulatory capture and lobbying, that is, attempts to write the rules of the game, as opposed to navigating them as they are (Ades and Di Tella, 1999; Kroszner and Stratmann, 1998; Djankov et al., 2002). The corporate strategy literature lends more attention to this, but typically adopts the perspective of a single firm, without considering the impact of the regulatory environment on industrial organization and aggregate outcomes (e.g. Wilson and Veuger (2015)).

We emphasize the risks associated with intellectual property claims and public insurers' reimbursement policies. Initial patent and product approval are not guaranteed to be permanent. The risks of patent invalidation and revocation of product approval thus have straightforward implications for innovations' expected returns. Similarly, public insurers are not obligated to maintain any initially negotiated reimbursement rates.

These institutional risks have received limited attention in the literature on medical innovation. Below we estimate the asset market incidence of two recent realizations of such risks. The first involves the Supreme Court's invalidation of a subset of the patent

claims held by Myriad Genetics, Inc. Following the invalidation of Myriad’s patent claims, the federal Medicare program re-evaluated the reimbursement rates it pays for the relevant medical products.¹ Our second piece of analysis thus involves the asset market incidence of a major announcement in the reimbursement redetermination process.

Our analysis of these instances of product-specific reimbursement risk can be contrasted with the implications of recent work on aggregate medical reimbursement risk (Koijsen et al., 2014). Diversification across product lines can provide relief from idiosyncratic reimbursement risk, but not against aggregate reimbursement risk. Because aggregate reimbursement risk cannot be diversified away, it has implications for the industry-wide risk premium and the volume of innovative activity. By contrast, product-specific reimbursement risks create a rationale for pooling the revenue streams associated with a diverse array of medical products. The same can be said for the risk of product-specific patent invalidation.

In the remainder of this paper, our purpose is to demonstrate the dramatic implications that institutional risks can have for medical innovators. Our particular empirical setting highlights the high importance of such risks to small-scale innovators, with implications for the sector’s industrial organization.

III The Importance of Within-Market Policy Risks: Evidence from the Case of Myriad Genetics

This section presents evidence that institutional risks can indeed exert significant influence over the fortunes of medical innovators and their investors. The evidence takes the form of events involving legal and reimbursement rate determinations affecting Myriad

¹Reimbursement changes may alter the returns to innovation through effects on both prices and on the quantity demanded. In some cases, the quantity demanded is mediated by health providers’ technology adoption decisions. An expanding body of research, including studies by Acemoglu and Finkelstein (2008), Clemens and Gottlieb (2014), and Freedman et al. (2012), finds that technology adoption responds to reimbursement policy in the standard direction.

Genetics, Inc (hereafter simply “Myriad”). Myriad provides molecular diagnostic screening and holds patents covering a variety of claims related to the services it provides. As detailed below, Myriad’s revenue stream was highly exposed to the performance of a single product line. The legal and reimbursement determinations we analyze thus involved sufficient risk that, as shown, the resolution of the associated uncertainties significantly moved Myriad’s market capitalization.

III.a Background on Myriad Genetics

Myriad, founded in 1991, is an American molecular diagnostic firm headquartered in Salt Lake City, Utah, and traded publicly on the NASDAQ Global Select Market (Myriad Genetics, Inc., 2014b). The firm’s market capitalization has averaged \$2.1 billion over the past five years, while its net income averaged some \$130 million (YCharts, 2014). It develops and commercializes medical tests that analyze individuals’ genomes and proteomes to establish their proneness to diseases, to diagnose diseases, to prognosticate the progression of diseases, and to assess the suitability of modes of treatment for the individuals in question (Myriad Genetics, Inc., 2014b).

Within its industry, Myriad is relatively unique in terms of its exposure to the performance a single product. Its *BRACAnalysis* product for assessing risk for breast and ovarian cancer accounted for 75 percent of its \$613 million in total revenue for the fiscal year ending in June 2013 and 67 percent of its \$778 million in total revenue in the year ending in June 2014 (Myriad Genetics, Inc., 2013, 2014b). Indeed, legal decisions and Medicare reimbursement determination linked to precisely this product line form the basis for our empirical analysis.

Our focus is on two significant events in Myriad’s recent history. The first event is the June 2013 Supreme Court (SCOTUS) decision in *Association for Molecular Pathology v. Myriad Genetics, Inc.* The case in question was originally heard in the Southern District

Court of New York. At stake were certain patents obtained by Myriad that gave it “the exclusive right to synthetically create BRCA cDNA.” After the decision of the District Court, two hearings in the United States Court of Appeals for the Federal Circuit, and two petitions to the Supreme Court, the Supreme Court, in a unanimous decision, invalidated a number of Myriad’s patent claims on June 13, 2013 (Hamel et al., 2013).

Following the Supreme Court’s decision, Medicare reassessed its reimbursements for the affected diagnostic tests. The institutional mechanics of Medicare’s reimbursement re-determination require a bit of elaboration. The Supreme Court’s decision facilitated competitors’ entry into Myriad’s previously exclusive markets. When Myriad supplied monopolistically, the determination of its reimbursement rate involved Medicare and Myriad alone.² Prospective competitors, including Ambry Genetics, submitted data to Medicare implying that they could provide the relevant services at lower cost. Medicare initially responded to this pricing information by reducing Medicare’s reimbursement rate from \$2,795 to \$1,438 per test. The market responded moderately to this initial downward revision, which appears to have been largely anticipated as a consequence of prior events. During a period of public comment, however, Myriad convinced Medicare to partially reverse its reduction through the submission and analysis of new pricing data. Medicare’s upward revision, announced on April 1, brought its reimbursement from \$1,438 to \$2,184 per test (GenomeWeb, 2014; Reeves, 2014). This second payment change, which appears in Myriad’s stock movements to have contained significant new information, is the second event we analyze.

²The relevant market institutions, namely those of the market for a health care service financed primarily through third-party payment, and in particular by Medicare, distinguish the pricing problem from the standard monopoly case. The payment is effectively determined through a negotiation between Medicare and Myriad that is guided by Myriad’s submission of cost information to the Center for Medicare and Medicaid Services. Medicare implicitly acknowledges that providers like Myriad require compensation for the fixed costs of research and development, enabling pricing above marginal cost.

III.b Overview of Our Empirical Analysis

In the remainder of this section we analyze the “abnormal” returns of Myriad genetics stock. Our goal in constructing these abnormal returns is to estimate the effects of decisions by the Supreme Court and CMS on Myriad’s market capitalization. That is, our goal is to estimate the asset market incidence of these instances of intellectual-property invalidation and reimbursement rate redetermination, and we define abnormal returns as Myriad’s returns relative to the expected return in the absence of the events we study. More specifically, Myriad’s abnormal return from day t to day $t + 1$ is:

$$\frac{\text{Actual Return}_{t+1} - \text{Actual Return}_t}{\text{Actual Return}_t} - \frac{\text{Normal Return}_{t+1} - \text{Normal Return}_t}{\text{Normal Return}_t} \quad (1)$$

At least two difficulties must be overcome for our estimates to be informative regarding our questions of asset market incidence. The first difficulty involves the standard empirical problem of establishing a relevant counterfactual: the expected return. We will address this in two different ways

First, we use benchmark indices to approximate what would have happened to Myriad’s market capitalization in the absence of the events we analyze. The ideal benchmark index here would include firms subject to similar aggregate shocks. The benchmark indices we use include the NBI, the S&P 400 and 500, and the CCMP. The NBI is the NASDAQ Biotechnology Index, which includes firms classified as either biotech or pharmaceuticals that have a market capitalization at least of \$200 million and that meet several other eligibility criteria. The S&P 400 includes U.S. mid-cap companies, companies with an unadjusted market capitalization ranging between \$1 billion and \$4.4 billion. The S&P 500 includes the 500 largest firms that trade on either NASDAQ or the New York Stock Exchange. To qualify, firms must have an unadjusted market capitalization of at least

\$4.0 billion as well as headquarters located in the U.S., and meet several other criteria. The CCMP is the NASDAQ Composite Index, which includes all stocks listed on NASDAQ that are not exchange-traded funds, derivatives, preferred shares, etcetera. It includes over 3,000 firms. As noted above, the ideal benchmark for our analysis would be an index including firms subject to similar aggregate subjects and exhibiting similar degrees of volatility under “normal” market conditions. Because the NBI includes other firms in the biotechnology sector, it is relatively well-suited from the perspective of capturing firms that would experience aggregate shocks similar to those experienced by Myriad. We use the S&P 400 because, as an index of mid-cap firms of which Myriad is one, it may capture the degree of volatility one might expect for a firm of Myriad’s size. The S&P 500 and CCMP have less to recommend them as benchmarks for Myriad *per se*, but provide a broader sense of the performance of equities over the analysis period. As revealed below, our characterization of Myriad’s performance depends little on the index to which we compare it.

Second, we use an event study methodology to calculate cumulative abnormal returns. We apply the standard “market model” (MacKinlay, 1997) using the same indices discussed earlier. Here, normal returns, R_{it} , are calculated by estimating $R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$, under the assumption that $E[\varepsilon_{it}] = 0$ and $Var[\varepsilon_{it}] = \sigma_{\varepsilon_i}^2$, where R_{mt} is the return of a given market index. The abnormal return, AR_{it} , is then computed as the difference between the actual return, A_{it} , and the normal return predicted by the model: $AR_{it} = A_{it} - (\alpha_i + \beta_i R_{mt})$. The sum of these abnormal returns over select trading days is then the cumulative abnormal return.

The second difficulty we face involves the role of expectations. Abnormal returns capture changes in the expected net present value of a firm’s stream of future profits relative to the market. Expectations regarding the events we analyze will, of course, be reflected in Myriad’s valuation prior to the event’s realization. It was known, for example, that

the Supreme Court would issue a decision. It was unknown whether that decision would go “for” or “against” Myriad and to what degree. For simplicity, suppose the decision was binary and that it was, at time t , expected to go against Myriad with probability p . Letting π_t denote Myriad’s profit in period t and δ the relevant discount factor, we write the decision’s impact on Myriad’s profitability as:

$$\sum_{t=0}^{\infty} \frac{(1-p)\pi_t^{\text{FOR}} + p\pi_t^{\text{AGAINST}}}{(1+\delta)^t} - \sum_{t=0}^{\infty} \frac{\pi_t^{\text{AGAINST}}}{(1+\delta)^t} \quad (2)$$

The change in market capitalization thus captures

$$(1-p) \sum_{t=0}^{\infty} \frac{\pi_t^{\text{FOR}} - \pi_t^{\text{AGAINST}}}{(1+\delta)^t}, \quad (3)$$

which is the decision’s total incidence scaled by $1-p$.

The total incidence of the events we study could thus be recovered given knowledge of the relevant probabilities. As we do not have such knowledge, we are only able to estimate suggestive bounds. Importantly, the estimates will in no case overstate an event’s total impact on Myriad’s expected profit stream. Commentary surrounding the timing of the Supreme Court decision suggests a significant division of views regarding the extent to which the court’s ruling would invalidate Myriad’s intellectual property. By contrast, CMS’s April 1st increase in the reimbursement rates applicable to *BRACAnalysis* was largely unexpected. The abnormal returns to the latter event thus likely come close to approximating the CMS decision’s total incidence. The abnormal returns to the former event likely represent closer to half of the Supreme Court ruling’s total incidence of $\sum_{t=0}^{\infty} \frac{\pi_t^{\text{FOR}} - \pi_t^{\text{AGAINST}}}{(1+\beta)^t}$.

III.c An Initial Look At Myriad's Returns Relative to the Market

Figure 1 presents Myriad's cumulative returns relative to each of the benchmark indices over an interval extending from May 2013 through September 2014.³ The interval encompasses the Supreme Court's decision of June 13, 2013, and CMS's April 1, 2014, reimbursement re-determination. Both events are indicated in the figure by dashed vertical lines. Two facts are readily apparent from the figure. First, this extended interval of legal challenges and reimbursement re-determinations has been associated with substantial volatility in Myriad's stock price. Second, while volatility has been the rule rather than the exception, the Supreme Court decision and announcement of Medicare's reimbursement decision emerge as noteworthy events within the history. The analyses presented in Figure 2, Figure 3, and Table 1 further elaborate on the impact of these events.

III.d Event 1: The Effect of Patent Invalidation on Myriad's Stock Price

Figure 1 reveals that Myriad experienced a large, negative abnormal return following the Supreme Court's invalidation of its patents. Figure 2 displays the size of Myriad's decline relative to the changes in the price of each stock in the benchmark indices, with changes calculated from June 13th to June 19th of 2013. The first panel, for example, presents a histogram of the price changes for each firm in the CCMP, while the second panel presents a histogram of the price changes in the BMI. The percentage change in Myriad's stock price, a decline of 23.59%, is represented in each panel by a dashed line. The histograms reveal Myriad's decline to be well below experience of other firms in the comparison indices. The bulk of price changes over this interval ranged from -5 to 5%.

³Note that in this and the subsequent figures we technically do not yet present "abnormal" returns in the sense described by equation 1; those are shown in Table 1. In Figure 1 we simply present cumulative relative returns of the form:

$$\frac{\text{Myriad}_{t+1} - \text{Myriad}_t}{\text{Myriad}_t} - \frac{\text{Benchmark Index}_{t+1} - \text{Benchmark Index}_t}{\text{Benchmark index}_t}. \quad (4)$$

Table 1's Panel A presents an analysis of Myriad's abnormal returns over a set of shorter windows surrounding the Supreme Court's decision. These include the day of the event (from closing the day before to closing the day of), the four day period starting at close before the event, and the four day period that commences at close three days before the event. Cumulative abnormal returns are calculated using the standard "market model" and are again presented relative to each of the four comparison indices described above. Below each estimate of the relevant abnormal return, we present t-statistics implied by standard errors that characterize variation in Myriad's abnormal returns over a period of relative legal calm. Across the presented permutations of event windows and benchmark indices, our estimate of Myriad's abnormal returns range between -19% and -27%. The estimates are statistically distinguishable from 0 at conventional significance levels in all cases.

Figure 1 further reveals that Myriad's market capitalization recovered over the course of late 2014. It is difficult to link these gains directly to any one event. Of interest, however, is that in spite of the Supreme Court's decision, Myriad effectively maintained its standing as the exclusive provider of *BRACAnalysis*. The market's reaction to the Supreme Court's decision appears to have overstated its implications for Myriad's legal position to enforce its exclusivity. Competitor Ambry Genetics, for example, unexpectedly found itself opposed by a plaintiff's coalition including Myriad and Toronto's SickKids Hospital, which benefits from royalties linked to Myriad's patents (Crowe, 2013). A flurry of further legal action ensued, with Myriad filing suit against no fewer seven potential competitors and at least three firms filing suit against Myriad. Appendix I details these and a broad set of additional events following the Supreme Court's decision.⁴

⁴Beyond cataloguing court cases, the appendix details events related to Myriad's strong early-2014 performance, which was buoyed in part by favorable news involving research on new prospective product lines.

III.e Event 2: The Effect of an Unanticipated Reimbursement Shock on Myriad's Stock Price

Figure 1 shows that Myriad experienced a large, positive abnormal return following the announcement of Medicare's increase in the reimbursements for Myriad's tests. Mirroring Figure 2, Figure 3 shows the size of Myriad's gain relative to the changes in the price of each stock in the benchmark indices. In this case the changes are calculated from April 1st through April 7th of 2014. It is again apparent that Myriad's experience falls outside the experience of the vast majority of stocks in the benchmark indices over the relevant period.

Table 1's Panel B presents an analysis of Myriad's abnormal returns over a set of shorter windows surrounding CMS's reimbursement rate re-determination. As in Panel A, these include the day of the event (from closing the day before to closing the day of), the four day period starting at close before the event, and the four day period that commences at close three days before the event. Across the presented permutations of event windows and benchmark indices, our estimate of Myriad's abnormal returns range between 13% and 20%. The estimates are statistically distinguishable from 0 at conventional significance levels in all cases, though not as easily as in the analysis of the Supreme Court's invalidation of Myriad's patents.

III.f Implications of the Magnitudes of Myriad's Changes in Market Capitalization

We begin this section by more fully assessing the magnitudes of the observed changes in Myriad's market capitalization. Both the Supreme Court decision and the reimbursement re-determination altered Myriad's market capitalization by around \$500 million.⁵ The precise nature of the information transmitted by these decisions is, of course, difficult to determine. It is unclear, for example, with what probability investors expected the

⁵Although the latter event involved a smaller change in percent terms, Myriad's early-2014 performance was sufficiently positive that its baseline market capitalization was higher.

Supreme Court's decision to go against Myriad, and to go against it to the degree that it did. \$500 million is a clear lower bound on the full economic value of the decision's impact.

We now turn to Medicare's reimbursement rate redetermination. In the fiscal year ending June 30th, 2014, Myriad generated \$520 million in revenue from its *BRACAnalysis* product line. Were these services reimbursed at \$1,438 rather than \$2,184, the resulting revenue would have been \$340 million. The differential, assuming application of Medicare's rate for all services, thus amounts to \$180 million per year. The increase in Myriad's market capitalization is nearly three times this amount.

Medicare accounts for a modest share of Myriad's *BRACAnalysis* revenues. Over the period of Medicare's reimbursement re-determination, analysts put Medicare's share at 10 percent (Britt, 2013). The direct effect of Medicare's reimbursement rate increase would thus have improved Myriad's net income by only \$18 million per year. The change in Myriad's market capitalization thus amounts to nearly 30 years of the implied change in Myriad's Medicare revenue. This far exceeds the remaining life of any of the relevant patents. Rationalizing the change in Myriad's market capitalization thus requires effects beyond Medicare itself. Market analysts anticipated such changes, noting that "While Medicare represents only 10 percent of [Myriad's] sales, one would expect commercial plans to follow suit" (Britt, 2013). While the rationale underlying private insurers' reliance on Medicare's payment rates is not necessarily what "one would expect," it has been documented to be a widespread phenomenon (Clemens and Gottlieb, 2013). In the present case, private payment spillovers of this form appear to have significantly amplified the effects of Medicare's payment change.

IV Discussion and Conclusion

Past theoretical research has shown how uncertainty about the broader environment in which firms operate can affect their behavior (Rodrik, 1991; Hassett and Metcalf, 1999). Here we have documented the relevance of policy risks for this kind of decision-making. There are strong theoretical grounds to believe that these micro-level adjustments can have important aggregate implications (Friedman, 1968; Bernanke, 1983), and recent empirical evidence appears to bear these theories out (Bloom, 2009; Shoag and Veuger, 2014).

As an example, Myriad's degree of exposure to intellectual property and reimbursement rate risk has clear implications for the organization of medical innovation. In both instances, the risks we analyze could effectively be smoothed away by increasing the scope of Myriad's activities for the purpose of diversifying across product lines. Indeed, "Diversifying Our Portfolio" made column 1 of the "Dear Shareholders" letter in Myriad's 2014 Annual Report (Myriad Genetics, Inc., 2014a). Such diversification would benefit many of Myriad's stakeholders, including its owners, who would be less burdened by the non-diversifiable cost of (potential) financial dire straits. Further, because the relevant institutional uncertainties are primarily downside risks, they depress expected returns and can be expected, by extension, to reduce aggregate levels of technology development. Whether one believes that levels of medical innovation are sub-optimally low (Murphy and Topel, 2003), or worries about its cost and direction (Weisbrod, 1991), the stakes associated with health-sector innovation policy and the institutional uncertainty it can produce are high.

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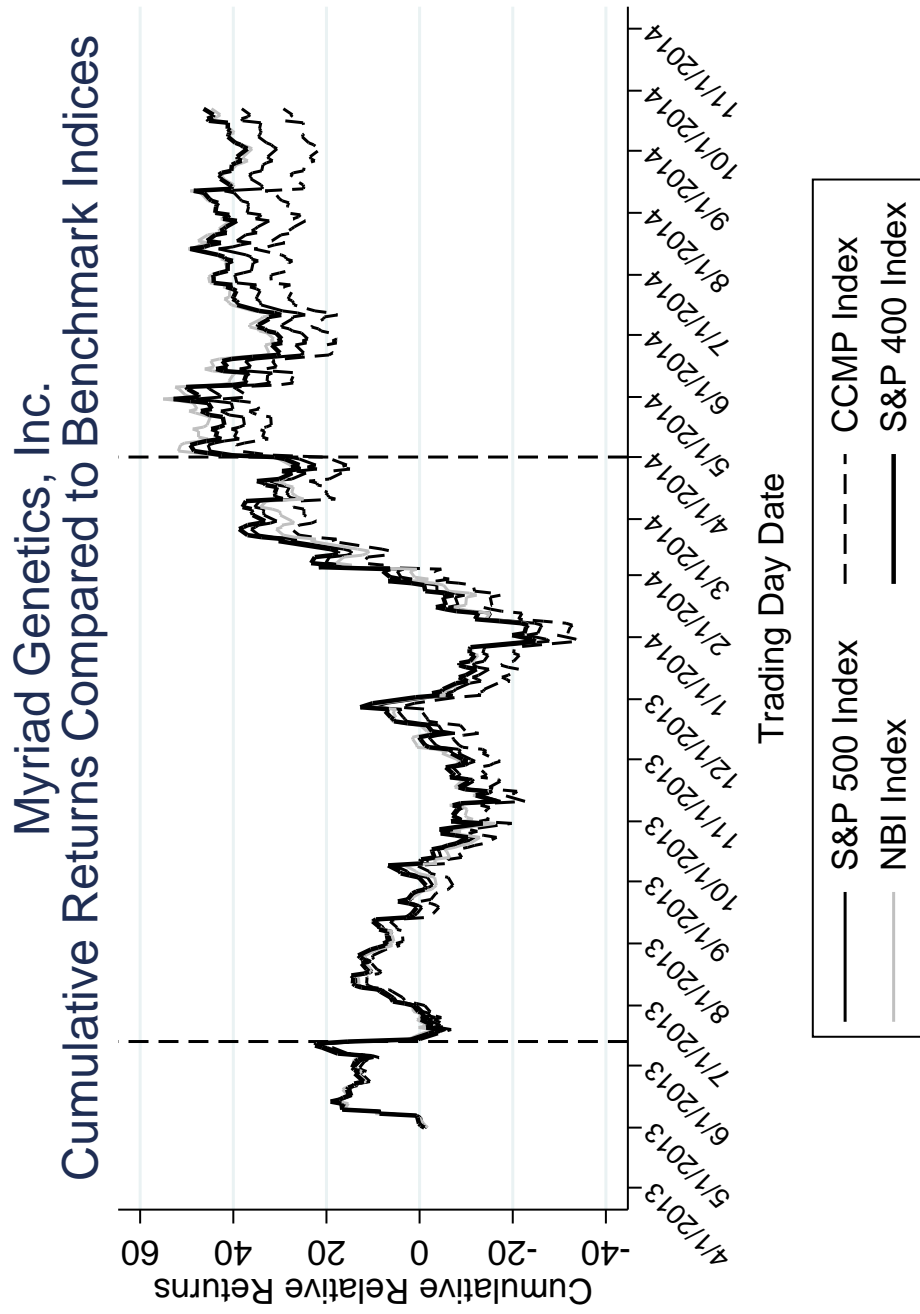


Figure 1. Myriad Genetics, Inc., Cumulative Returns Relative to Benchmark Indices
 This figure shows the cumulative relative returns to Myriad Genetics common stock for the period from April 2013 till November 2014, compared to the S&P 500 Index, the NBI Index, the CCMP Index, and the S&P 400 Index. The dashed vertical lines indicate the two events we focus on: the Supreme Court's decision in Association for Molecular Pathology v. Myriad Genetics, Inc., and Medicare's reimbursement reassessment decision. Data are from Bloomberg.

Distribution of Price Changes Over Supreme Court Window

Percent Change in Equity Price from June 13, 2013 to June 19, 2013

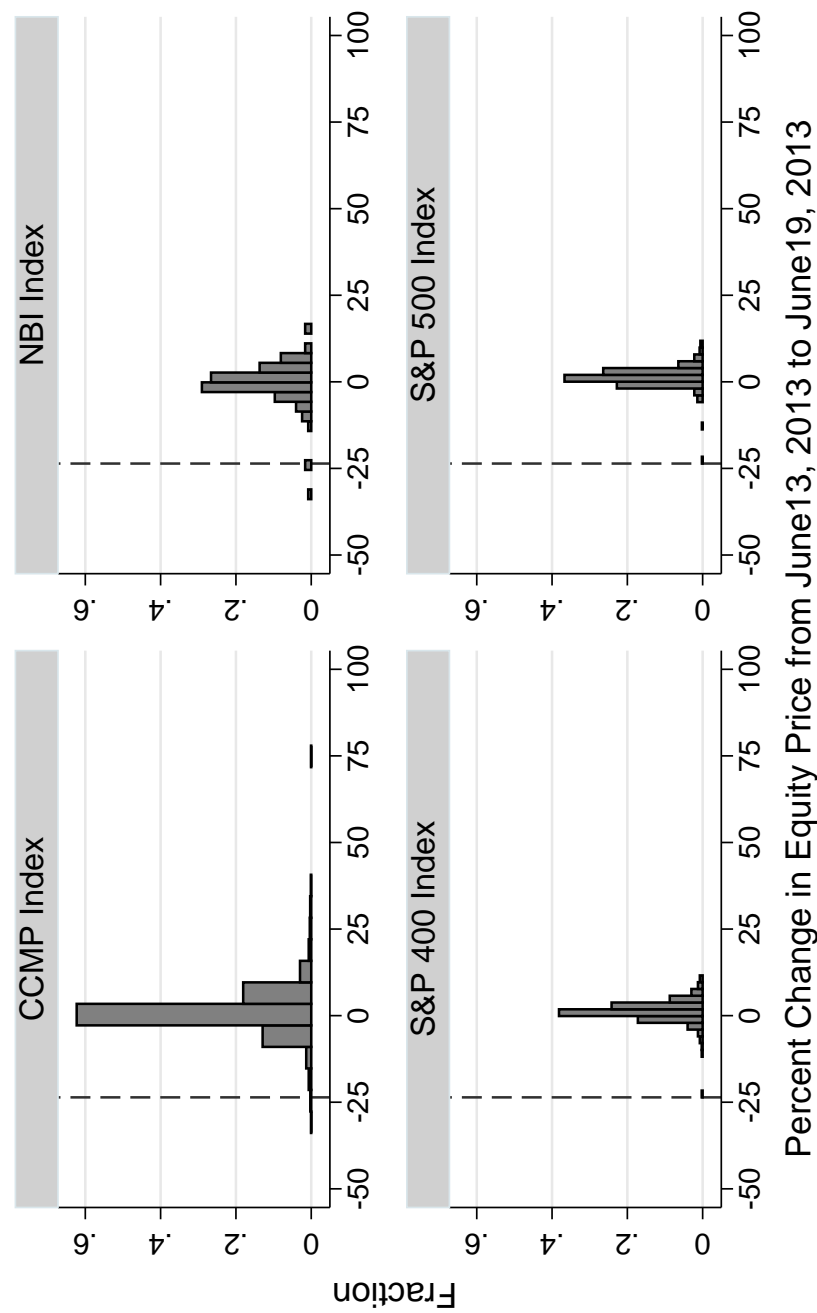


Figure 2. Distribution of Price Changes over Supreme Court Window

These histograms present the price change for each stock in four benchmark indices (the S&P 500 Index, the NBI Index, the CCMP Index, and the S&P 400 Index) from June 13th to June 19th, 2013, around the Supreme Court's decision in Association for Molecular Pathology v. Myriad Genetics, Inc. The change in Myriad's stock price is represented in each panel by a dashed vertical line.

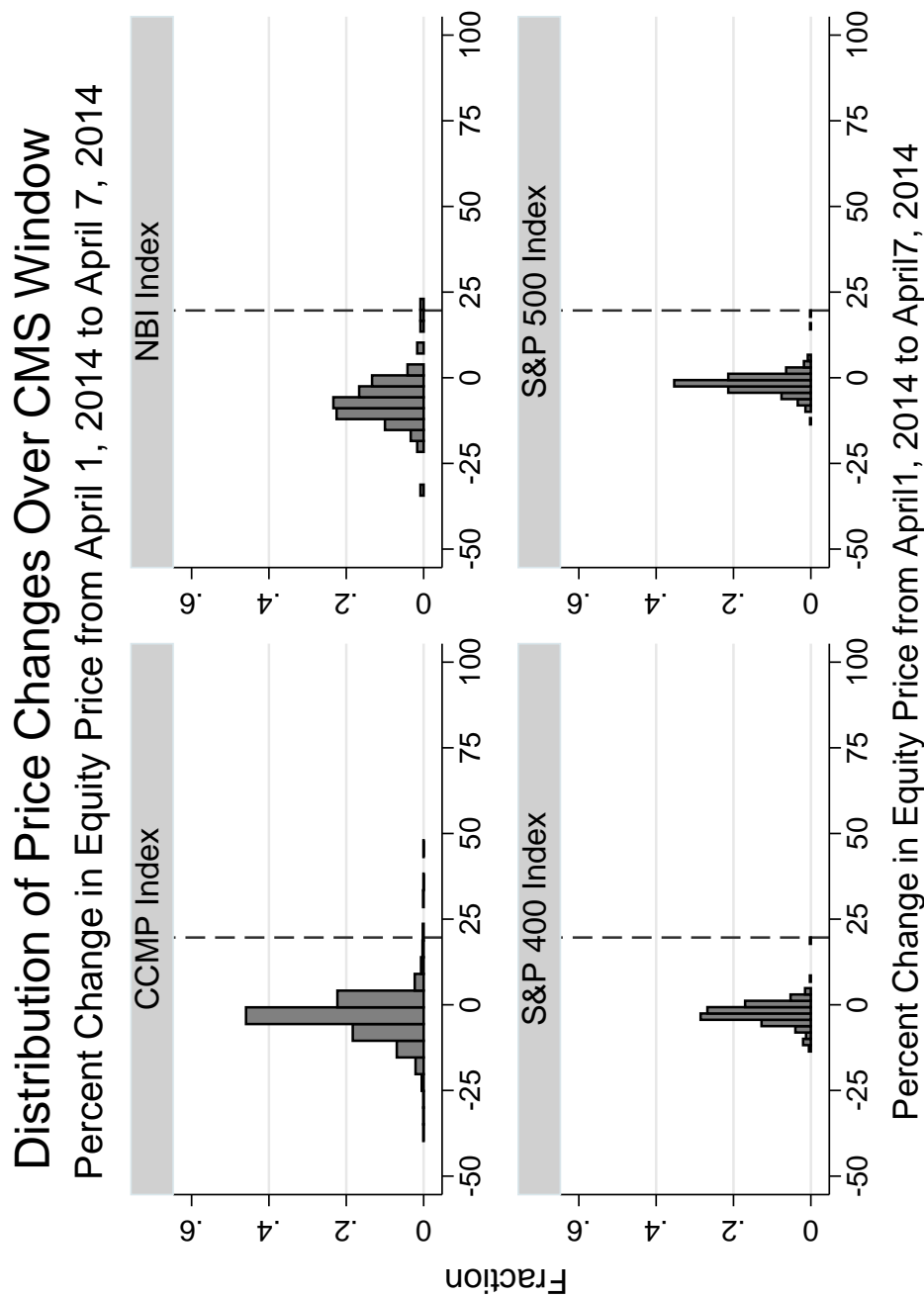


Figure 3. Distribution of Price Changes over Medicare Reassessment Window
 These histograms present the price change for each stock in four benchmark indices (the S&P 500 Index, the NBI Index, the CCMP Index, and the S&P 400 Index) from April 1st to April 7th, 2014, around Medicare's reimbursement reassessment. The change in Myriad's stock price is represented in each panel by a dashed vertical line. Data are from Bloomberg.

Table 1. **Supreme Court and CMS Event-Study Analyses**

	Event Period		
	1 0 to 1	2 0 to 4	3 -2 to +2
Panel A: Supreme Court Decision			
S&P 500 Index	-20.00 (-4.58)	-26.35 (-3.82)	-23.04 (-3.34)
CCMP Index	-19.85 (-4.59)	-26.50 (-3.87)	-22.88 (-3.34)
NBI Index	-19.69 (-4.83)	-24.96 (-3.88)	-21.63 (-3.36)
S&P 400 Index	-20.27 (-4.71)	-26.44 (-3.89)	-22.96 (-3.38)
Panel B: CMS Pricing Decision			
S&P 500 Index	13.63 (2.77)	18.50 (2.38)	18.04 (2.32)
CCMP Index	13.48 (2.77)	18.78 (2.44)	18.29 (2.38)
NBI Index	13.38 (2.93)	19.48 (2.70)	19.21 (2.66)
S&P 400 Index	13.74 (2.81)	18.38 (2.38)	18.21 (2.36)

Note: Cumulative abnormal returns are calculated using the standard “market model”: normal returns, R_{it} , are calculated by estimating $R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$, under the assumption that $E[\varepsilon_{it}] = 0$ and $Var[\varepsilon_{it}] = \sigma_{\varepsilon_i}^2$, where R_{mt} is the return of a given market index. The abnormal return, AR_{it} , is then computed as the difference between the actual return, A_{it} , and the normal return predicted by the model: $AR_{it} = A_{it} - (\alpha_i + \beta_i R_{mt})$. The sum of these abnormal returns over select trading days is then the cumulative abnormal return. Abnormal returns are given relative to four benchmark indices (the S&P 500 Index, the NBI Index, the CCMP Index, and the S&P 400 Index). The estimation window runs from 150 trading days before to 30 days after the event. Data are from Bloomberg.

A Appendix

This appendix provides further information regarding important legal and business events in the recent history of Myriad Genetics, Inc. The event listings serve two purposes. First, they further flesh out the context within which our asset market analyses take place. Second, in some instances they characterize Myriad's responses to the business and legal environment it faced.

I.a Supreme Court Time Line

The list below summarizes major events in the case *Association for Molecular Pathology v. Myriad Genetics, Inc.*. The content is marginally adapted from the timeline provided by the American Civil Liberties Union (ACLU) at <https://www.aclu.org/timelines/association-molecular-pathology-v-myriad-genetics-timeline-events>:

- March 29, 2010: NY Federal Court Rules BRCA1 and BRCA2 gene patents invalid
- July 29, 2011: Federal Appeals court ruled that companies can obtain patents on genes
- March 26, 2012: The Supreme Court vacates the decision of the appeals court
- August 16, 2012: Federal Appeals court reaffirms its prior ruling
- September 25, 2012: The plaintiffs petition the Supreme Court
- November 30, 2012: The Supreme Court grants a writ of certiorari
- April 15, 2013: The Supreme Court hears oral arguments
- June 13, 2013: The Supreme Court unanimously invalidates gene patents:

I.b Post Supreme Court Competitor Entry

Following the Supreme Court's decision, several competitors immediately entered the markets in which Myriad had previously enjoyed exclusivity. Additional competitors entered at later dates. Cost information provided by the earliest entrants would have contributed to CMS's subsequent reimbursement decisions. The number of potential entrants illustrates the high relevance of intellectual property protections for the revenue streams of medical technology innovators.

- Ambry Genetics Corporation on June 13, 2013
- GeneDx, Inc., on June 13, 2013
- DNA Traits on June 13, 2013
- Quest Diagnostics Incorporated and Quest Diagnostics Nichols Institute on October 15, 2013
- Invitae Corporation on December 11, 2013
- Laboratory Corporation of America Holdings on Dec 2, 2013
- Counsyl, Inc., on May 9, 2014
- Pathway Genomics Corporation on June 3, 2014

I.c Post Supreme Court Legal Action

Following the Supreme Court's decision, a series of further legal actions were taken by both Myriad and its competitors (Myriad Genetics, Inc., 2014a). These legal actions support two conclusions regarding the intellectual property uncertainties associated with new medical technologies. First, they illustrate that intellectual property uncertainties are

not easily resolved. Following the Supreme Court's decision, further legal determinations were needed to flesh out what the Supreme Court's decision would mean in practice. In matters involving new technologies, it may be too much to expect legal rulings to provide sufficient specificity and be sufficiently broadly applicable to fully resolve either the matter at hand or a broader class of issues. Second, the actions taken by Myriad provide a window into Myriad's business strategy following the Supreme Court's ruling. To initial analysts' surprise, Myriad determined that it had sufficient legal grounds to continue enforcing intellectual property claims associated with BRCA1 and BRCA2. The limits of its enforceable intellectual property claims would not be settled for another year.

Suits filed by Myriad:

- Ambry Genetics Corporation on July 9, 2013
- GeneDx, Inc., on October 16, 2013
- Quest Diagnostics Incorporated and Quest Diagnostics Nichols Institute on October 22, 2013
- Invitae Corporation on November 25, 2013
- Laboratory Corporation of America Holdings on December 3, 2013
- Counsyl, Inc., on June 13, 2014
- Pathway Genomics Corporation on June 16, 2014

Suits filed against Myraid:

- Counsyl, Inc., on September 30, 2013
- Invitae, Inc., on November 26, 2013

- Quest on October 10, 2013

I.d Major Business Events in Myriad's Recent History

Below are brief descriptions of several major business events in Myriad's recent history. Notably, it has engaged in significant merger-and-acquisition activity, as reported in its annual report (Myriad Genetics, Inc., 2014a). It has also forwarded product lines distinct from *BRACAnalysis*. We take both sets of activities to be illustrative of Myriad's effort to diversify and reduce its exposure to fluctuations in the revenues generated by *BRACAnalysis*.

- February 2014: Acquisition of Crescendo Bioscience for \$270 million.
- May 2011: Purchase of Rules-Based Medicine, Inc. for \$80 million cash.

Below are additional events relevant for understanding developments in Myriad's market capitalization over the period we study. One of the most prominent features of Figure 1 is the steady, significant rise in Myriad's market capitalization during January and February of 2014. The events below underlie at least a portion of this rise.

- January 28, 2014: Myriad publishes positive data regarding a new product line (myVision).
- February 4, 2014: Myriad's second quarter earnings report significantly exceeds expectations.
- February 7, 2014: Myriad and Gene-by-Gene settle their lawsuit.