Report Cards, Incentives, and Quality Competition in Health Care

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Abstract

Throughout the health care sector, report card programs, which collect and publicize information on providers' quality, have been gaining popularity as a means of improving quality. However, to date the empirical evidence of the efficacy of these programs has been mixed. This paper undertakes a theoretical investigation of the impact on providers' behavior of making better quality information available to consumers. While better quality information often increases quality, it need not necessarily do so. Further, improving the quality of information available to consumers need not improve welfare, especially in environments such as health care, where prices are set administratively.

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1 Introduction

Low-quality health care is a major cause for concern in the United States. For example, the National Committee for Quality Assurance (NCQA) estimates that gaps in quality between the nation's highest- and lowest-quality health plans account for 39,000 - 83,000 preventable deaths, $2.8 - $4.2 billion dollars in avoidable medical costs, 83.1 million sick days, and $13 billion in lost productivity each year (NCQA, 2005, p. 10).[1] Among the tools that have been brought to bear on what the Institute of Medicine (2001) has termed the "quality chasm" are so-called "report card programs," (RCPs) which collect and publicize information on health care providers' quality. In recent years health care report card programs have been adopted for health plans, hospitals, managed care organizations, and even individual physicians.

The rationale behind RCPs relies on the widespread principle in economics that "more information is better." In his seminal article, Kenneth Arrow (1963, p. 951) says of the medical care industry: "uncertainty as to the quality of the product is perhaps more intense here than in any other important commodity."[2] The idea that a lack of information can lead to suboptimal outcomes can be traced back at least to Stiglitz (1961) and Akerlof (1970), who argued that market failures are possible when the quality of objects for sale cannot be costlessly observed. One solution to the asymmetric information problem is to eliminate the asymmetric information by making quality information available to consumers through certification by a credible intermediary. Credible report cards are one way of doing so.

Another justification for RCPs is that they reduce consumers' cost of acquiring information, the so-called "search cost" explanation (Nelson, 1970). For most consumers, the cost of acquiring and understanding information about the quality of health care providers is very high. Quality information is highly complex, and the causal connection between changes in provider quality and patient outcomes is difficult to accurately identify. Consequently, it is not surprising that, in the absence of user-friendly quality information, consumers often choose low-quality providers.[3] Since RCPs reduce the cost of acquiring usable information on quality, their supporters hope that lowering search costs will lead consumers to seek out and patronize higher-quality providers, and that once consumers are selecting providers based on quality providers will begin to increase quality as a means of increasing market share. Thus, making quality information available to consumers induces providers such as doctors, hospitals, and health plans to compete to be the highest-quality provider.[4]

While the rationale underlying report card programs appears compelling, the empirical evidence on their effectiveness has been mixed. Some report card programs have been quite successful. For example, NCQA estimates that increases in quality due to its own HEDIS program, which reports on how well health plans comply with certain quality standards, saved between 40,195 and 67,802 lives over the period between 2000 and 2004 and prevented many other adverse health events (NCQA, 2005, p. 8).[5] Jin and Leslie (2003) document another successful RCP, Los Angeles's implementation of a requirement that restaurants publicly display their health inspection grade cards. They find evidence that the program increased restaurants' health inspection grades and

[1] See McGlynn *et al.* 2003 for an overall appraisal of the state of healthcare quality in the United States. Supporting the idea that insufficient quality is a problem, the authors look at 439 markers for quality of care for 30 different conditions and find that, on average, patients received only 54.9 percent of recommended care.

[2] Taking Arrow's (1963) work as a starting point, Dranove and White (1994) provide a survey on recent theory of competition in hospital markets.

[3] See for example Hibbard and Jewett (1997), Wicks and Meyer (1999), Schneider and Lieberman (2001).

[4] See, for example, Marshall et al. (2000) and the references therein.

[5] These numbers do not attempt to compare the changes to what would have happened in the absence of HEDIS and consequently likely overstate the effects of the program.

consumer sensitivity to health inspection grades, and reduced the incidence of hospitalizations due to food borne illness.

Not all RCPs have been successful, however. Dranove et al. (2003) study two of the most widely known RCPs, the cardiac surgery report card programs in New York and Pennsylvania. Using Medicare data, they find that these programs led to "increased expenditures for both healthy and sick patients, marginal health benefits for healthy patients, and major adverse health consequences for sicker patients," leading them to conclude that these report card programs led to worse overall outcomes, especially for sicker patients, and that the report card programs reduced welfare (Dranove et al., 2003, p. 577).[6]

The argument in favor of report cards relies on the belief that increasing competition will lead providers to increase quality. However, the empirical evidence on this point is also mixed, especially in the case of government purchasers. Gowrisankaran and Town (2002) argue that while increased competition was associated with higher quality for California HMO patients, it was associated with decreased quality for Medicare enrollees. This supports the claim made above that markets such as Medicare in which providers have little ability to set price may not give providers sufficient incentive to compete on quality. In another market with reduced pricing power, Propper and Burgess (2003) study the UK National Health Service and find evidence of a negative relationship between competition and quality of care.

The mixed success of RCPs (as well as the tenuous link between increased competition and better quality) in health care suggests that the relationship between the nature of consumer information about quality and provider behavior may be more complicated than it at first appears. Three features of the health care sector increase the challenge of implementing successful RCPs. First, while RCPs certainly lower search costs, they also change the *nature* of information available to consumers. For example, in the absence of report cards it may be that consumers can distinguish a terrible from an adequate provider but can't distinguish an adequate from an excellent provider, whereas report cards make it possible to distinguish among all three. This difference in the *type* of information available to consumers will also affect providers' incentives. While this change often induces providers to increase quality it may also induce them to reduce quality or to provide excessive quality.

A second reason why the standard intuition underlying report card programs may not apply in the health care sector is that much of the incentive to increase quality in the standard story comes from the fact that increasing quality allows the providers to increase prices. However, due to the strong price-setting role of Medicare and other government programs, in many (but not all) parts of the health care sector providers have relatively little ability to raise prices.[7] Even in cases where providers have the ability to raise prices, the prices they can affect are usually the reimbursements that health plans pay them for particular services, not consumers' out-of-pocket costs. Hence there is no connection between providing consumers with additional value through higher quality and the providers' revenues (at least in the short run). While an increase in market share provides some incentive to increase quality, the powerful incentive that comes with the ability to increase prices is (often) absent in the health care sector. In the absence of the price conduit, even well-designed report-card programs may not put sufficient pressure on providers to lead to significant increases in quality.

[6] See Section 2.1 and 2.2 for further discussion of current RCPs, and a detailed discussion of the evidence on the NY/PA cardiac RCP.

[7] See Chalkley and Malcomson (2000) for a survey of quality incentives with government purchasers. Although for a slightly different reason than the one proposed here, Newhouse (2002) suggests that the pervasiveness of administrative pricing may account for at least part of the "quality chasm." Dafny and Dranove (2005) suggest that HMOs participating in Medicare are likely to have difficulty coupling quality increases with price increases.

Third, the standard quality-competition intuition assumes the actors are reasonably similar, both in terms of cost structure and flexibility in choosing quality. However, due to differences in the ownership structures and missions of different providers as well as differences in the scale and scope of their operations, health care providers are highly heterogeneous, and this heterogeneity often leads to differences in the cost of increasing quality. For example, to the extent that quality improvements must be given to all patients – including those such as the poor and elderly who have little ability to change providers in order to take advantage of quality differences – the cost of improving quality in order to attract additional patients is likely to vary widely across providers. As illustrated below, when providers are heterogeneous, increasing the intensity of quality competition through report cards could lead high cost-of-quality providers to give up trying to compete with lower-cost rivals. Again, to the extent that high cost-of-quality hospitals are likely to be large public hospitals with poor or otherwise disadvantaged patient bases, this effect may be particularly alarming.

Provider heterogeneity may also affect whether competition is better thought of as a simultaneous-move game or a sequential one, with one provider playing the role of leader and the others as followers. For example, in the case of a market consisting of several private, for-profit providers, a model of simultaneous quality choice would seem appropriate. However, in the case where a for-profit hospital competes with a public hospital, it may be more reasonable to think of the nimble for-profit as a leader and the bureaucratic public hospital as a follower. The outcome of competition under the two scenarios is quite different.

As a final note on the structure of health care markets and the RCPs' likelihood of success, it is important to recognize that lack of quality information is not the only difference between typical health care markets and the ideal market. For example, health care markets frequently depart from the competitive ideal in that there are only a small number of players in any area, and these actors are large enough relative to each other that strategic effects are important. Because of this, health care markets may be better modeled as oligopolies than perfectly competitive markets. Health care markets are also riddled with agency problems that distort from efficiency. Since it is well known that imperfect competition and agency problems lead to inefficiencies, it may be that even if RCPs fully address the consumer-information issues, the other market imperfections will remain, and we may find that uncertainty about quality is responsible for a relatively small part of the "quality chasm."

The fact that RCPs have not been universally successful suggests the need for a systematic study of the theoretical underpinnings of RCPs in order to address questions of critical importance to policymakers regarding the relationship between providing consumers better information through RCPs and providers' quality choices. For example, do RCPs necessarily increase quality and can they ever lead to excessive quality? Do all consumers benefit equally from RCPs, or do they have redistributive implications, i.e., can some people be harmed by RCPs even when there is an overall benefit?[8] Are there circumstances in which we expect RCPs to be more or less successful? Are there other tools such as performance incentives that can be combined with RCPs in order to improve their performance?

This paper focuses on the relationship between providing consumers better information via RCPs, providers' incentives, and competition in determining the level of quality provided. It shows that while RCPs may lead to increased quality, the mechanism may be more complicated than it at first appears. It is important to note that the phenomenon highlighted in this paper is different in nature than other potential drawbacks of report card programs that have been discussed in the literature. These include the that RCPs may not provide consumers with information that

[8] See Davies et al. (2002) for a discussion of why report cards may not serve vulnerable populations well.

is new and useful (e.g., Dafny and Dranove, 2005), that report cards may encourage providers to "game the system" through selection behavior such as dumping sick patients or performing unnecessary treatments on healthy ones (e.g., Kessler and Geppert (2005); Dranove et al. (2003)), and that RCPs may encourage providers to "teach to the test," shifting resources from unmeasured aspects of quality to measured ones (Sullivan, 2005). This paper focuses on a different, more basic, mechanism – that changing the information structure changes providers' competitive incentives in ways that do not necessarily result in either higher quality or more efficient quality choices. As discussed/illustrated below, this mechanism can profoundly affect the performance of report card programs, and understanding it is crucial for designing report card programs that effectively bridge the quality chasm.

The remainder of the paper proceeds as follows. Section 2 discusses a number of RCPs currently being used in health care and the related literature Section 3 presents a model of continuous quality choice in order to illustrate the relationship between the precision of consumers' information about quality and providers' quality choices. Section 4 considers an alternative approach to thinking about RCPs, where in the context of a discrete quality choice model the introduction of an RCP is treated as a refinement in consumers' information partition rather than merely a reduction in white noise. Section 5 concludes.

2 Background and Related Literature

2.1 Report Card Programs

Although this study is focused on the use of RCPs in health care, RCPs have also been used widely in other areas. Examples of programs include the publicizing of schools' performance on standardized tests, firms' use and emissions of toxic substances, airlines' on-time performance, and restaurants' health inspection performance.[9]

Report card programs have been especially prevalent in health care. Here we briefly discuss a few examples in order to give a sense of their subject matter and scope. Many of these programs are also discussed in the excellent surveys by Marshall and coauthors (Marshall et al., 2000; 2003).

One of the best-known programs in the United States is the NCQA's Health Plan Employer Data and Information Set (HEDIS) program. NCQA (www.ncqa.org) is a private, nonprofit organization whose mission and vision are "to improve the quality of health care" and "to transform health care quality through measurement, transparency and accountability." They operate under the belief that "NCQA's information empowers people to make informed decisions."[10] The HEDIS data set collects information on health plans' performance on various measures of care and service quality, including asthma medication use, blood pressure control, antidepressant medication management, treatment with beta-blockers after a heart attack, breast cancer screening, and immunization status.[11] They also collect data on access to care, overall satisfaction, preventative care, and treatment (primarily of chronic diseases). Together with U.S. News and World Report, NCQA publishes an annual list of "America's Best Health Plans." As part of its mission, NCQA also offers an accreditation program, whereby it certifies managed care organizations that meet certain quality standards.

The Consumer Assessment of Healthcare Providers System (CAHPS) program is run by the U.S. Agency for Health Care Research and Quality (AHRQ) and a consortium of public and private

[9] See Snyder, Miller and Stavins (2003) for a discussion of the Toxics Release Inventory, Hoxby (2003) and Figlio and Lucas (2004) for school report cards, Foreman and Shea (1999) for airline on-time performance, and Jin and Leslie (2003) for restaurant health inspections.

[10] www.ncqa.org/about/about.htm, accessed February 27, 2006.

[11] www.ncqa.org/Communications/Publications/overviewncqa.org, accessed February 27, 2006.

research organizations. Begun as a program for collecting data on enrollee and patient satisfaction with health plans, the program has expanded to consider a wider range of health care services, including individual providers, medical groups, hospitals, nursing homes, and other aspects of care.[12] The CAHPS surveys are designed to generate scientifically accurate, comparable data that can be used by consumers, regulators, purchasers, providers, and health plans, and the data they generate are used in academic and policy research.[13]

Federal law requires all managed care plans participating in Medicare to provide quality information (including the HEDIS data and the additional Consumer Assessment of Health Plans Study (CAHPS) data) to the Centers for Medicare and Medicaid Services (CMS), which then makes this quality information public (Dafny and Dranove, 2005).

The Hospital Quality Initiative (HQI) is program run by CMS in conjunction with the Hospital Quality Alliance, an organization that includes the American Hospital Association, the Federation of American Hospitals, and the Association of American Medical Colleges. The goal of the HQI is to develop publicly available, credible, and user-friendly measures of the quality of care provided by American hospitals.[14] Although reporting is voluntary, federal law imposes a 0.4 percentage point reduction in its annual payment update from CMS on any hospital that does not submit the ten quality measures in the HQI "starter set." The broader set of HQI quality measures include indicators such as use of aspirin and beta-blockers for heart attack victims, smoking cessation counseling, pneumonia vaccination, and use of antibiotics. The quality information is made available to consumers through a web site, www.hospitalcompare.hhs.gov. As part of the HQI, CMS is also conducting preliminary studies on pay-for-performance, where hospitals that exhibit superior performance (top 20%) on quality measures for heart attacks, heart failure, pneumonia, coronary artery bypass graft, and hip and knee replacements will receive a financial bonus.

There are also a number of state quality-reporting programs. The most widely known and studied programs are the programs in New York and Pennsylvania that publish hospital and individual physician Coronary Artery Bypass Graft (CABG) surgery mortality rates, in both raw and risk-adjusted forms.[15] Although often not as detailed, a number of other states (including CA, FL, IA, MD, NJ, WA, and WI) also publish quality information, most often the volume of particular procedures done at particular hospitals. This information is available through the individual states' web sites, and it is accessible through a unified portal at www.healthcarechoices.org.

The Joint Commission on Accreditation of Healthcare Organizations is a private, nonprofit organization that "is committed to making relevant and accurate information about surveyed health care organizations available to interested parties," including health care organizations, employers, unions, benefits consultants and the general public.[16] The Joint Commission gathers information on the quality and safety performance of more than 15,000 health care providers. Accreditation involves an on-site review of the providers procedures every three years. In addition to general accreditation of hospitals, the Joint Commission also offers accreditation in specialty areas such as assisted living, behavioral health care, home health care, long-term care, managed care, laboratory procedures and others. A searchable list of accredited providers is posted on the Joint Commissions "Quality Check" web site.

[12] See www.cahps.ahrq.gov/content/cahpsOverview/OVER_Program.asp, accessed February 27, 2006.

[13] See www.cahps.ahrq.gov/content/cahpsOverview/OVER_Publications.asp for a list of published articles using the CAHPS data.

[14] Additional suppport is provided by AHRQ, the National Quality Form, the Joint Commission on Accreditation of Healthcare Organizations, AMA, ANA, AFL-CIO, and AARP, among others. See http://www.cms.hhs.gov/HospitalQualityInits/downloads/HospitalOverview200512.pdf, accessed February 27, 2006.

[15] See Dranove et al., 2003 and Cutler et al., 2004 for discussions of these programs.

[16] See www.jcaho.org/general+public/who+jc/. Accessed February 28, 2006.

A number of private employers or private employer groups also have quality RCPs. The Pacific Business Group on Health (a group of large employers in California) produces quality ratings through HealthScope, "an independent public information source ... to help you select the best quality plans, hospitals, doctors, and medical groups."[17] The HealthScope web site provides general quality information on individual physicians, medical groups, and health plans. Health plans are rated based on performance on categories such as diabetes care, heart care, cancer screening, mental health, children's health, and smoking cessation. Medical groups are rated based on patient feedback regarding "overall care," "getting treatment," "communicating with patients," "coordinating patient care," and "timely care and service." The only quality indicator for individual doctors is number of years in practice.

The Leapfrog Group (motto: "Informing Choices. Rewarding Excellence. Getting Health Care Right.") is made up of over 170 companies that purchase health care. The goals of the Leapfrog Group include to "reduce preventable medical mistakes and improve the quality and affordability of health care;" to "encourage public reporting of health care quality and outcomes so that consumers and purchasing organizations can make more informed health care choices;" and to "reward doctors and hospitals for improving the quality, safety and affordability of health care."[18] The Leapfrog Group's hospital quality information includes voluntarily disclosed data on "leaps" that the Group feels are scientifically proven to reduce unnecessary deaths and injuries including use of a Computerized Physician Order Entry (CPOE) system to order medications, tests, and procedures; staffing of intensive care units with specially trained "intensivists;" use of Evidence-Based Hospital Referral to direct patients who need high-risk procedures to hospitals with significant experience (and success) performing such procedures; and use of 27 "Safe Practices" defined by the National Quality Forum. The National Quality Forum is, itself, a private, nonprofit organization whose mission is "to improve American healthcare through endorsement of consensus-based national standards for measurement and public reporting of healthcare performance data that provide meaningful information about whether care is safe, timely, beneficial, patient-centered, equitable and efficient."[19]

There are also a number of private-sector companies involved with quality reporting. The annual list of "100 Top Hospitals" was originally compiled by two consulting firms, HCIA and Mercer Inc., and is now produced by Solucient (the company created when HCIA merged with another consulting company – www.solucient.com). The purpose of the list is to provide the public with the information they need to choose the right hospital. Membership in the Top 100 appears to take into account both quality and financial performance (Chen et al., 1999). Consistent with Chen's analysis, Solucient has products directed at helping the public select a hospital and also products directed at helping hospitals improve "performance," which seems to include both quality and financial aspects.

HealthGrades (www.healthgrades.org) is a "healthcare ratings, information, and advisory services company" whose mission is to improve American health care "using our proprietary, objective provider ratings and expert advisory services." While some HealthGrades information is available to the public without charge, other data require the user to pay a fee. According to its web site, HealthGrades envisions drawing clients from the ranks of hospitals, employers, health plans, liability insurers, and individual physicians.

The Massachusetts General Insurance Commission, the state board that coordinates insurance coverage for state employees, has recently instituted a "tiered" system under which plans covering state employees must separate hospitals and physicians into different tiers. The exact criteria for

[17] See www.healthscope.org/. Mehrotra et al (2003) discuss other employer-based programs.

[18] See www.leapfroggroup.org. Accessed February 27, 2006.

[19] See www.qualityforum.org. Accessed February 27, 2006.

the tiers are left up to the plans, and left rather vague. In many cases, the tiers seem to combine both quality and financial considerations, as evidenced by the fact that some of the clear high-quality hospitals in the area are sometimes not placed in the top tier. Along with the classification system, the health plans charge consumers different copayments depending on in which tier the provider they choose reside. Thus when a consumer chooses a middle or lower tier provider, they pay more out of pocket.

Finally, RCPs are also being used outside the United States. Marshall et al. 2003 includes a list of major reporting programs in the United Kingdom, including government programs (e.g., the Department of Health's Commission for Health Improvement and National Health Service surveys of patient satisfaction) and private initiatives (e.g., Dr. Foster, www.drfoster.co.uk, which posts hospital quality data on the web and publishes a *Good Hospital Guide* and *Good Birth Guide* in conjunction with the *Sunday Times*).

2.2 Performance of RCPs

The evidence on how whether RCPs induce beneficial changes in behavior is somewhat mixed, and because of the complexity of the problem the effects of RCPs are extremely difficult to identify. Marshall et al. (2000; 2003) provide surveys of the evidence on the results of RCPs in the United States and United Kingdom. A number of general themes emerge. First, although consumers say they want more information about health care quality, they appear to make only limited use of such information. For example, a survey of recent coronary surgery patients in Pennsylvania revealed than less than 25% of them had made use of the CABG report card program information in choosing a surgeon.[20] Marshall and coauthors (2000) conclude that consumers' failure to use report card data stems from the fact that people find the data difficult to use, not relevant to the choice at hand, not trustworthy and too out-of-date, and that people believed they did not have a choice of providers. People appear to be more willing to trust family and friends than anonymous data sets. As the web sites discussed above illustrate, however, the Internet has made data easier to access, understand, and use, and so it is possible that the public will grow more comfortable with quality data over time.

Second, while early on purchasers (primarily employers) seemed more interested in RCP data as a means of finding low-cost providers, there appears to be increasing interest in using the data to select high-quality providers. Third, individual physicians express distrust of the quality data and are therefore reluctant to use it. Physicians appear particularly concerned that the data do not properly adjust for risk. Fourth, of all the involved parties, hospitals seem to be the most responsive to quality data. Since, in many cases, hospital quality shortcomings can be addressed relatively cheaply (e.g., giving aspirin to heart attack patients), hospitals have been willing to adopt many of these "best practices."

The most extensive attempt to evaluate the connection between a report card program and clinical quality has been in the context of the New York/Pennsylvania coronary artery surgery (CABG) RCP. The evidence has been hotly debated. Hannan et al. (1994) found that risk-adjusted mortality rates fell from 4.17% when the RCP was introduced in 1989 to 2.45% in 1992. However, this finding was later criticized (Ghali et al. 1997) on the grounds that Massachusetts, which had no report card program, experienced a similar trend during the period in question (risk-adjusted mortality fell from 4.7% in 1990 to 3.3% in 1994). Chassin (2002a) rejects this criticism on

[20] A recent study by Dafny and Dranove (2005) corroborates this idea. They show that consumers appear to learn about as much from report cards as they do through other "market-based" channels. While the report card is reasonably strong, it appears to be driven by other consumers' overall satisfaction ratings rather than by more complex quality information.

the grounds that the Massachusetts and New York data are not comparable, and in turn argues that report cards reduced mortality rates. Dranove (2002) criticizes Chassin (2002a) on the grounds that he does not correct for unobserved variations in severity. Dranove et al. (2003) find evidence of selection behavior by physicians that was not previously considered. As a result, they conclude that report cards decreased patient welfare, especially for the sickest patients.[21] Finally, Cutler, Huckman, and Landrum (2003) employ a provider-level analysis and conclude that hospitals that performed poorly initially has subsequent decreases in risk-adjusted mortality. As is plain to see, even in the case of one of the oldest, most well-established RCPs in the country, establishing a causal link between the RCP and quality improvement has been difficult.

2.3 Theoretical Literature

There has also been theoretical examination of the relationship between the precision of consumers' information and firms' quality choices, although none has been tailored to the case considered here – quality competition by heterogeneous providers facing administratively determined prices and insured consumers. Nevertheless, to the extent that the existing literature casts light on the problem at hand, the models suggest that the relationship between noise in consumers' perception of quality and providers' quality choices is not necessarily straightforward.

The studies to date have focused on the case where the provider(s) can choose price as well as quality. Kehoe (1996) considers a monopolistic provider and argues that the monopolist always chooses the efficient level of quality, but that increases in noise about the level of the monopolist's quality may induce the monopolist either to increase or decrease its price. Dranove and Satterthwaite (1992) consider a symmetric search model in which firms choose prices and qualities. They show that increasing the precision of consumers' information about providers' prices and qualities leads providers to increase quality but may either increase or decrease welfare. However, it is important to note that their model is one in which higher qualities allow providers to charge higher prices. It is also unclear whether the Dranove-Satterthwaite results generalize to the case of asymmetric providers.

Kranton (2001) studies a related model in which firms set price and quality in competition for market share. She shows that when firms price competitively and compete fiercely for market share there may be no equilibrium in which firms offer high quality. Although the Kranton model is set in a dynamic context, the factors leading to non-existence of the high-quality equilibrium (i.e., the inability to reap the benefits of higher quality in the form of higher prices) are also prominent in health care.

The analysis of this paper draws heavily on discrete choice models of oligopoly competition. Anderson, de Palma, and Thisse (1992) is the seminal text on the subject. Anderson and de Palma (1992; 2001) also provide useful results.

3 Quality Competition with Noisy Quality Information

We begin our investigation of the effect of giving consumers better information through RCPs by considering a simple discrete-choice model in which consumers receive a noisy signal of providers' qualities and choose the provider they perceive to offer the highest quality. In this environment, implementing an RCP can be thought of as reducing the noisiness of the consumers' perceptions

[21] Chassin (2000b) responds to Dranove's (2000) criticism by attacking the validity of the approach in Dranove et al. (2003).

of the provider's quality, making it more likely that the consumers correctly choose the provider offering the highest quality.

Quality improvements can affect a provider's cost in different ways. In some cases, a provider's quality primarily affects its marginal cost of treating each patient, as in the case of quality measures such as whether a health plan screens for diseases such as colorectal, breast, or cervical cancer. In other cases, the cost of quality may behave more like a fixed cost that does not affect the cost of treating any particular patient. For example, a provider can improve its mortality rates by hiring better staff, purchasing more sophisticated monitoring equipment, or investing in information technology such as electronic medical records systems, all of which are costly but (up to capacity constraints) do not involve additional marginal costs of treating any particular patient.

While in most cases quality improvement will involve both fixed and marginal costs, in the following analysis we focus on the two polar cases where quality improvements only affect fixed cost and where quality improvements only affect marginal costs. The results are a mixture of analytic results and numerical analysis of how providers' equilibrium quality choices vary as consumers' information about quality becomes more precise.

For most of the analysis, we focus on the case where providers prices are fixed. In many parts of health care, especially in the case of government purchasing programs such as Medicare, this is certainly the appropriate model, and so the no-pricing case should not be neglected. We provide some analysis of quality-competition with pricing for comparison.

3.1 An Illustrative Analogy

Before turning to the technical presentation, consider the following analogy between providers who compete by setting quality and the effort put forth by runners in a race. We begin with the standard story, in which improved information leads to better performance. Consider a 100 meter race with three contestants of approximately equal ability. To begin, suppose that the technology is such that if the contestants are very close together it is difficult for the judges to determine who the actual winner is. Given this technology, the race's short length, and the fact that the runners are all of the same ability, the runners will realize that even if they try their hardest they will be unable to establish enough of a lead to definitively win the race. As a result, each runner will have an incentive to run just fast enough to stay in the leading group of runners. The result is that overall performance in the race will be mediocre. Now, suppose that "photo finish" technology is introduced, allowing the judges to clearly determine the winner even if the fastest runner is only slightly ahead of the competition. In this case, since a small extra effort can result in a clear win, each runner will have an incentive to push as hard as possible to win. As a result, both the winning time and the average time will be better when the judges have more precise information about the performance of the competitors.

In health care, the report card plays the role of the photo finish technology, allowing consumers to identify much finer differences in quality than they could before report cards were introduced. When report cards work well, as in the case of the race described above, they improve quality of not only the best providers but also of the average provider, since all have an incentive to try to gain market share (i.e., win the race) by outdoing their competition. They also result in average quality increasing, since the market share of high quality providers increases.[22]

While it seems reasonable that report cards would increase quality in the above situation, they need not always do so. To see why, consider the following two variations on the race example described above. In the first case suppose that, instead of all racers having equal ability, two of the

[22] This effect would be present even if the RCP had no effect on provider behavior.

contestants are fast while the third is slow. Even though some contestants are faster than others, if the race is not long enough for one of the runners to emerge as a clear winner with the initial technology (i.e., without photo finish), the two fast contestants will run just fast enough to be in the top group, and the slow contestant will run at full speed, just barely eking his way into the top group. The result is that all of the contestants finish in a pack, and once again their overall time is mediocre. Notice, however, that the different types of runners have different incentives to put forth effort. The slow runner is working much harder to achieve this outcome than the fast ones.

Once photo finish is introduced, the two fast runners will have an incentive to run at full speed, since now they can win the race by being just a bit faster than their rivals. The slow runner, on the other hand, will know that he cannot win the race when the top runners are going at full speed, and will either put forth minimal effort or drop out of the race entirely. Thus, in the case where the runners are heterogeneous, making better performance information available can lead those with the highest cost of effort to put forth less effort than they did with lower-precision information. Making the analogy to health care quality, it may be that if a report card makes it easier to distinguish the excellent from the merely good, those providers with the highest cost of providing quality may react to the institution of report cards by reducing quality, since they cannot keep up with their lower-cost rivals once they are given strong incentives to compete on quality.

Increasing the precision of information may also have detrimental effects on the (inherently) best performers. For example, consider the same race with one fast runner and two slow runners. With the original technology, the fast runner knows that in order to be the clear winner he must beat the other two by a wide margin, and so he will put forth a lot of effort to do so. Knowing they can't win, the two slow runners will put forth minimal effort. Installing photo finish technology reduces the size of the lead that the fast runner must establish in order to distinguish himself from the pack. As a result, photo finish will lead the fast runner to reduce his effort to the point where it is just enough to clearly beat the other runners. Thus, in this case, more precise information leads the best (i.e., lowest-cost) agent to reduce effort.

In each of these cases, changing the precision of the information on performance that is available to the "judges" affects the actors' incentives to put forth effort. And, as these examples show, the changed incentives do not always favor increasing effort.

3.2 Competition with Quality Dependent Fixed Costs

3.2.1 Monopoly

Before turning to the more-complicated situation in which multiple providers choose quality, we begin by studying the case in which a monopolistic provider chooses quality, and consumers purchase if their perception of the monopolist's quality is greater than some threshold level. The threshold level can be thought of as the quality of a passive provider whose quality level is fixed. For each patient it treats, the monopolistic provider receives reimbursement $p > 0$ and incurs constant marginal cost $c > 0$ for each patient treated, with $p - c > 0$. There is a total mass of N potential consumers in the market.

The monopolistic provider chooses the quality of its service, denoted q. The consumer does not observe quality directly. Rather, the consumer observes a signal of the monopolist's quality. Let the signal be given by $s = q + \varepsilon$, where ε is a zero-mean random variable with probability density function $f(\varepsilon)$ and cumulative distribution function $F(\varepsilon)$. Let σ denote a measure of the noisiness of the signal (e.g., standard deviation). Often we will treat $f()$ and $F()$ as functions parameterized by σ. For notational simplicity, we do not formally denote this dependence but nonetheless take derivatives with respect to σ.

The consumer's utility function is $u_i = q$, and so the consumer chooses to purchase from the monopolist if its perceived quality is greater than some threshold, i.e., consumer purchases from the monopolist if $s \geq \bar{q}$, where $\bar{q} > 0$ is a reservation quality.[23] Interestingly, because this consumer is risk neutral over quality, changes in the variance of ε that do not affect its mean do not affect the consumer's decision rule.

The monopolist's cost of quality is $K(q)$, with $K(0) = 0$, $K'(q) > 0$, and $K''(q) > 0$. The monopolist's optimization problem is to choose q in order to maximize

$$\begin{aligned} & (p-c) N \Pr(q + \varepsilon \geq \bar{q}) - K(q) \\ = \; & (p-c) N (1 - F(\bar{q} - q)) - K(q). \end{aligned}$$

Differentiating with respect to q yields first-order condition

$$(p-c) f(\bar{q} - q^*) - K'(q^*) = 0,$$

and second-order condition

$$-(p-c) N \frac{df(\bar{q} - q^*)}{dq} - K''(q^*) < 0.$$

The introduction of an RCP can be interpreted as a decrease in σ, i.e., an increase in the precision of consumers' information about the monopolist's quality. Thus, the comparative static of interest is $\frac{dq^*}{d\sigma}$. Implicitly differentiating the first-order condition yields and rearranging yields:

$$\frac{dq^*}{d\sigma} = \frac{(p-c) N \frac{\partial f(\bar{q} - q^*)}{\partial \sigma}}{pN \frac{\partial f(\bar{q} - q^*)}{\partial q} + K''(q^*)}$$

Proposition 1 *The sign of* $\frac{dq^*}{d\sigma}$ *is the same as the sign of* $\frac{\partial f(\bar{q} - q^*)}{\partial \sigma}$.

Proof. *The denominator is positive by the second-order condition, hence the sign of* $\frac{dq^*}{d\sigma}$ *is the same as the sign of* $\frac{\partial f(\bar{q} - q^*)}{\partial \sigma}$. ■

The term $\frac{\partial f(\bar{q} - q^*)}{\partial \sigma}$ represents the impact of increasing σ on the monopolist's marginal probability of making a sale. If it is positive, then increasing the precision of the consumer's information (which amounts to *decreasing* σ) decreases the marginal value of increasing quality and leads the monopolist to reduce its optimal quality choice. On the other hand, if $\frac{\partial f(\bar{q} - q^*)}{\partial \sigma} < 0$, then increasing the precision of the consumer's information increases the marginal value of increasing quality, which induces the monopolist to increase quality in response.

The dependence of the monopolist's quality response on the sign of $\frac{\partial f(\bar{q} - q^*)}{\partial \sigma}$ suggests that the nature of the monopolist's response will be dictated by the shape of the noise distribution. Three examples using standard distributions show that increasing the precision of the quality signal could induce the monopolist to either increase or decrease quality.

Example 1 ***Uniformly Distributed Noise***. *Suppose that ε is distributed uniformly over some*

[23] Such consumers are not fully Bayesian in the sense that they do not infer the monopolist's quality level from its equilibrium behavior. Such behavior would, however, be optimal if the consumer had no information about which provider was active and which provider was passive, or if the consumer did not know the monopolist's cost function.

interval, $[-a, a]$*. Then,* ε *is distributed as:*

$$f(y) = \begin{cases} 0 & \text{if } y < -a \\ \frac{1}{2a} & \text{if } -a \leq y \leq a \\ 1 & \text{if } k > a \end{cases} .$$

There are three possible types of optimal solutions. The first is where $|\bar{q} - q^*| < a$*. Taking* a *as the relevant measure of spread,* $\frac{\partial f(\bar{q}-q^*)}{\partial a} = -\frac{1}{2a^2}$ *if* $|\bar{q} - q^*| \leq a$*. Hence increasing noise decreases quality, or, a reduction in noise increases quality. This is due to the fact that increasing the precision of the consumer's information (i.e., decreasing a) increases the signal density for all quality choices that occur with positive probability, which increases the monopolist's marginal incentive to increase quality. The other two possibilities for* q^* *are that* $q^* = \bar{q} + a$ *(since any quality increase beyond this level is costly but wins no additional customers) or* $q^* = 0$ *(since quality values between* 0 *and* $\bar{q} - a$ *are costly but win no sales). Because of the discontinuities in the provider's marginal revenue curve, optimal responses to changes in a are potentially ambiguous in these cases. For this reason we will focus on the logistic case (Example 2) and normal case (Example 3), which do not exhibit such discontinuities, for the remainder of the paper.*

Example 2 ***Logistic Noise.*** *The logistic distribution underlies the logit choice model. Suppose that* ε *is distributed according to the logistic distribution with mean* 0 *and scale parameter* $\mu > 0$*. The variance of this distribution is* $\mu^2\pi^2/3$*. The density of this distribution is* $f(x) = \frac{\exp(-x/\mu)}{(1+\exp(-x/\mu))\mu}$*. Differentiating* $f(x)$ *with respect to* μ*, evaluating at* $x = \bar{q} - q^*$*, and simplifying yields that* $\frac{\partial f(\bar{q}-q^*)}{\partial \mu} > 0$ *if and only if*

$$(\bar{q} - q^*)(\exp((\bar{q} - q^*)/\mu) - 1) > \mu(1 + \exp((\bar{q} - q^*)/\mu)).$$

Although this condition is somewhat difficult to interpret, it is straightforward to numerically compute the provider's optimal quality choice as a function of the spread parameter, μ*. Figure 1 presents a graph of the provider's optimal quality choice when* $(p - c) = 1$*,* $N = 100$*,* $\bar{q} = 0$*,* $K(q) = q^2$*, and* μ *varies between* 0 *and* 6*. Lower values of* μ *correspond to more precise consumer information. Quality is maximized at* $\mu \approx 2.17$

Example 3 ***Normally Distributed Noise.*** *The normal distribution underlies the probit choice model. Suppose that* ε *is distributed normally with mean* 0 *and standard deviation* σ*. Letting* $y = \bar{q} - q^*$*,* $f(y) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{y}{\sigma}\right)^2}$*, and* $\frac{d}{d\sigma}(f(y)) = \frac{e^{-\frac{1}{2}\left(\frac{y}{\sigma}\right)^2}}{\sigma^2\sqrt{2\pi}} \left(\frac{y^2-\sigma^2}{\sigma^2}\right)$*. Hence* $\frac{\partial f(\bar{q}-q^*)}{\partial \sigma}$ *is positive for* $|\bar{q} - q^*| > \sigma$ *and negative when* $|\bar{q} - q^*| < \sigma$*. In this case, as in the logistic case, whether improving the quality of information increases or decreases quality will depend on the initial quality choice. Figure 2 illustrates the monopolist's optimal quality choice as a function of the standard deviation of* ε*, for the case where noise is normally distributed,* $(p - c) = 1$*,* $N = 100$*,* $\bar{q} = 0$*, and* $K(q) = q^2$*.*

In the logistic and normal noise cases (which will be the main models we consider) increasing the precision of consumers' information induces the monopolist to first increase and then decrease quality. The intuition for why this pattern is optimal is as follows. When the consumer's information about the monopolist's quality is very imprecise (i.e., σ or μ is high), the monopolist has little to gain by increasing quality because doing so incurs a cost but does not increase the likelihood of a sale by much. As the precision of the consumer's information increases, the monopolist's marginal benefit of increasing quality (i.e., increase in the likelihood of a sale) increases, which

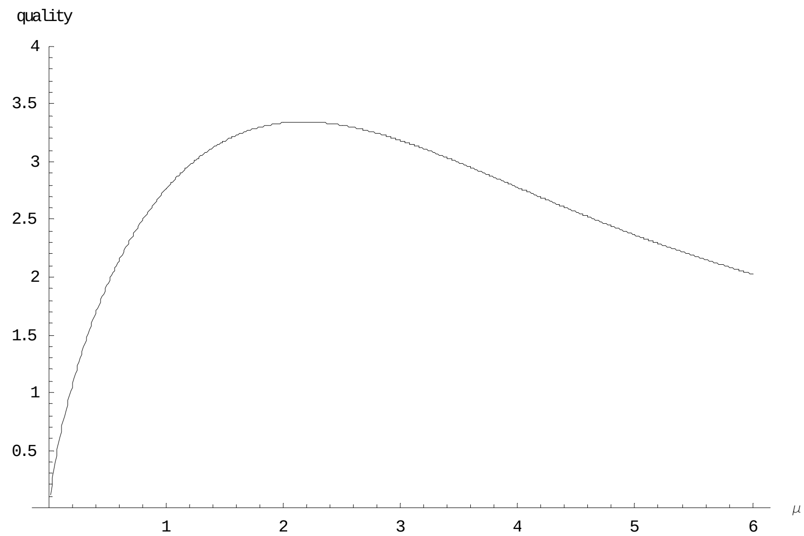

Figure 1: Logistic Noise: Quality as a function of scale parameter.

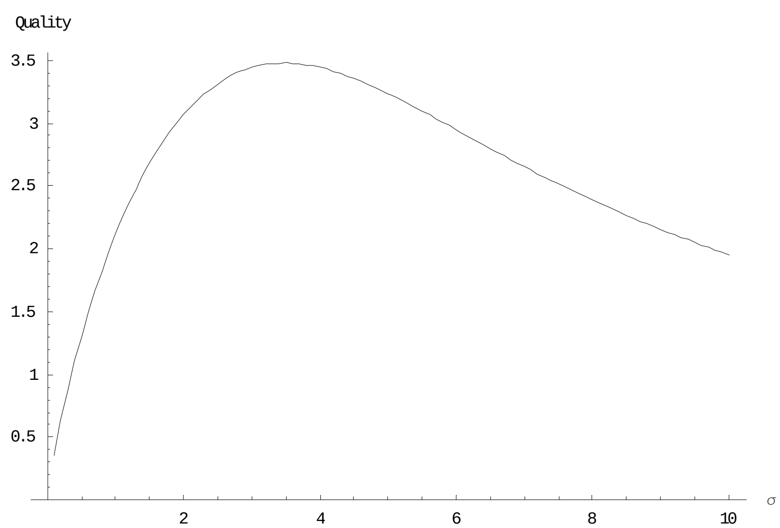

Figure 2: Normal Noise: Quality as a function of standard deviation.

gives the monopolist an incentive to increase quality. However, eventually the consumer's signal about the monopolist's quality becomes so precise that the monopolist only needs to provide a quality slightly higher than $\bar{q}$ to virtually ensure a sale. Thus, as the information becomes very precise, the monopolist's optimal quality decreases to $\bar{q}$ (which in this case is zero).

Interestingly, the monopoly case illustrates that counterintuitive quality incentives can arise even in the case where the provider does not face competition (although the reserve quality acts as a sort of passive competitor). Thus, some of the complications in the effect of changing the precision of quality information are purely informational, as opposed to strategic, in nature.

In this model each consumer assigns value 1 to an additional unit of quality. Hence the social marginal value of quality is N, the total mass of consumers. Since there are decreasing returns to quality provision (i.e., $K(q)$ is convex) and constant returns in *quantity,* the Pareto Optimal quality provision is for the monopolist to provide quality $q^* \in \arg\max Nq - K(q)$, or $N = K'(q)$. In examples 2 and 3 above, $N = 100$ and $K(q) = q^2$, so $q^* = 50$. However, in these examples quality is maximized around 3.5, thus there is no value of σ for which the monopolist provides the correct quality. For a sufficiently large price-cost margin $(p - c)$, there is presumably a value of σ that would induce the monopolist to choose the socially optimal quality level. Notice, however, that the optimal quality level would be achieved for a strictly positive level of σ (the single-peaked shape of the quality-noise curve remains the same as $(p - c)$ is increased). Thus, while there are ways to induce the monopolist to provide the socially optimal level of quality, Figures 1 and 2 at least suggest that increasing precision through report cards could lead the monopolist to provide inefficiently little quality, and that, from a public policy perspective, there are circumstances in which it would be better to provide consumers with less information rather than more. Although this conclusion is extreme, it provides additional support to the idea that report cards may not be the "one-size fits all" solution for quality deficiencies and that, to the extent that report card programs are used, careful attention should be paid to their design. It may be that information-based programs should be combined to price-based instruments such as pay-for-performance.

3.2.2 Duopoly

Next, we consider a model in which two providers compete to sell to a single consumer by setting quality. Let q_1 denote provider 1's quality and q_2 denote provider 2's quality. The consumer observes each provider's quality with some error. Thus if provider i chooses q_i, the consumer observes $q_i + \varepsilon_i$, where ε_i, $i \in \{1, 2\}$, represent the observation errors. The consumer's utility from choosing provider i is given by $u_i = q_i - r_i$, where r_i represents the consumer's out-of-pocket cost of provider i. The consumer purchases from provider 1 if and only if $q_1 - r_1 + \varepsilon_1 \geq q_2 - r_2 + \varepsilon_2$. As is common in health care, we will assume that the consumer's out-of-pocket cost does not depend on which provider he chooses, and so the consumer chooses provider 1 whenever $u_1 \geq u_2$, or $q_1 - q_2 \geq \varepsilon_2 - \varepsilon_1 \equiv \varepsilon$. This behavior is optimal if the consumer does not know the providers' cost functions and hence cannot not predict the providers' equilibrium quality choices. We will focus on the case where ε is normally distributed (probit). Some results using logistically distributed noise are presented at the end as a robustness check.[24]

The providers' service price is fixed at $p > 0$. Suppose the cost to provider i of choosing quality q_i is given by $K_i(q_i) = k_i q^2$, assumed to be increasing, convex, and not necessarily the same for both providers. In this environment, provider 1 chooses q_1 to maximize $(p - c) N (1 - F(q_2 - q_1)) - K_1 q_1^2$

[24] If ε_1 and ε_2 are independent normal random variables, then $\varepsilon = \varepsilon_2 - \varepsilon_1$ is normally distributed, yielding the probit model. If ε_1 and ε_2 are independently double-exponentially distributed with the same scale parameter, then $\varepsilon = \varepsilon_2 - \varepsilon_1$ is logistically distributed, yielding the logit model. The primary difference between the normal and logistic distribution is in the shape of the distributions' tails. See Anderson, de Palma and Thisse, 2002.

and provider 2 chooses q_2 to maximize $(p-c)\,NF\,(q_2-q_1)-K_2q_2^2$, where $F\,(x)$ is the cumulative distribution function of ε. In the case where ε is normally distributed, we will index F by the standard distribution, σ, while when ε is logistically distributed we will index F by the scale parameter, μ.

Simultaneous Quality Choice We begin by considering the case where the firms have different costs of producing quality, $k_1 \neq k_2$, and suppose without loss of generality that provider 1 has a lower cost of increasing quality than provider 2, $k_1 < k_2$. For most of this section, we will consider the case where ε is normally distributed (i.e., the probit choice model), since it is more amenable to analytic analysis. At the end of the section we show that the qualitative features of the model are the same for the logit choice model.

If both providers choose quality simultaneously, then a Nash equilibrium of this game is found by looking for quantities (q_1^*, q_2^*) such that $q_1^* \in \arg\max\,(p-c)\,N\,(1-F\,(q_2^*-q_1,\sigma))-k_1q_1^2$ and $q_2^* \in (p-c)\,NF\,(q_2-q_1^*,\sigma)-k_2q_2^2$.

Proposition 2 establishes the analog to Proposition 1 for the duopoly case.

Proposition 2 *At any stable pure strategy equilibrium,* $\frac{dq_i^*}{d\sigma}$ *has the same sign as* $\frac{\partial f\left(q_2^*-q_1^*\right)}{\partial\sigma}$.

Proof. The usual comparative statics techniques yield the following expressions:

$$\frac{\partial q_i^*}{\partial\sigma}=\frac{pc_j''\left(q_j^*\right)\frac{\partial f\left(q_2^*-q_1^*\right)}{\partial\sigma}}{\Delta},$$

where $\Delta = pc_2''\,(q_2^*)\,\frac{\partial f\left(q_2^*-q_1^*\right)}{\partial q}+c_1''\,(q_1^*)\left(c_2''\,(q_2^*)-p\frac{\partial f\left(q_2^*-q_1^*\right)}{\partial q}\right)>0$ in any stable equilibrium (see Fudenberg and Tirole, 1991, p. 24).[25] ■

Proposition 2 establishes that whether reducing consumers' uncertainty about quality increases or decreases equilibrium quality depends on whether increasing σ increases or decreases the density of the signal distribution at the optimal qualities. To help understand the proposition, consider a single-peaked, symmetric noise distribution such as the normal, where reducing noise increases the density near the peak and reduces it in the tails. In this case, Proposition 2 suggests that decreasing noise decreases quality when the two providers' qualities are initially far apart, and increases quality when the two providers' qualities are initially close together.

Proposition 2 is stated for any stable equilibrium, which leaves aside the question of whether a pure strategy equilibrium exists. Proposition 3 gives a necessary condition that any interior equilibrium must satisfy, which we will go on to use in addressing the question of whether a pure strategy equilibrium of the simultaneous quality-setting game exists.

Proposition 3 *If ε is distributed normally, any interior equilibrium of the simultaneous quality setting game must satisfy:*

$$q_1^*=\frac{k_2}{k_1}q_2^*$$

Proof. *Follows immediately from the first-order conditions.* ■

Using the above solution, we can examine the relationship between quality and the precision of the consumer's information at points satisfying the first-order necessary conditions for a Nash

[25] If the equilibrium is unstable, then the sign of the denominator reverses, and so $\frac{dq_1}{d\sigma}$ and $\frac{\partial f\left(q_2^*-q_1^*\right)}{\partial\sigma}$ have opposite signs.

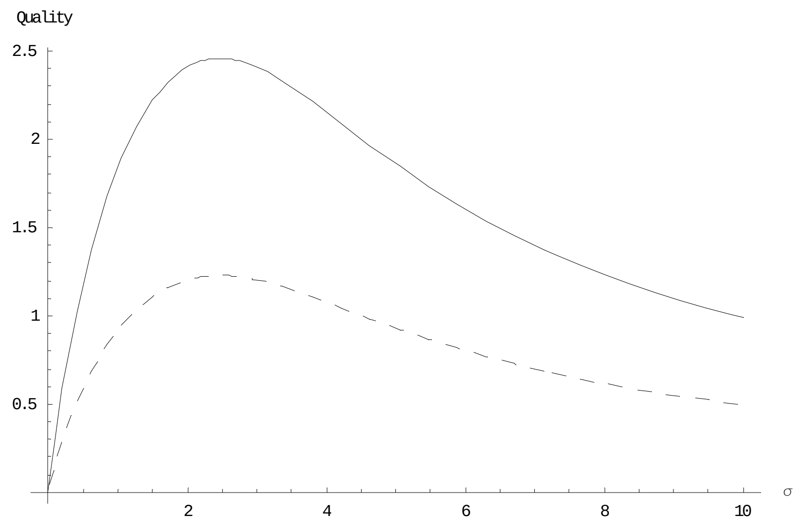

Figure 3: q_1^* = Solid Curve, q_2^* = Dashed Curve.

Equilibrium. However, because (especially when consumers' have very precise information about quality) the providers' objective functions are not necessarily concave, points satisfying the first-order conditions are not necessarily equilibria. Taking $p - c = 1$, $N = 100$, $k_1 = 1$, and $k_2 = 2$, Figure 3 depicts q_1^* and q_2^* as functions of σ. Note that, because q_2^* is proportional to q_1^*, both curves peak at the same quality level.

The fact that both providers reduce quality as noise becomes sufficiently small is curious. However, it turns out that in this model equilibrium existence breaks down just to the left of the peak quality levels. For the case depicted in Figure 3, equilibrium ceases to exist $\sigma \leq 2.45$. Thus, for most of the range over which the σ-quality curves are increasing there is no pure strategy equilibrium of the game.

To get a sense of why the equilibrium breaks down, consider a model where there is a very low degree of noise, and suppose that, as in the diagram, Provider 1 chooses low quality and Provider 2 chooses slightly less quality. In this case, Provider 2 can increase its quality to slightly above q_1^*, gain the entire market and a significant jump in profits at only slightly greater cost. It is this steep jump in profit that causes Provider 2's profit to be non-concave in quality, preventing an interior pure strategy equilibrium of the simultaneous quality game from existing when noise is sufficiently small. In effect, Provider 2's profit function becomes double-peaked, with local maxima at qualities above and below that of q_1. Figure 4 depicts Provider 2's profit when $\sigma = 2.2$ and $q_1 = 4.9$. Proposition 3 tells us that if there is an equilibrium, it has $q_2 = 2.45$. However, this level of q_2 corresponds to a local minimum for Provider 2. The best response for Provider 2 is to choose almost the same quality as Provider 1, splitting the market. However, this cannot be an equilibrium since any equilibrium must have $q_2 = q_1/2$. Hence, equilibrium existence breaks down. We can also rule out possible pure strategy equilibria where one or both provider choose zero quality. Consider the case in which the high-cost provider chooses $q_2 = 0$. When μ is small, in order to make this a best response for provider 2, q_1 must be high enough that Provider 2 is indifferent between choosing $q_2 = 0$ and choosing a quality slightly higher than q_1 and stealing the entire market. Hence, in order to keep provider 2 out of the market, provider 1 must choose $q_1 > 0$. However, it cannot be a best response for provider 1 to do so since, when provider 2 chooses $q_2 = 0$ and noise is sufficiently small, provider 1 can reduce quality, which reduces cost, without losing a

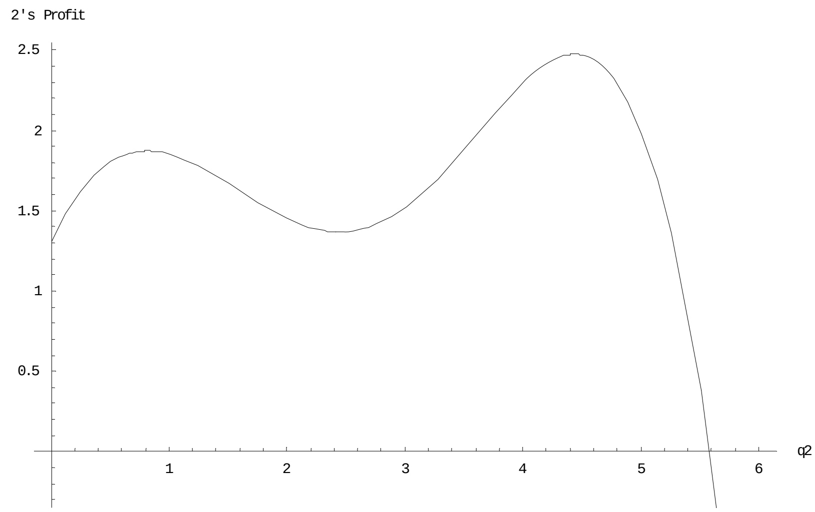

Figure 4: For σ small enough, Player 2's profit is dual-peaked.

significant market share.[26]

Corollary 4 *When $k_1 \neq k_2$, for σ sufficiently small there is no pure strategy equilibrium of the simultaneous quality-setting game.*

Proof. *Any interior pure strategy equilibrium must satisfy $q_1^* = \frac{k_2}{k_1} q_2^*$ and*

$$q_1^* = \frac{k_2 \sigma}{|k_1 - k_2|} \sqrt{W\left(\frac{1250\,(k_1 - k_2)^2}{k_1^2 k_2^2 \pi \sigma^4}\right)},$$

where $W()$ denotes the Lambert W function, i.e., the inverse function of $f(W) = We^W$.[27] As $\sigma \to 0$, $q_1^* \to 0$, and therefore (as in Figure 3) $q_2^* \to 0$. However, as $\sigma \to 0$, Provider 2 can gain nearly the whole market by choosing quality $q_1^* + 3\sigma$. The revenue gained from such a deviation is approximately $N(p - c)$, and the cost of doing so is $(q_1^* + 3\sigma)^2 - \left(\frac{k_1}{k_2} q_1^*\right)^2$, which approaches 0 as $\sigma \to 0$. Hence there can be no pure strategy equilibrium in which both providers choose a positive quality level. The possibility that there is a pure strategy equilibrium with $q_i > 0$ and $q_j = 0$ is ruled out by the fact that, for σ sufficiently small, provider i can reduce cost by decreasing quality without losing sufficient market share. The possibility that $q_1 = q_2 = 0$ is an equilibrium is ruled out by the fact that $c_i'(0) = 0$, and so either provider can earn a first-order gain in revenue at no first-order cost by increasing quality slightly above zero. ■

The behavior of the equilibrium is slightly different when the players have the same cost of quality, although non-existence of pure strategy equilibrium when the level of noise is sufficiently small remains a problem.

[26] In effect, when μ becomes sufficiently small, the payoff functions of the players become nearly discontinuous, and games with discontinuous payoffs frequently suffer from non-existence of pure strategy equilibria.

[27] see http://mathworld.wolfram.com/LambertW-Function.html.

Proposition 5 *If ε is distributed normally, then if there is a pure strategy equilibrium in the duopoly game when $k_1 = k_2$, it must satisfy:*

$$q_1^* = q_2^* = \frac{N(p-c)}{2k_1\sigma\sqrt{2\pi}}.$$

Hence, $\frac{\partial q^*}{\partial \sigma} < 0$ if an equilibrium exists.

Proof. Firm i's first-order condition is given by:

$$N(p-c)\,p\frac{e^{\left(-\frac{\left(q_i^*-q_j^*\right)^2}{2\sigma}\right)}}{\sigma\sqrt{2\pi}} = 2k_i q_i^*.$$

Notice that the left-hand side is the same for firm 1 and firm 2, which implies that the equilibrium (if it exists) must be symmetric with $q_1^* = q_2^*$. Letting $q_i = q_j$, the first-order condition simplifies to:

$$q_i^* = \frac{N(p-c)}{2k_i\sigma\sqrt{2\pi}}.$$

■

Notice that, unlike in the case of asymmetric providers, when providers have the same cost functions decreasing noise always increases equilibrium quality (the σ-quality curve is hyperbolic), provided a pure strategy equilibrium of the game exists. However, once again, when consumers' information is sufficiently precise, there may not be a pure strategy equilibrium of the game. In any symmetric pure strategy equilibrium, each provider wins half the market. When consumers' information is very precise, however, a slight increase in quality can result in winning the whole market – doubling revenues at almost no cost. This leads to the following:

Corollary 6 *When firms are symmetric, for σ sufficiently small, there is no pure strategy equilibrium of the simultaneous quality-setting game.*

Proof. *Note that $q_i^* = \frac{N(p-c)}{2k_i\sigma\sqrt{2\pi}}$ in any pure strategy equilibrium. Hence $\lim_{\sigma\to 0} q_i^* = \infty$. The firm's net revenue is bounded above by $N(p-c)$. Since cost is convex in quality, profit becomes negative for σ sufficiently small (since $q_i^* \to \infty$). Note that the firm always earns non-negative profit by choosing $q_i = 0$. Hence for σ sufficiently small $q_i^* = \frac{N(p-c)}{2k_i\sigma\sqrt{2\pi}}$ is dominated by $q_i = 0$, and hence cannot be a best response for provider i. Since any interior pure strategy equilibrium must have $\frac{N(p-c)}{2k_i\sigma\sqrt{2\pi}}$, there cannot be an interior pure strategy equilibrium. Equilibria in which one or both firms choose $q_i = 0$ are ruled out by the same argument as in Corollary 4.* ■

A mixed strategy equilibrium of these games may exist for σ sufficiently small. This is the subject of ongoing research.

As a final note, we can consider the question of whether the providers choose the socially efficient level of quality. First, it should be noted that the technology exhibits an increasing marginal cost of quality but constant returns in quantity. Since all consumers served by a provider benefit equally from a given investment in quality, quality is a public good. Hence the social optimum is to have a single provider giving positive quality to all consumers, with the other provider choosing quality zero and serving no one. Neither the symmetric nor asymmetric games above feature this. In the symmetric game, quality is increasing as noise decreases, which implies that there are combinations of price-cost margin and σ that result in the providers choosing the efficient quality, provided that the equilibrium exists at the efficient quality level.

The efficient quality level has only the lower-cost provider choosing positive quality (or either provider if they are symmetric) and choosing the level of quality where $N = c'(q^*)$. In the case where both producers have cost $c(q) = q^2$ and $N = 100$, this implies the efficient quality level solves $100 = 2q^*$, or $q^* = 50$. In order for competition to yield this level of quality, it must be that the marginal revenue from quality is 1 at $q^* = 50$, given the other provider's quality choice. In discreet choice models such as the ones we have been studying, Provider i's marginal revenue curve is steeply sloped in an area around q_j, and flat otherwise, and this is especially true as consumers' perceptions of quality become very accurate. Thus, for Provider i to be willing to supply the efficient quality level when σ is small, it must be that Provider j is also supplying quality near the efficient quality level (otherwise, Provider i's marginal revenue curve would be flat near the efficient quality level). However, as argued above it cannot be fully efficient for both providers to choose positive quality. Because the cost of quality is an ex ante investment, the fact that Provider j chooses a positive quality yields a loss in efficiency even if, ultimately, no consumers choose Provider j.

Because the Pareto Optimal allocation here involves a single provider giving positive quality, it may be that efficiency is achievable once we consider entry and exit. This is the subject of ongoing work.

Sequential Quality Choice The non-existence of pure strategy equilibria in game such as this is of concern to policy-makers, since it implies that it may be fundamentally difficult to predict the effect of reducing noise on the market outcome. It is quite possible that a mixed strategy equilibrium exists, although such equilibria seem unlikely to be helpful in understanding quality choice in health care markets. In light of this, in order to ensure equilibrium and illustrate more about the nature of quality competition, we next turn to a sequential move game. We adopt the natural assumption that the low-cost provider moves first.

The equilibrium concept for the sequential-move game is subgame perfect Nash equilibrium. That is, for each choice of q_1, provider 2 chooses $q_2(q_1) \in \arg\max N(p-c)F(q_2 - q_1) - k_2 q_2^2$. Provider 1 then chooses q_1^* such that $q_1^* \in \arg\max N(p-c)(1 - F(q_2(q_1) - q_1)) - k_1 q_1^2$.

The equilibrium is difficult to characterize analytically, but straightforward to compute numerically. Figure 5 depicts the equilibrium quantities for Providers 1 and 2 as functions of the standard deviation of consumers' signals about the providers' qualities when $k_1 = 1$, $k_2 = 3/2$, $N = 100$, and $p - c = 1$.

Inspection of Figure 5 reveals that the equilibrium of the sequential-move quality-setting game depends on the degree of precision of consumers' information in a non-trivial way. In particular, it need not be the case that reducing σ increases quality. In fact, there are ranges of σ over which both providers' reduce quality as σ decreases.

When σ is large, the game is characterized by a high degree of noise. In such cases, consumers' perceptions of the providers' qualities are dominated by the noise term, and hence providers have relatively little to gain by increasing quality. In such cases, both the leader and the follower choose relatively low qualities. As σ decreases, better information makes it possible for one provider to distinguish itself and win a large share of the market through a relatively small quality increases. This accounts for the increase in equilibrium quality levels as σ decreases. As the amount of noise decreases even further, small quality advantages translate to market dominance. In this environment, the leader can drive its competitor out of the quality market by choosing a relatively large quality. The follower, faced with the need to produce a large quality to gain a small market share (and a higher cost of doing so than the leader), chooses instead to avoid the cost of investing in quality altogether. Although this results in a small share of the market, the cost savings makes

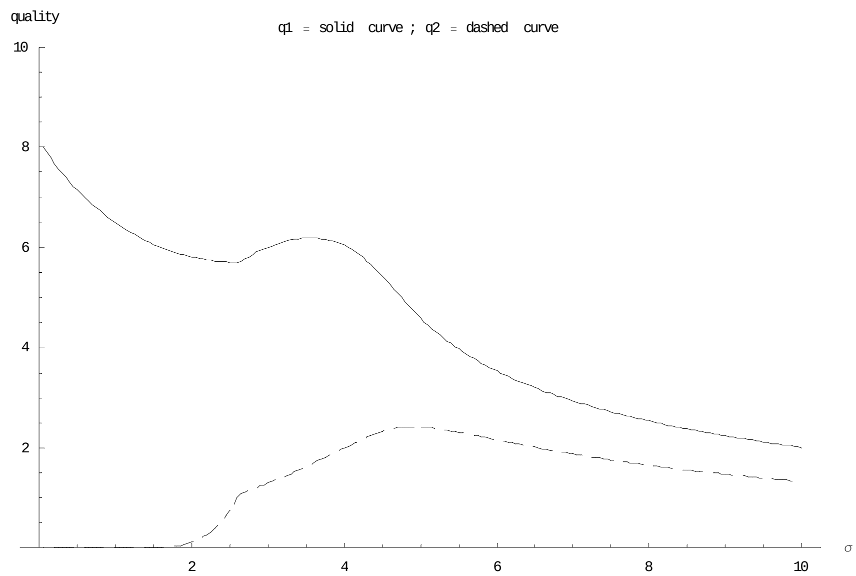

Figure 5: Quality as a function of σ.

up for this.

This aspect of competition corresponds to the portion of the graph where both providers' qualities decrease as σ decreases. Eventually, noise is reduced to such a degree that the leader can completely preempt the follower. By choosing a very large quality, the follower would have to spend so much on quality to gain enough market share to justify the investment that it is better off by providing $q_2 = 0$.

The general shape of the curves in Figure 5 is robust to a wide range of parameter values. Further, similar curves arise in the case where the providers have equal costs, suggesting that the behavior of the equilibrium follows more from the sequential nature of the game than from the fact that the leader is also the low-cost provider.

Figure 5 establishes that the effects of decreasing σ on quality are not obvious. While they establish that some consumers are likely harmed by reducing noise, we might also be concerned with the average level of quality. Since the gap between the leader's quality and the follower's quality grows as noise decreases, we might expect that the leader's market share grows as well. Figure 6 illustrates that this is, in fact the case.

The fact that essentially all of the customers are choosing the high-quality provider as $\sigma \to 0$ lessens the potential harm resulting from provider 2's low quality. Figure 7 illustrates the average quality consumers receive as a function of σ. Because Provider 1's market share approaches 1 as σ decreases to zero, this decreases the impact of the follower's low quality on average quality and welfare. Thus, while quality does decrease as σ decreases over a range (e.g., σ between 2.5 and 4), average quality more-or-less increases as noise decreases. Figure 8 depicts average welfare for the same situation. As in the case of average quality, there is a range of σ over which welfare σ and welfare are positively related. Finally, note that the no-noise limit of the quantity average quantity is less than the first-best (50) and the no-noise limit of welfare is less than its first-best level (2500).

While Figures 7 and 8 are encouraging, they are also a bit deceiving. This is because they depict average quality and welfare only for those consumers who are able to select the provider that offers the greatest perceived quality. These quality-elastic consumers benefit from better information.

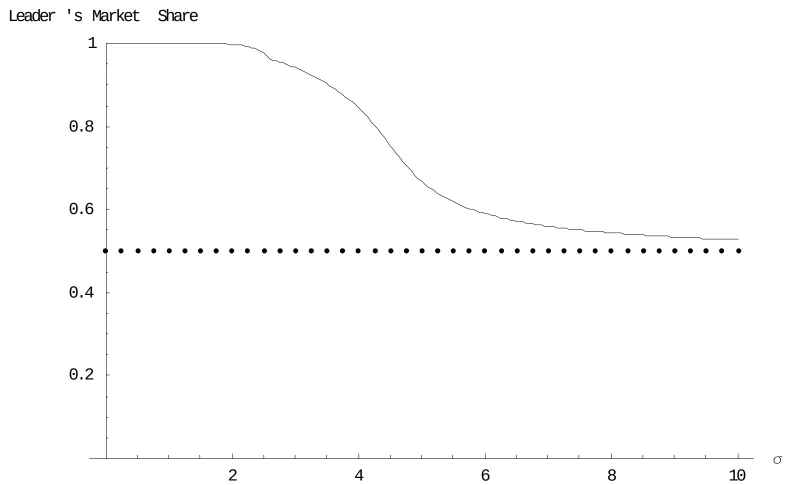

Figure 6: Leader's market share as a function of σ.

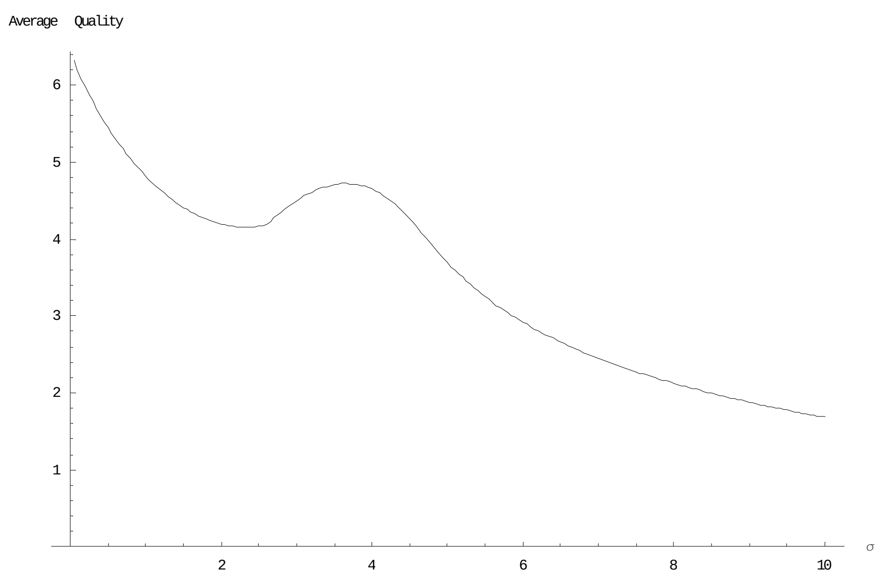

Figure 7: Average quality as a function of σ.

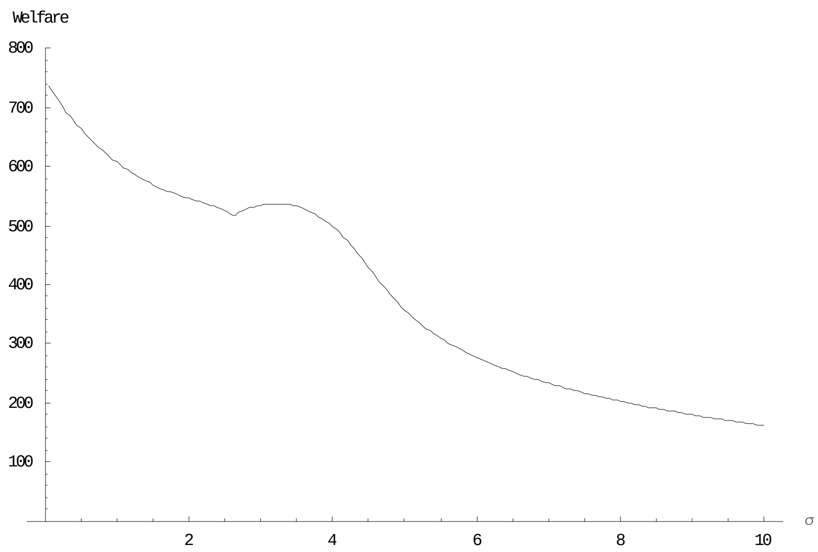

Figure 8: Welfare as a function of σ (100 patients).

However, not all consumers are able to respond to perceived quality differences. The poor, sick, and elderly may lack the ability to make use of the more accurate quality information or to travel to the provider offering the highest perceived quality even if they value quality just as much as their more mobile counterparts. We call such quality-inelastic demand "baseline demand." Many of these patients will be "stuck" patronizing the follower provider and receive lower quality as σ decreases as a result. The redistributive impact on baseline demand is especially important if we believe that the type of providers these people are likely to patronize are more likely to fit into the follower position than the leader position. This would be the case, for example, if we believe that public providers are more likely to have higher costs of increasing quality and be slower to innovate than private or non-profit providers. Figure 9 depicts average quality as a function of σ under the assumption that there is 1 unit of quality-elastic demand (1 unit = 100 consumers) and 1 unit of baseline demand at Provider 1. The three curves represent average quality for the cases where provider 2's baseline demand, b_2, is 1 unit, 2 units, and 4 units. There are two features of note. First, the fact that there is more quality inelastic demand at the low-quality provider shifts the average quality curve down, and shifts it down further as Provider 2's baseline demand grows. Second, as the low-quality provider's baseline demand grows and thus Provider 2's quality is weighted more heavily in determining average quality, the range over which reducing noise decreases average quality grows. Figure 10 depicts average welfare (per 100 consumers), which follows the same general pattern as average quality.

Logistic Noise: The Logit Choice Model The results of this section are somewhat surprising and cut against the prevailing wisdom that giving consumers more precise information about quality necessarily leads providers to increase quality. In light of this, it is natural to consider whether the results are due to the particular functional forms or parameter values chosen in the model. The non-existence results in Corollaries 4 and 6 are analytic, and so hold for any values of the parameters (as long as cost is quadratic and the noise is normally distributed). The general shape of the graphs are robust to changes in the cost of the firms, prices, and number of consumers.

In this subsection we briefly explore an alternative representation of uncertainty using the

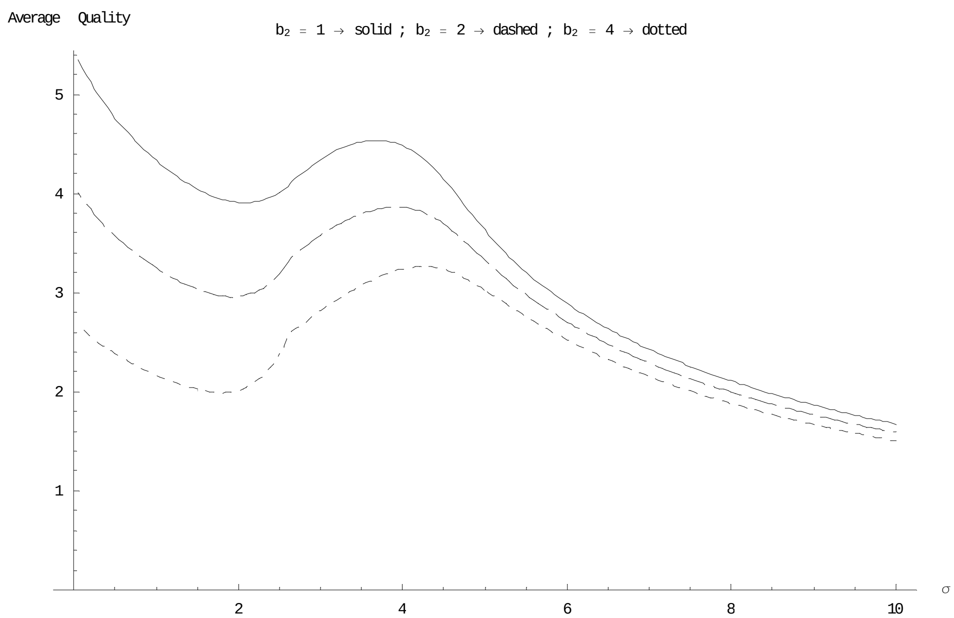

Figure 9: Average quality as a function of σ as baseline demand varies.

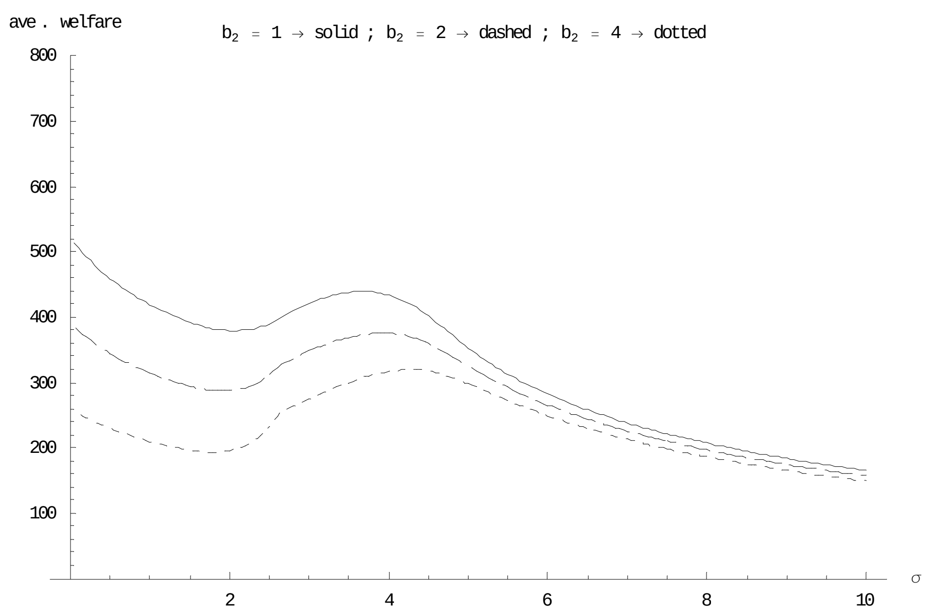

Figure 10: Average welfare as a function of σ as baseline demand varies.

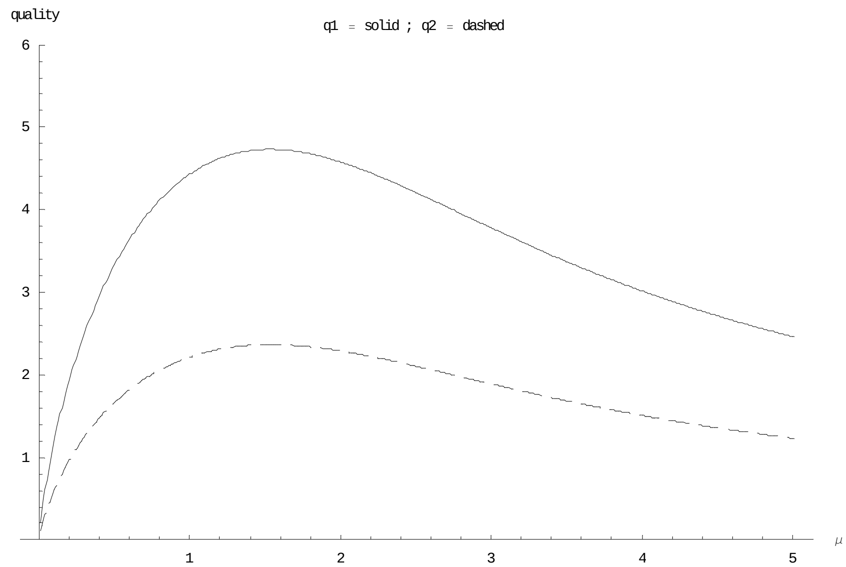

Figure 11: Logit choice model: quality as a function of μ.

logistic distribution and the logit choice model. Because of its tractability, the logit choice model is very popular in both theoretical and applied settings. Using the same general setup as in the simultaneous choice model above, if ε_1 and ε_2 are independently distributed according to double exponential distributions with the same scale parameter, then $\varepsilon = \varepsilon_2 - \varepsilon_1$ is distributed according to the logistic distribution. In turn, this implies that if providers 1 and 2 choose qualities q_1 and q_2, then the mass of consumers who perceive provider i as having the higher quality (and therefore choose provider i) is given by

$$P_i = \frac{\exp(q_i/\mu)}{\exp(q_1/\mu) + \exp(q_2/\mu)},$$

where μ is the scale parameter. The variance of the noise in consumers' assessments of quality is $\pi^2\mu^2/3$, and hence a decrease in μ represents an increase in the precision of consumers' information.

Although the logit choice model is often useful in theoretical work because it allows for closed-form solutions, in the case of fixed-price competition with quality-dependent fixed costs, it is not possible to derive a closed-form characterization of the equilibrium. Nevertheless, it is possible to numerically compute equilibria for any specifications of the parameters and to perform numerical comparative statics as above. In order to illustrate that the conclusions of this section are not particular to the case of normal noise, we provide analogs to Figures 3 and 5. Figure 11 illustrates that if a pure strategy exists, quality must approach zero as consumers' precision increases, in which case the same issues related to the non-existence of pure strategy equilibrium will arise as noise approaches zero. Figure 12 illustrate that the same sort of foreclosure effects arise in the sequential game under logistic noise as arose in the sequential game under normal noise.

3.3 Competition with Quality-Dependent Marginal Costs

In this section we consider quality competition where increasing quality affects providers' marginal costs. This would be the correct model in situations where increasing quality involves providing additional tests or services, such as cancer screening or physical therapy. We return to the simul-

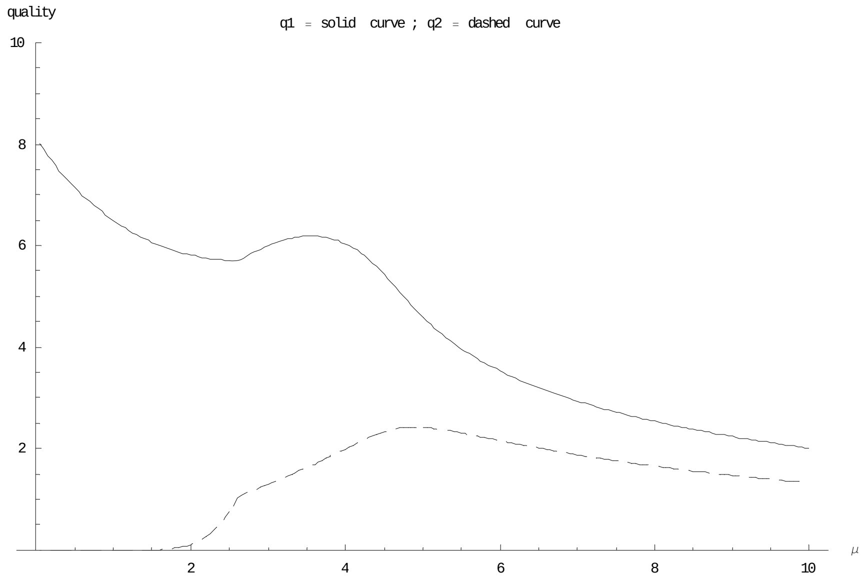

Figure 12: Logit choice model: quality as a function of μ.

taneous quality-choice model in which two providers simultaneously choose quality.[28] Profit for firms 1 and 2 are given by:

$$y_i = (p_i - c_i(q_i)) X_i(u_1, u_2),$$

where $c_i(q_i)$ now represents the provider's quality-dependent marginal cost and X_i represents demand for provider i as a function of the u_1 and u_2, the utility each of the providers offers to the consumers. Thus, we eliminate the investment-cost component of cost and instead consider the case where provider i's marginal cost is given by $c_i(q_i)$, a strictly increasing, strictly convex function. In order to facilitate the analysis, we will work primarily with the logit demand model. In this case, $X_i(u_1, u_2) = N\frac{\exp\left(\frac{u_i}{\mu}\right)}{\exp\left(\frac{u_1}{\mu}\right)+\exp\left(\frac{u_2}{\mu}\right)}$, where N once again represents the total number of consumers.

3.3.1 A Model with Pricing

For the most part, we will consider quality competition in the case where consumers' out-of-pocket prices do not depend on quality. However, for the sake of comparison it is instructive to consider a model in which direct-to-consumer pricing does play a role. In this case, we let each provider choose a price-quality pair, (p_i, q_i). A consumer's perceived value for Provider i is given by $u_i = q_i - p_i + \varepsilon_i$. In this case, if ε_i are distributed independently and double-exponentially, then this is a logit choice model, and the choice probabilities are given by

$$P_i = \frac{\exp\left(\frac{q_i - p_i}{\mu}\right)}{\exp\left(\frac{q_1 - p_1}{\mu}\right) + \exp\left(\frac{q_2 - p_1}{\mu}\right)}.$$

As is typical in the literature, we will consider the case where providers first choose qualities

[28] Equilibrium existence turns out to be less of concern in the case of quality-dependent marginal costs because payoffs are always concave in own-quality.

and then choose prices. In such a model, a standard result is that equilibrium prices are given by:

$$p_i^* = c_i(q_i^*) + \frac{\mu}{1 - P_i^*}.$$

Making use of this fact, Anderson, de Palma, and Thisse (1992) prove the following result.

Proposition 7 *(Anderson, de Palma, and Thisse, 1992, Proposition 7.2): The two-stage quality-price game has a unique subgame perfect equilibrium where, in equilibrium, $c_i'(q_i^*) = 1$ and $p_i^* = c_i(q^*) + 2\mu$.*

This proposition is of interest for several reasons. First, note that the equilibrium quality levels are independent of μ. Thus, the providers' optimal quality choices are independent of the degree of noise in consumers' perceptions of quality. Second, since consumers' utility functions are $u_i = q_i - p_i + \varepsilon_i$, $\partial u_i / \partial p_i = 1$, and hence the equilibrium involves all providers (which may have different cost functions) setting the marginal cost of quality equal to its marginal utility. In the case of symmetric providers, this implies that the providers' quality choices are efficient. When providers are asymmetric, while each provider sets the marginal cost of quality equal to its marginal utility, the efficient allocation would have all consumers choosing the higher-quality provider, which occurs only in the limit as μ approaches zero. Thus, in the asymmetric case the quality choices are efficient but the assignment of patients to providers is not. Finally, while equilibrium qualities are independent of μ, the equilibrium prices are not. In the standard interpretation of the logit model, high values of μ are associated with situations where the idiosyncratic component of consumers' tastes is strong, and thus the fact that p_i^* increases with μ captures the intuition that with strong idiosyncratic tastes the providers are highly differentiated, and thus each individual provider possesses more local monopoly power. In our interpretation of the logit, higher μ corresponds to greater imprecision in consumers' perceptions of value. Thus, the positive relationship between prices and μ captures the intuition that when μ is high there are strong chances that consumers will perceive Provider i's value as high even when it is really low, or that they will perceive Provider j's value as low even when it is high. Both of these forces mitigate the extent to which Provider i suffers when it increases its price, leading to higher prices in equilibrium.

Applying these insights to quality competition and the use of RCPs in health care suggests that, to the extent that quality is "too low" in health care, this is not due only to noise in consumers' information about quality. In this model, providers choose the optimal quality regardless of the noise level.[29] How precisely consumers perceive quality does affect providers' strategies, but it affects them on the price margin. The lower the noise, the lower are prices. This suggest that in a market in which providers are free to price, RCPs would affect prices but not quality. Of course, two of the hallmarks of health care markets are the prevalence of insurance and administrative pricing. Nevertheless, the model suggests that since poor information about quality is not the sole source of the problem, it may not be the sole solution. The best road to quality improvement may involve informational approaches such as RCPs as well as strengthening the connection between providers offering high quality and earning greater rewards through higher prices.[30]

[29] This feature is due to the fact that, even though consumers do not perceive quality directly, their signal about quality is unbiased. However, there are other ways beside white noise in which imperfect information about quality can manifest itself. See Section 4 for one such alternative model.

[30] In ongoing work, I consider a model where providers price to health plans but not consumers.

3.3.2 Quality Competition without Pricing

Next we turn to the case where providers are unable to affect consumers' out-of-pocket prices. The closed-form solution to the equilibrium problem in the model with pricing is made possible by the fact that providers' optimal second-stage prices significantly simplify the expressions for the providers' profits. In the absence of pricing, closed form solutions for the equilibrium are no longer possible. Nevertheless, we can make some headway in characterizing the equilibrium, especially for extremely large and extremely small values of μ.

Assuming consumers' out-of-pocket expenditures are independent of the provider chosen and therefore do not affect the likelihood of a consumer choosing one or the other provider, provider i's payoff function is:

$$y_i = N\left(p - c_i\left(q_i\right)\right)\frac{\exp\left(\frac{q_i}{\mu}\right)}{\exp\left(\frac{q_1}{\mu}\right)+\exp\left(\frac{q_2}{\mu}\right)}.$$

Differentiating with respect to q_i and simplifying, the first-order conditions for a Nash Equilibrium in quality are:[31]

$$\begin{aligned}\frac{\mu c_1^{'}\left(q_1\right)}{\left(p-c_1\left(q_1\right)\right)} &= \frac{\exp\left(\frac{q_2}{\mu}\right)}{\exp\left(\frac{q_1}{\mu}\right)+\exp\left(\frac{q_2}{\mu}\right)}, \text{ and}\\ \frac{\mu c_2^{'}\left(q_2\right)}{\left(p-c_2\left(q_2\right)\right)} &= \frac{\exp\left(\frac{q_1}{\mu}\right)}{\exp\left(\frac{q_1}{\mu}\right)+\exp\left(\frac{q_2}{\mu}\right)}.\end{aligned}$$

Notice that the left-hand side of each expression is the other provider's market share. Hence we have

$$\frac{\mu c_1^{'}\left(q_1\right)}{\left(p-c_1\left(q_1\right)\right)}+\frac{\mu c_2^{'}\left(q_2\right)}{\left(p-c_2\left(q_2\right)\right)}=1.$$

It follows immediately that at least one of $\left(p-c_1\left(q_1\right)\right)$ and $\left(p-c_2\left(q_2\right)\right)$ must approach zero as $\mu \to 0$.[32]

Let $q_1^*\left(\mu\right)$ and $q_2^*\left(\mu\right)$ denote the equilibrium quantities viewed as functions of the scale parameter.

Proposition 8 *Suppose that $c_1\left(q\right) < c_2\left(q\right)$ and $c_1^{'}\left(q\right) \leq c_2^{'}\left(q\right)$ for all $q \geq 0$. In any pure strategy equilibrium with $\mu > 0$, $q_1^*\left(\mu\right) > q_2^*\left(\mu\right)$. As $\mu \to 0$ the equilibrium qualities of the providers converge to q^* satisfying $p = c_2\left(q^*\right)$.*

Proof. To show that $q_1\left(\mu\right) > q_2\left(\mu\right)$ for $\mu > 0$, first rule out that $q_2\left(\mu\right) > q_1\left(\mu\right)$. If this is the case, then provider 2's market share is greater than provider 1's, hence it must be that $\frac{\mu c_1^{'}(q_1)}{(p-c_1(q_1))} = \frac{\exp\left(\frac{q_2}{\mu}\right)}{\exp\left(\frac{q_1}{\mu}\right)+\exp\left(\frac{q_2}{\mu}\right)} > \frac{\exp\left(\frac{q_1}{\mu}\right)}{\exp\left(\frac{q_1}{\mu}\right)+\exp\left(\frac{q_2}{\mu}\right)} = \frac{\mu c_2^{'}(q_2)}{(p-c_2(q_2))}$. However, this can only be the case if $q_1 > q_2$, a contradiction. To rule out the case where the providers choose equal qualities note that if $q_1 = q_2$ and $\frac{\mu c_2^{'}(q_2)}{(p-c_2(q_2))} = \frac{1}{2}$, $\frac{\mu c_1^{'}(q_1)}{(p-c_1(q_1))} > \frac{1}{2}$, violating the the optimality conditions.

[31] For convex marginal cost $c_i\left(q_i\right)$, y_i is strictly concave, and hence the first-order conditions are sufficient for a Nash Equilibrium.

[32] We leave aside issues of existence of equilibrium and existence of a limit point for now. In numeric computations, equilibria of this game have existed and been unique.

By the above, either $p - c_1(q_1^*(\mu))$ or $p - c_2(q_2^*(\mu))$ must converge to zero. If $p - c_1(q_1^*(\mu))$ converges to zero, then Provider 2's market share must converge to 1, which implies that $q_2^*(\mu) > q_1^*(\mu)$ for μ sufficiently small and positive, a contradiction. Hence $p - c_2(q_2^*(\mu))$ must converge to zero. ■

The intuition underlying quality competition when μ approaches zero is similar to that underlying Bertrand competition with symmetric firms. In the Bertrand model, equilibrium prices are where the high-cost firm earns zero profit, and the low-cost firm earns a rent. The quality-setting game with perfect perception of quality has the same flavor. Competition drives quality to the point where the high-cost firm earns zero profit. The low-cost firm steals the entire market by offering just slightly higher quality.

Corollary 9 *For symmetric firms, $c_1(q) = c_2(q)$ for all q, the equilibrium qualities converge to q^* satisfying $p = c_1(q^*)$ as $\mu \to 0$. For any μ, $q_1^*(\mu) = q_2^*(\mu)$.*

On the other hand, when noise becomes extremely important, neither firm has an incentive to provide any quality.

Proposition 10 *As $\mu \to \infty$, equilibrium qualities $q_1^*(\mu)$ and $q_2^*(\mu)$ approach zero.*

Proof. *As $\mu \to \infty$, $\frac{\exp\left(\frac{q_i}{\mu}\right)}{\exp\left(\frac{q_1}{\mu}\right)+\exp\left(\frac{q_2}{\mu}\right)} \to \frac{1}{2}$ and $D_{q_i}\left(\frac{\exp\left(\frac{q_i}{\mu}\right)}{\exp\left(\frac{q_1}{\mu}\right)+\exp\left(\frac{q_2}{\mu}\right)}\right) \to 0$, implying that the marginal revenue of increasing quality converges to zero. Since quality is costly, this implies that in the limit providers offer $q_i^* = 0$.* ■

The preceding propositions characterize the limiting behavior of the equilibrium, but not its path, i.e., whether quality is uniformly increasing as μ decreases. The upper (solid) curve in Figure 13 illustrates the relationship between equilibrium qualities when $p = 1$, $c_1(q_1) = q_1^2$, and $c_2(q_2) = q_2^2$. Since costs are symmetric, both providers choose the same quality in equilibrium. We choose $p = 1$ to emulate competitive pricing. Since consumers assign marginal utility 1 to a unit of quality, the socially optimal quality is where the marginal cost of quality is equal to 1, $2q = 1$, or $q^* = \frac{1}{2}$. Setting price equal to the marginal cost of the efficient quality level yields $p = 1$. Notice that, as predicted, the limit quality as $\mu \to 0$ is 1, which satisfies $p - c_1(q) = 1 - (1)^2 = 0$. However, the efficient quality level is $q^* = \frac{1}{2}$. Hence while reducing the noise in consumers' information about quality increases quality, the μ at which quality is optimal is strictly greater than zero. Hence beyond a point decreasing μ actually induces the providers to increase quality beyond the socially efficient level. Hence:

Remark 11 *RCPs that reduce μ do not necessarily induce efficiency-improving quality changes. Decreasing μ may lead to excessive quality.*

By changing the price we can shift the μ-quality curve in order to have quality increase to the efficient quality in the limit. In particular, let $p = c\left(\frac{1}{2}\right)$, i.e., $p = \frac{1}{4}$. In this case, the μ-quality curve is depicted in the lower (dashed) curve in Figure 13. Since at $\mu = 0$ quality is equal to the efficient quality level, for a properly chosen price, reducing μ always increases quality and always improves efficiency. Welfare as a function of μ is depicted in Figure 14.

Remark 12 *Let q^* denote the efficient quality level. Let $p = c(q^*)$. In this case, reducing μ increases quality and increases efficiency.*

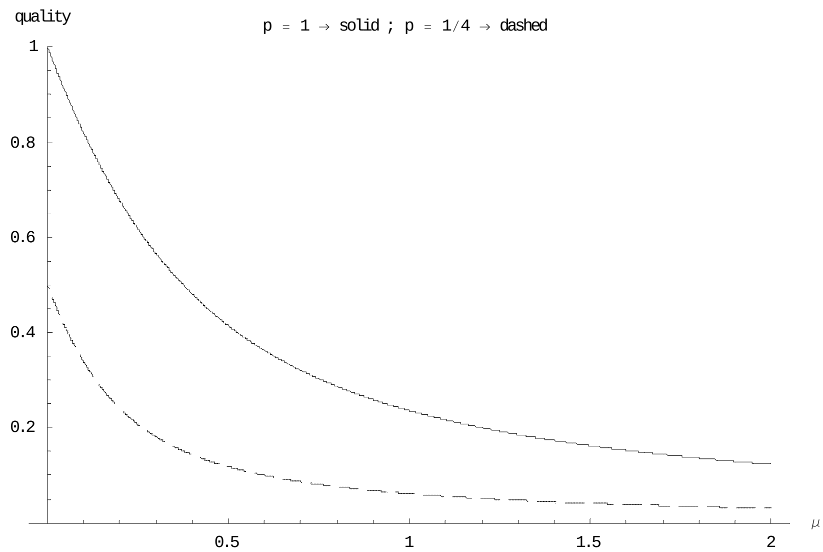

Figure 13: Quality as a function of μ at different prices.

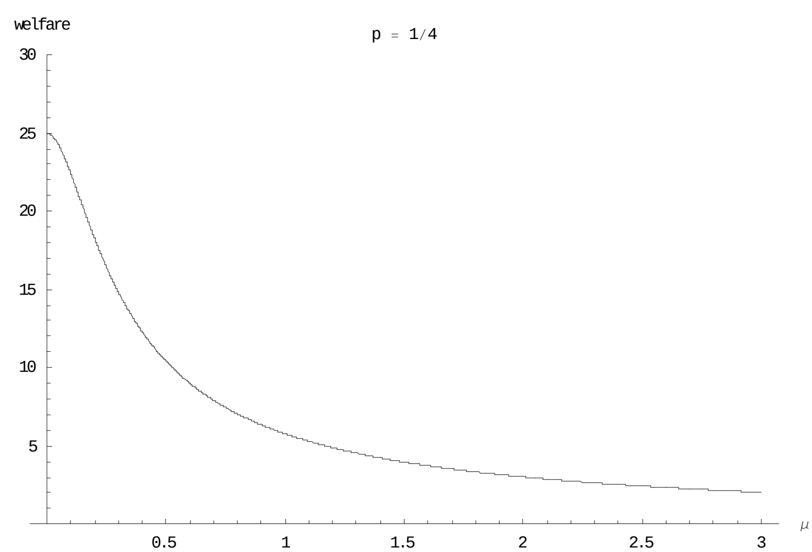

Figure 14: Welfare as a function of μ.

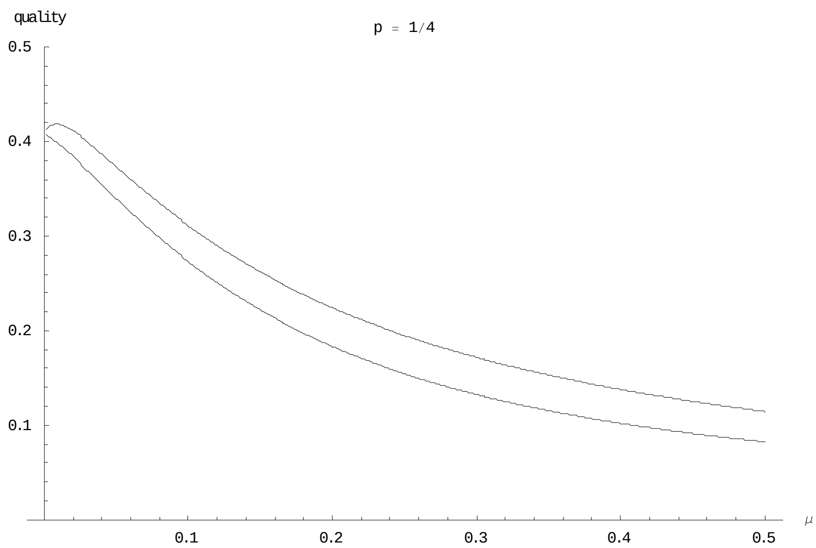

Figure 15: Quality as a function of μ.

Next, consider the relationship between μ and quality when the providers are not symmetric. Let $c_1(q_1) = q_1^2$ and $c_2(q_2) = \frac{3}{2}q_2^2$. In this model, the efficient quality levels are $q_1 = 1/2$ and $q_2 = 1/3$. The providers' costs at these levels are $c_1\left(\frac{1}{2}\right) = \frac{1}{4}$ and $c_2\left(\frac{1}{3}\right) = \frac{1}{6}$. Figure 15 illustrates the μ-quality curves for $p = 1/4$. The upper curve is $q_1(\mu)$, and the lower curve is $q_2(\mu)$. Notice that for sufficiently small μ, $q_1(\mu)$ decreases as μ decreases. Also, the limiting quality is where $\frac{1}{4} - \frac{3}{2}q^2 = 0$, or $q = \sqrt{1/6} = 0.41$. Thus, marginal cost pricing equal to the low-cost provider's marginal cost at the efficient output level does not induce efficient quality.

Figure 16 depicts the μ-quality curves for the two providers for three different prices. The middle set of curves (dashed) correspond to the μ-quality curves when $p = 1/4$ (as in Figure 15). The lower set of curves (dotted) correspond to $p = 1/6$, which is provider 2's marginal cost when it chooses its efficient quality, $q_2 = 1/3$. When $p = 1/6$ the limiting quality is $1/3$. Thus $p = 1/6$ induces Provider 2 to choose its efficient quality in the no-noise limit. Of course, since Provider 1 chooses a higher quality than Provider 2, in the no-noise limit Provider 1 serves the entire market. Thus, all consumers receive too little quality when $p = 1/6$.

Thus, neither $p = 1/4$ nor $p = 1/6$ induce an efficient outcome. However, we know that there should exist a price such that provider 1 chooses a quality near $1/2$ in the limit. This price is found by solving $p = 3/2\,(1/2)^2 = \frac{3}{8}$, the price where provider 2 just breaks even at quality $q = 1/2$. The upper set of curves (solid) depicts the equilibrium μ-quality curve in this case. Note that while provider 1 chooses the efficient quality in the limit (and its market share approaches 1), for a range of μ just above zero too much quality is provided. Further, as provider 2's efficient quality is $q = 1/3$, there is a wide range of values of μ for which provider 2 supplies excessive quality.

As Figures 15 and 16 illustrate, while reducing μ will often lead to an increase in quality, it need not always do so. More importantly, decreasing μ may lead to excessive quality on the part of the high-quality provider and insufficient quality on the part of the low-cost provider. Further, since the two providers' qualities converge in the limit, this suggests that these two problems cannot simultaneously be eliminated. Of course, in the no-noise limit, the low-cost provider has almost 100% of the market, and so there may be relatively little loss involved with choosing prices such

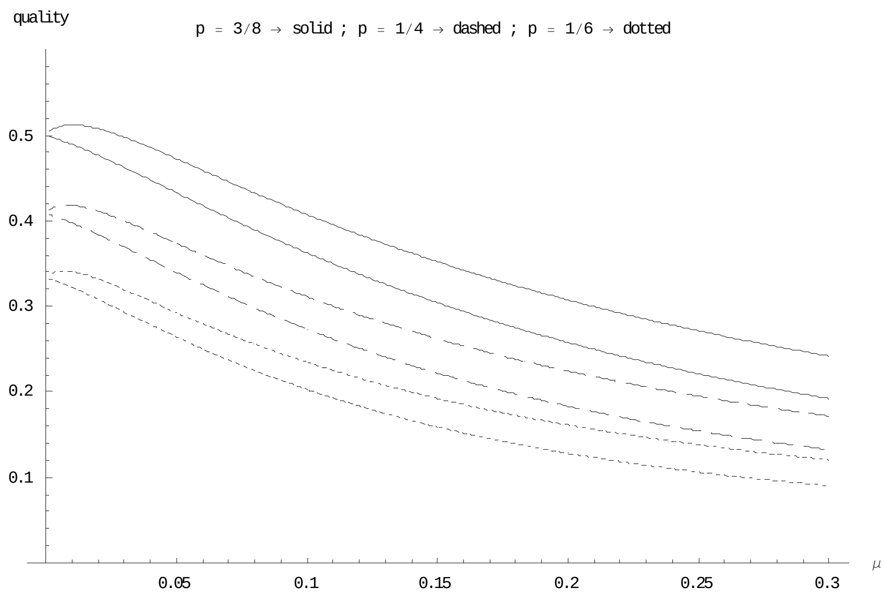

Figure 16: Quality as a function of μ for three different prices.

that the limit quality converges to the efficient quality of the low-cost provider.[33] Figure 17 depicts welfare as a function of μ when $p = 3/8$. Indeed, welfare uniformly increases as μ decreases. Of course, the price needed to induce the first-best quality in the no-noise limit is the price where the high-cost provider breaks even at the low-cost provider's efficient quality. At this price, the low-cost provider will earn a rent, possibly a significant one. If there is a cost to public funds, this suggests that the second-best quality will be less than the first-best.

3.3.3 Quality Competition with Baseline Demand

Finally, we consider the model of quality competition with quality-dependent marginal costs and add the possibility of baseline demand. Recall that baseline demand is quality-inelastic demand that chooses a provider regardless of its quality choice. Despite their lack of mobility, baseline consumers still value quality. Baseline demand effectively increases the provider's cost of quality, since quality improvements meant to attract quality-elastic demand must also be given to baseline demand. As expected, the inclusion of baseline demand further complicates the relationship between the precision of consumers' information about quality and providers' quality choices, and raises the possibility of some particularly perverse outcomes.

Let b_i denote provider i's baseline demand. In this case, provider i's payoff function is given by:

$$y_i = (p - c_i(q_i)) \left(K \frac{\exp(q_i/\mu)}{\exp(q_1/\mu) + \exp(q_2/\mu)} + b_i \right).$$

As above, we consider a simultaneous quality-choice game and numerically derive the providers' equilibrium qualities for various values of μ. Figure 18 depicts the equilibrium for the case where $p = 1/4$, $K = 100$, $c_1(q_1) = q_1^2$, $c_2(q_2) = q_2^2$, $b_1 = 0$, and $b_2 = 300$. That is, Provider 2 has a large baseline demand, whereas Provider 1 has no baseline demand. This situation corresponds to the

[33] Of course, if the high-cost provider also has quality inelastic demand, then these consumers will receive excessive quality.

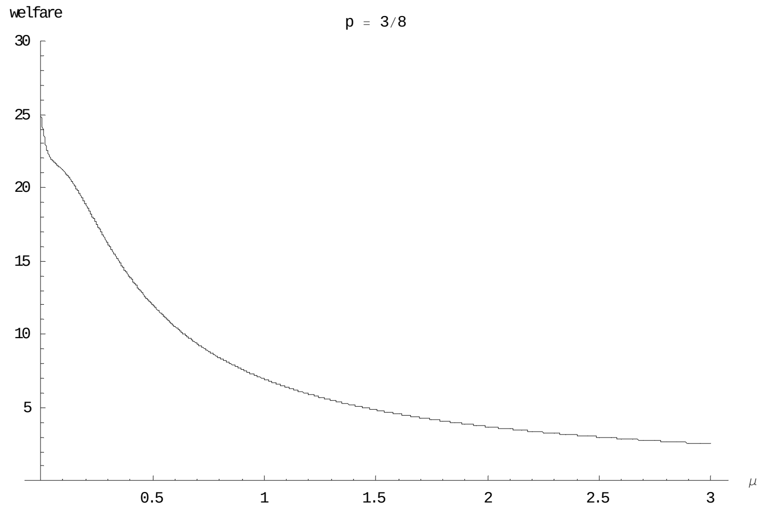

Figure 17: Welfare as a function of μ.

game depicted by the dashed line in Figure 13 with the addition of Provider 2's baseline demand.

Several features of Figure 18 merit mention. First, relative to the dashed line in Figure 13, the presence of baseline demand leads both providers to decrease quality. Provider 2 decreases quality because its baseline demand effectively increases its marginal cost of quality. Provider 1 reduces quality because it no longer needs to provide as much quality in order to distinguish itself from Provider 2. Second, instead of quality increasing uniformly as μ decreases to zero, in the game with baseline demand there is a point beyond which decreases in μ lead to decreases in quality. This is because, as μ decreases to zero, Provider 1's cost of dominating the market decreases, and so it is more likely to do so. Eventually, Provider 2 is gaining very little market share. Without baseline demand Provider 2 is still willing to provide quality even if it attracts very few patients since it pays the cost of quality only for those patients who choose it. With baseline demand, on the other hand, Provider 2 must pay for the quality given to the baseline demand even when very few quality-elastic consumers choose it. Of course, with a large baseline demand and little noise in consumers' perceptions there is a high cost of quality and almost no benefit from increasing quality, which is why Provider 2's quality falls to zero as μ decreases to zero. Figure 19 depicts welfare (per 100 people) for the case of $b_1 = 0$ and $b_2 = 300$.

Finally, it should be noted that the same sort of non-existence problem arise in this game with baseline demand as in the case of quality-dependent fixed costs. This should not be too surprising, since baseline demand operates in a manner similar to quality-dependent fixed costs.

4 An Alternative Approach[34]

Until now, we have considered models where consumers can perceive a continuous range of quality levels and implementing an RCP reduces the noisiness of their observations. Consumers' uncertainty about providers' qualities takes the form of white noise. While this allows us to perform comparative statics with respect to the amount of noise in order to learn about the relationship between the precision of consumers' information and providers' quality incentives, it is not always correct to think of consumers' uncertainty taking the form of white noise.

[34] This section can be skipped without loss of continuity.

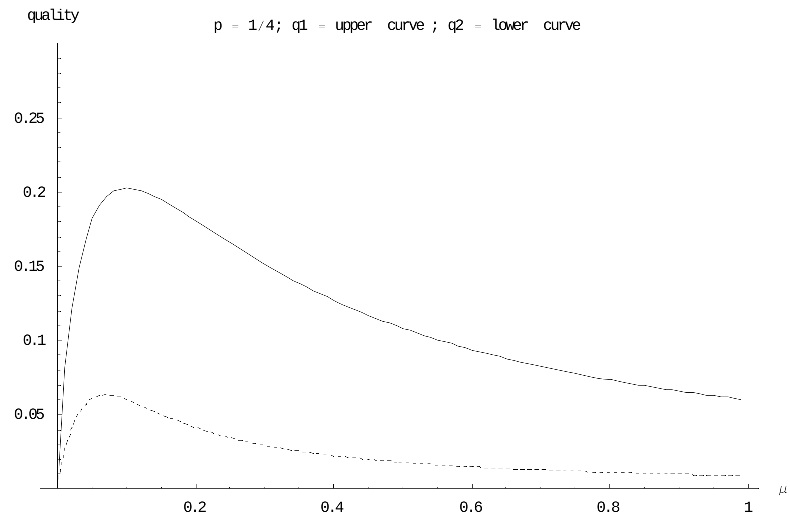

Figure 18: Quality as a function of μ with baseline demand.

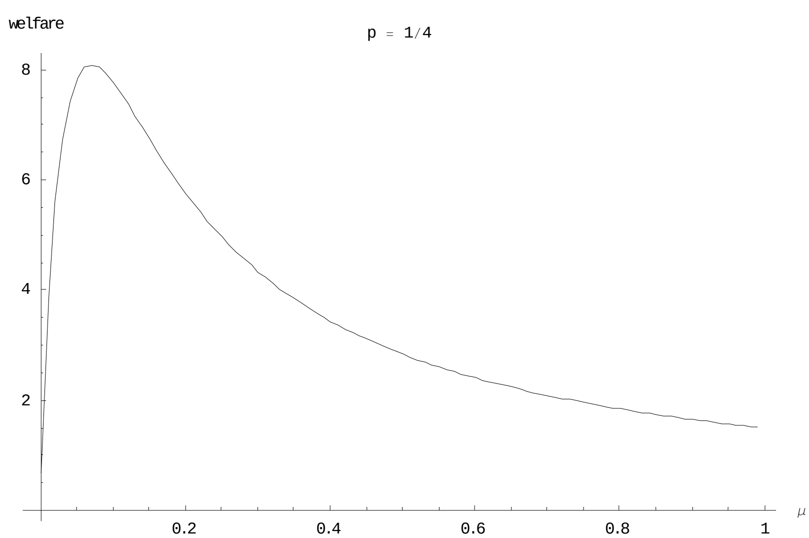

Figure 19: Welfare as a function of μ.

For example, consider a model with three quality levels, low, medium, and high, as might be the case under the new Massachusetts GIC tiered provider program described earlier. One reasonable way in which consumers' uncertainty about quality may manifest itself is that consumers can identify low-quality providers but cannot distinguish between medium- and high-quality providers. In such a model, the implementation of an RCP can be thought of as allowing consumers to distinguish between quality levels that, ex ante, were indistinguishable. Thus the RCP refines consumers' information partition.

In this section we investigate a number of examples that illustrate the nature of quality incentives in such models. As we will see, because of the variety of ex ante and ex post information partitions as well as the wide variety of possible cost structures, "anything can happen" following the implementation of an RCP in these models. While quality can uniformly increase, it is possible that quality increases for some providers and decreases for others, or even that quality uniformly decreases.

Consider a model in which three providers compete for consumers using quality. Denote the three providers by A, B, and C, and let i denote a generic provider. Each provider can choose one of three quality levels, which we denote 1, 2, and 3, with the understanding that higher numbers correspond to higher qualities. We will use the notation $q_i = j$ to denote the event that provider i chooses quality $j \in \{1, 2, 3\}$.

In order to study the behavior of consumers, we must first develop a way of representing the information available to them when they make their decisions. Consider the seven non-empty subsets of set $\{1, 2, 3\}$: $\{1\}$, $\{2\}$, $\{3\}$, $\{1, 2\}$, $\{1, 3\}$, $\{2, 3\}$, and $\{1, 2, 3\}$. We will adopt the shorthand notation $p_1 = \{1\}$, $p_{23} = \{2, 3\}$, etc. Let P denote a partition of the quality space, with the interpretation that consumers can distinguish quality only at the level of precision specified by P. For example, if $P = \{p_1, p_{23}\}$, then consumers can distinguish whether a provider's quality is $q_i = 1$ or not, but they cannot distinguish between $q_i = 2$ and $q_i = 3$.

The institution of a report program can be thought of as moving from a partition P_0 to a more refined partition $P_R \neq P_0$, where any distinction between quality levels consumers can make under partition P_0 can also be made under partition P_R. For example, if $P_0 = \{p_{123}\}$, and $P_R = \{p_{12}, p_3\}$, then instituting report cards moves consumers from a situation where they cannot observe any quality information to one where they can identify only whether the providers chose high quality ($q_i = 3$) or not ($q_i = 1$ or $q_i = 2$).

We assume that there are two types of consumers. The first type of consumer is not sensitive to quality. These "baseline" consumers can be thought of as consumers who are local to one of the providers, or who, for institutional reasons, are not free to choose which provider they will patronize. For example, many localities require ambulances to bring trauma victims to the closest suitable hospital. Or, elderly consumers may have limited options about which physician to see due to transportation difficulties. We denote the quantity of baseline demand for each provider by b_i.

The other type of consumer is sensitive to quality and chooses which provider to patronize based on what is known about their quality offerings. In order to characterize the behavior of this group of consumers, we must specify how demand for each provider depends on the information available. It is easiest to explain our assumptions in this regard via an example. Suppose the partition is $P = \{p_1, p_{23}\}$. If consumers observe that provider i's quality is in p_1, which we denote $q_i \in p_1$, then they know that $q_i = 1$. If they observe that $q_i \in p_{23}$, then they know only that $q_i = 2$ or $q_i = 3$. However, since consumers know that quality is costly and that providers know consumers cannot distinguish between quality levels 2 and 3, consumers rationally believe that if they observe $q_i \in p_{23}$, provider i has chosen $q_i = 2$. More generally, if consumers observe that $q_i \in p$, they treat the provider as if its quality is π_i, where $\pi_i = \min \{j \in p\}$ (i.e., they assume the provider has chosen the lowest-quality level consistent with their observation).

Let N denote the total number of consumers. Let $n_i(\pi_A, \pi_B, \pi_C)$ denote the number of consumers who choose provider i when the three providers' perceived quality choices are π_A, π_B, and π_C. To simplify the examples, we will let $n_i(\pi_A, \pi_B, \pi_C) = N\frac{\pi_i}{\pi_A+\pi_B+\pi_C}$.

The cost to provider i of choosing quality j is given by $C_i(j, n_i) = c_{ij}n_i$. We assume the cost of quality is positive and increasing, i.e., $c_{ij} > 0$ and $c_{i1} < c_{i2} < c_{i3}$ for $i \in \{1, 2\}$. The provider's objective function depends on the number of people it serves and the cost of providing quality: $U_i(q_A, q_B, q_C) = (v_i - c_{ij})(n_i + b_i)$.

The equilibrium requirements in this game are simple. Given the information structure and the relationship between quality and demand in $n_i(\pi_A, \pi_B, \pi_C)$, each provider chooses the quality level that maximizes its payoff, given the quality choices of the other two providers. Thus, we look for a Nash equilibrium in quality.

We now provide four examples to illustrate the role of quality competition in this environment. The first example illustrates the prototypical case where instituting a report card program uniformly increases quality. The second two examples, which correspond to the two types of races discussed above, illustrate ways in which report cards may decrease at least some providers' quality. The final example illustrates a particularly perverse case in which instituting report cards leads to a uniform decline in quality.

4.1 Report Cards Increase Quality.

Suppose providers are identical, i.e., $v_i = v$, $C_i(j, n) = c_jn$, and $b_i = b$ for $i \in \{A, B, C\}$. Let $P_0 = \{p_{123}\}$, and $P_R = \{p_1, p_2, p_3\}$. That is, without report cards no quality information is available, and with report cards quality is perfectly observed.

Without report cards, quality improvements are not observed by consumers and therefore do not increase demand. Since increasing quality is costly, in the absence of information on quality the Nash equilibrium quality choices have each provider choosing the lowest quality available, $q_i = 1$.

The situation after report cards are introduced is more complicated, and the equilibrium depends on the values of the parameters. However, it is straightforward to derive conditions under which report cards eliminate the low-quality equilibrium (i.e., where each provider chooses $q_i = 1$). If each provider chooses minimal quality, $U_i(1, 1, 1) = (v - c_1)\left(\frac{N}{3} + b\right)$. If provider A were to choose quality $q_A = 2$ or quality $q_A = 3$ instead, its payoff would be $U_A(2, 1, 1) = (v - c_2)(n_A(2, 1, 1) + b)$ or $U_A(3, 1, 1) = (v - c_3)(n_A(3, 1, 1) + b)$, respectively. Thus, minimal quality ceases to be an equilibrium if either $U_A(1, 1, 1) < U_A(3, 1, 1)$ or $U_A(1, 1, 1) < U_A(2, 1, 1)$. (Since the providers are identical, the corresponding inequalities for providers B and C imply the same mathematical restrictions.) As one expects, since increasing quality increases demand, the above conditions show that provider A will prefer to choose $q_A = 2$ or $q_A = 3$ when the other providers choose $q_B = q_C = 1$ whenever c_1, c_2, and c_3 are sufficiently close together, i.e., whenever it is not very costly to increase quality.

Before going on, it is instructive to study the above inequalities in order to understand the role of baseline demand b in the providers' decision process. Consider condition $U_A(2, 1, 1) > U_A(1, 1, 1)$. Expanding and rearranging this expression yields:

$$v * (n_A(2, 1, 1) - n_A(1, 1, 1)) \leq c_2\left(n_1(2, 1, 1) - \frac{N}{3}\right) + (c_2 - c_1)(n_A(1, 1, 1) + b). \qquad (1)$$

That is, provider A prefers not to increase its quality from 1 to 2 if the additional revenue from doing so (i.e., the left-hand side of (1)) is less than the additional cost of doing so (i.e., the right-hand side of (1)). However, note that part of the additional cost of increasing quality consists of the fact that the provider's baseline demand is now given quality 2 instead of quality 1, which costs an additional $(c_2 - c_1)$ dollars per person. However, while the provider's baseline demand adds to its cost of increasing quality, it does not increase revenue. This cost disadvantage makes providers with more baseline demand less likely to choose high quality levels. As discussed below, to the extent that baseline demand is likely to be higher at large public hospitals, this suggests that, all else equal, public hospitals (and the vulnerable populations they serve) will be at a disadvantage when quality competition is intense (as it is under report card programs).

After report cards are instituted, (again due to symmetry) it is a Nash equilibrium for all providers to provide highest quality whenever $U_A(3,3,3) \geq U_A(2,3,3)$ and $U_A(3,3,3) \geq U_A(1,3,3)$. Examining these conditions shows that they hold (i.e., it is an equilibrium for all providers to choose quality $q_i = 3$) whenever c_3 is not too much larger than c_1 and c_2. Hence, report cards increase quality whenever the cost of increasing quality is small relative to the increase in demand from doing so.

We conclude with a numeric example that exhibits these properties. Intuitively, the game being played corresponds to the first type of race discussed above. Let $N = 10$, $v = 10$, $c_1 = 5$, $c_2 = 5.5$, $c_3 = 6$, and $b = 2.5$. Let $P_0 = \{p_{123}\}$ and $P_R = \{p_1, p_2, p_3\}$. Table 1 depicts the payoffs in this game. (All tables are presented at the end of the Research Plan). Notice that when providers' quality choices are observable in this game, choosing high quality dominates both medium and low quality, and choosing medium quality dominates low quality. Thus, in this game, providers always have an incentive to choose the highest quality level that can be communicated to consumers. Without report cards, no quality information is available to consumers and so providers cannot gain market share by increasing quality. Consequently, the equilibrium is for all providers to choose low quality. After report cards are instituted, consumers observe when a provider chooses high quality. As a consequence, the providers are able to reap the benefits of quality improvements in the form of increased market share (i.e., choosing higher quality increases the provider's market share). Thus, as in the standard justification for report card programs, making quality information available makes consumers more responsive to quality improvements, which gives providers an incentive to increase quality. The result is that, after report card information is made available, the equilibrium of this game is for all providers to choose high quality ($q_i = 3$).

4.2 Report Cards Reduce High-Cost Providers' Quality.

Next, we turn to an example where report cards cause some providers to decrease quality. This example differs from the previous one in that the providers have heterogeneous costs of providing quality and the initial information state allows the consumers to distinguish some, but not all, quality levels. Specifically, consider a game in which two of the providers can produce quality at a lower cost than the third provider. Let the information structure before and after report cards be $P_0 = \{p_1, p_{23}\}$ and $P_R = \{p_1, p_2, p_3\}$. That is, initially consumers can identify low-quality providers but cannot identify whether a provider that is not low quality has quality 2 or 3. With report cards, consumers can distinguish among all quality levels. Suppose that providers A and B are low-cost providers with cost function $c_i(j,n) = c_j^l n$, and provider c is a high-cost provider with cost function $c_i(j,n) = c_j^h n$, where $c_1^h > c_1^l$, $c_2^h - c_1^h > c_2^l - c_1^l$, and$c_3^h - c_2^h > c_3^l - c_2^l$, i.e., provider C has higher variable, and marginal cost of quality. We will show that there are specifications of the parameters under which the no-report-card equilibrium has all providers choosing quality 2, while the report card equilibrium has providers A and B choosing quality 3 and provider C choosing quality 1. That is, competition induces the high-cost provider to reduce its quality.

Without report cards, no provider will ever choose quality 3 since consumers cannot distinguish quality-3 providers from quality-2 providers. For qualities $(2,2,2)$ to be an equilibrium without report cards, we must have that $U_A(2,2,2) \geq U_A(1,2,2)$ and $U_C(2,2,2) \geq U_C(2,2,1)$. (The condition for provider B is identical to that of provider A.) Since decreasing quality decreases demand, these conditions will hold provided that c_1^h and c_1^l are not too much smaller than c_2^h and c_2^l, respectively.

Next, consider the situation with report cards. We are looking for conditions under which it is an equilibrium for providers A and B to choose quality 3 and for provider C to choose quality 1. For provider A the following conditions must hold: $U_A(3,3,1) \geq U_A(2,3,1)$ and $U_A(3,3,1) \geq U_A(1,3,1)$. (Since B has the same cost function as A, the best-response conditions for B are identical to those of A.) For provider C to prefer quality $q_C = 1$, it must be that $U_C(3,3,1) \geq U_C(3,3,2)$ and $U_C(3,3,1) \geq U_C(3,3,3)$. Writing out these conditions, we see that setting c_1^l and c_2^l sufficiently small and c_3^l sufficiently close to c_2^l satisfies the conditions for the low cost providers, and setting c_2^h and c_3^h sufficiently high satisfies the conditions for the high-cost provider. Thus, it is possible for the environment to be such that without report cards providers choose quality 2, and that report cards induce low-cost providers to increase quality and high-cost providers to decrease quality.

To illustrate, consider the game depicted in Table 2, where $N = 10$, $c_1^l = 5$, $c_2^l = 5.5$, $c_3^l = 6$, $c_1^h = 5.5$, $c_2^h = 6.5$, $c_3^h = 8$, and $b = 2.5$ for each provider. Notice that this is a game where the cost of quality, especially high quality, is much higher for provider A than for providers B and C. Thus, while provider A is somewhat competitive with providers B and C when quality is 2, it is too costly for it to match its opponents' quality when they set quality 3. Without report cards, consumers are able to identify low quality providers ($q_i = 1$) but cannot distinguish between medium and high quality providers ($P_0 = \{p_1, p_{23}\}$). With report cards, consumers are able to perfectly discriminate different quality levels ($P_R = \{p_1, p_2, p_3\}$).

In this example, the equilibrium without report cards is for all providers to choose quality 2. To see this, note that for providers B and C, quality 2 dominates quality 1 (and without report cards no provider will ever set quality 3). And, in response to quality 2, provider A's best response is to choose quality 2. With report cards, providers may choose any quality level. Analyzing Table 2 shows that the unique equilibrium of this game is for provider A to set quality 1 and providers B and C to set quality 3. That is, instituting report cards leads provider A to reduce its quality (and providers B and C to increase theirs).

The intuition for this example corresponds to the second type of race discussed above. Here, there are two providers that have a cost advantage over the third, and this cost advantage is greatest when it comes to producing high quality. Consequently, while the high-cost provider can compete with the low-cost providers when quality competition is muted, as it is before report cards, it cannot be competitive when quality competition is intense. When report cards increase consumers' responsiveness to quality differences, they give the low-cost providers a strong incentive to compete with each other. And, as the low-cost providers increase quality, the high-cost provider becomes less able to compete. Since it is too costly for the high-cost provider to produce high quality in an attempt to win a greater market share, it chooses instead to drop out of the quality race, providing minimal quality instead. Finally, note that, even though quality increases on average in this example, the report card program has potentially harmful distributional consequences. The people who go to the high-cost providers (including its baseline demand) are worse off with report card programs than they were without them.

4.3 Report Cards Reduce the Quality of Low-cost Providers.

It is also possible that the institution of a report card system could cause the quality leaders in a market to reduce their quality, as in the third type of race discussed in the introduction. Suppose provider A is low cost and providers B and C are high cost, and consider an environment where $P_0 = \{p_{12}, p_3\}$ and $P_R = \{p_1, p_2, p_3\}$. Thus, before report cards are instituted, it is possible for consumers to identify very high quality providers but impossible to distinguish between medium and low quality providers. Report cards make all quality levels observable.

Without report cards, no provider would choose $q_i = 2$, since consumers cannot distinguish between low and medium quality. One possible configuration for the pre-report card equilibrium is for the low-cost provider to choose $q_A = 3$ and for the high-cost providers to choose $q_B = q_C = 1$. For this to be an equilibrium, it must be that $U_A(3,1,1) \geq U_A(1,1,1)$ and $U_B(3,1,1) \geq U_B(3,3,1)$. (Since providers B and C are identical, provider C's best-response condition is the same as provider B's.)

After report cards are instituted, provider A no longer needs to put forth as much effort to distinguish itself from providers B and C. Thus, it could be that $q_A = 2$, $q_B = 1$, and $q_C = 1$ becomes an equilibrium. For this to be the case, the following conditions must hold: $U_A(2,1,1) \geq U_A(3,1,1)$ and $U_A(2,1,1) \geq U_A(1,1,1)$ for provider A, and $U_B(2,1,1) \geq U_B(2,2,1)$ and $U_B(2,1,1) \geq U_B(2,3,1)$ for provider B. Again, due to symmetry, provider C's best response conditions are the same as provider B's.

One situation that satisfies these conditions is presented in Table 3, where $N = 10$, $c_1^l = 5$, $c_2^l = 5.5$, $c_3^l = 6.5$, $c_1^h = 5.5$, $c_2^h = 7$, $c_3^h = 9$, and $b = 2.5$ for each provider, with $P_0 = \{p_{12}, p_3\}$ and $P_R = \{p_1, p_2, p_3\}$. In this game, providers B and C have very high cost of quality. Regardless of the information structure and provider A's quality choice, providers B and C are never willing to choose quality greater than 1. Low-cost provider A, on the other hand, must decide how much quality it is willing to provide in order to distinguish itself from its rivals. Before report cards, consumers cannot distinguish between quality 1 and quality 2. Because of this, provider 1 can only demonstrate that it is higher quality than the other providers by choosing quality 3. However, once report cards are instituted and consumers can identify providers with quality 2, provider 1 prefers to choose quality 2 against opponents who choose quality 1.[35] This implies that the equilibrium with report cards is $(2,1,1)$. Therefore, in this case instituting report cards induces the low-cost provider to reduce its quality. Note, though, that there is a sense in which before report cards the low-cost provider was producing too much quality in order to distinguish itself from its rivals. Thus, while report cards reduce quality in this case, it is not clear whether doing so also reduces overall welfare. It is possible that report cards are actually removing a welfare-reducing distortion.

4.4 Report Cards Uniformly Reduce Quality.

Finally, we show that instituting report cards can uniformly reduce quality. The intuition is similar to that of the previous example. We study a situation where, although providers would rather choose medium quality, consumers are unable to distinguish medium quality from low. However, providing quality is relatively cheap, so that each provider has an incentive to choose high quality in an attempt to steal market share from the others. Without report cards, the equilibrium is for all providers to choose high quality. However, once report cards make consumers able to identify medium quality, the providers revert to this preferred strategy.

Rather than write down the equilibrium conditions, which are similar to those presented above,

[35] Indeed, in this game provider 1 has a dominant strategy to choose quality 2 when all quality levels are observable. It is only the coarse information structure before report cards are implemented that causes it not to do so.

we will jump immediately to an example. Table 4 presents such an example, where the providers are identical and the parameters are $N = 10$, $c_1 = 5$, $c_2 = 5.5$, $c_3 = 6.5$, and $b = 2.5$ for each provider. The partitions are $P_0 = \{p_{12}, p_3\}$ and $P_R = \{p_1, p_2, p_3\}$ Without report cards, all providers choose quality 3 (since quality 3 dominates quality 1, and no provider would choose quality 2). With report cards, each provider chooses quality 2. Thus, implementing report cards leads to a uniform decrease in quality.

5 Conclusion

This paper has examined the theoretical justification for the link between making better information about quality available to consumers through the implementation of quality report card programs and providers' quality choices. The analysis supports the idea that giving people better information about quality will lead them to seek out higher quality providers. However, the folk wisdom that firms facing more quality-elastic consumers will respond by increasing quality has been shown not to hold in general. While increasing the precision of consumers' information will often increase quality, it need not always do so. Better information can lead one or even all providers to reduce quality. Further, even in cases where better information increases quality, in the presence of insurance and administrative pricing there is no guarantee that providers will arrive at the right (efficient) quality. They may provide either too little or too much quality in equilibrium. These unattractive features are even more likely to manifest themselves when providers are highly heterogeneous or baseline demand is important. Thus while RCPs may be a useful policy device, they are certainly not a one-size-fits-all solution to the quality chasm.

While report cards may not be the silver bullet for quality, the theoretical analysis supports the idea that they can be a useful tool in increasing quality. Often the state of quality in health care is so clearly deficient that the finer details of whether a report card program can induce the efficient quality level is of second order importance relative to inducing any quality improvement. In such cases, RCPs can provide a useful tool for inducing providers to improve their own quality. One of the attractive features of is that they harness the power of markets to induce providers to increase quality, resulting in higher quality without the need for direct monitoring and regulation.

Based on the analysis here, in which circumstances are report cards likely to be most effective? Clearly, in situations where quality information is initially very poor, better information is more likely to lead to improvements. Further, better information is more likely to lead to improvements when the participants in the market are similar, both in terms of their cost of providing quality but also in terms of their market position. Finally, RCPs are more likely to increase quality when most of the relevant consumers are quality elastic. If consumers are unable (or unwilling) to respond to quality differences, then RCPs may result in inelastic consumers being stranded at low-quality providers.

What lessons for policy making can be drawn from the analysis? First and foremost, even when RCPs seem to be effective in raising average quality, they need not uniformly raise quality across all groups. Thus quality-inelastic consumers who are stuck at providers who lower their quality in response to competitive pressures may suffer from the increased competition. While the benefits to the quality elastic may outweigh these costs, the effects on these groups should not be overlooked. This is made all the more true by the fact that the quality-inelastic group is likely to include people such as the poor, sick, elderly, and others who have limited mobility and/or experience with the health care system. We must be careful that in providing benefits to those who can most easily seek out high quality care we are not inadvertently harming those who cannot. This suggests that RCPs may need to be accompanied by special provisions/programs aimed at helping those providers who have a high cost of providing care and a disproportionately large group of quality inelastic consumers.[36] It also suggests that care must be taken in providing quality measures that not only risk adjust for patient characteristics, but also adjust for provider characteristics and the status of those patients who are not directly affected by the quality measure.[37] Although the latter idea is related to risk adjustment, it is not exactly the same.[38] Even if baseline and quality-elastic patients have exactly the same health status, providers with higher baseline demand will have higher cost of improving quality. Thus while for-profit hospitals may be rated on one scale, nonprofit and/or public providers should perhaps be rated on another. It is possible that such "within category" competition will be more effective in raising quality across the board than one big race.

[36]The issue of baseline demand is also related to the types of selection behavior examined by Dranove et al. (2003), since public hospitals and other providers of last resort may have less ability to engage in selection of favorable patients than other providers.

[37] For example, consider two hospitals, one with twice as many beds as the other. In order to effect the same reduction in nurse-to-bed ratio, the larger hospital must hire twice as many additional nurses (at twice the cost) as the smaller hospital. If both hospitals have the same potential gain in market share by reducing nurse-to-patient ratio, the larger hospital will be less inclined to invest in increasing quality. Of course, if there are increasing returns to scale then the larger hospital may enjoy other cost advantages over the smaller. Even in this case, though, the fact remains that differences in scale and/or scope should be taken into account in the design of report card systems.

[38]See Van De Ven and Ellis (2000) for a general discussion of risk adjustment. See Cutler et al. (2004) for a discussion of using risk-adjusted mortality rates in the context of the New York's Cardiac Surgery Reporting System (CSRS).

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Payoffs are written with Provider A in the upper left, B in the center, and C in the lower right.

Table 1: Report cards induce a uniform increase in quality.

	$q_C = 1$			$q_C = 2$			$q_C = 3$		
	$q_B = 1$	$q_B = 2$	$q_B = 3$	$q_B = 1$	$q_B = 2$	$q_B = 3$	$q_B = 1$	$q_B = 2$	$q_B = 3$
$q_A = 1$	29.2 29.2 29.2	25 33.8 25	22.5 34 22.5	25 25 33.8	22.5 29.3 29.3	20.8 30 26.3	22.5 22.5 34	20.8 26.3 30	19.6 27.1 27.1
$q_A = 2$	33.8 25 25	29.3 29.3 22.5	26.3 30 20.8	29.3 22.5 29.3	26.3 26.3 26.3	24.1 27.1 24.1	26.3 20.8 30	24.1 24.1 27.1	22.5 25 25
$q_A = 3$	34 22.5 22.5	30 26.3 20.8	27.1 27.1 19.6	30 20.8 26.3	27.1 24.1 24.1	25 25 25	27.1 19.6 27.1	25 22.5 25	23.3 23.3 23.3

Table 2: Report cards induce high-cost providers to reduce quality.

	$q_C = 1$			$q_C = 2$			$q_C = 3$		
	$q_B = 1$	$q_B = 2$	$q_B = 3$	$q_B = 1$	$q_B = 2$	$q_B = 3$	$q_B = 1$	$q_B = 2$	$q_B = 3$
$q_A = 1$	26.3 29.2 29.2	25.5 33.8 25	20.3 34 22.5	22.5 25 33.8	20.3 29.3 29.3	18.8 30 26.3	20.3 22.5 34	18.8 26.3 30	17.7 27.1 27.1
$q_A = 2$	26.3 25 25	22.8 29.3 22.5	20.4 30 20.8	22.8 22.5 29.3	20.4 26.3 26.3	18.8 27.1 24.1	20.4 20.8 30	18.8 24.1 27.1	17.5 25 25
$q_A = 3$	17 22.5 22.5	15 26.3 20.8	16.6 27.1 19.6	15 20.8 26.3	13.6 24.1 24.1	12.5 25 22.5	13.6 19.6 27.1	12.5 22.5 25	11.7 23.3 23.3

Table 3: Report cards induce low-cost firms to reduce quality.

	$q_C = 1$			$q_C = 2$			$q_C = 3$		
	$q_B = 1$	$q_B = 2$	$q_B = 3$	$q_B = 1$	$q_B = 2$	$q_B = 3$	$q_B = 1$	$q_B = 2$	$q_B = 3$
$q_A = 1$	29.2 26.3 26.3	25 22.5 22.5	22.5 8.5 20.3	25 22.5 22.5	22.5 19.5 19.5	20.8 7.5 17.5	22.5 20.3 8.5	20.8 17.5 7.5	19.6 6.8 6.8
$q_A = 2$	33.8 22.5 22.5	29.3 19.5 20.6	26.3 7.5 18.8	29.3 20.3 19.5	26.3 17.5 17.5	24.1 6.8 16.1	26.3 18.8 7.5	24.1 16.1 6.8	22.5 6.25 6.25
$q_A = 3$	29.8 20.3 20.3	26.3 17.5 18.8	23.8 6.8 17.7	26.3 18.8 17.5	23.8 16.1 16.1	21.9 6.25 15	23.8 17.7 6.8	21.9 15 6.25	20.4 5.8 5.8

Table 4: Report cards uniformly reduce quality.

	$q_C = 1$			$q_C = 2$			$q_C = 3$		
	$q_B = 1$	$q_B = 2$	$q_B = 3$	$q_B = 1$	$q_B = 2$	$q_B = 3$	$q_B = 1$	$q_B = 2$	$q_B = 3$
$q_A = 1$	29.2 29.2 29.2	25 33.8 25	22.5 29.8 22.5	25 25 33.8	22.5 29.3 29.3	20.8 26.3 26.3	22.5 22.5 29.8	20.8 26.3 26.3	19.6 23.8 23.8
$q_A = 2$	33.8 25 25	29.3 29.3 22.5	26.3 26.3 20.5	29.3 22.5 29.3	26.3 26.3 26.3	24.1 23.8 24.1	26.3 20.8 26.3	24.1 23.8 23.8	22.5 21.9 21.9
$q_A = 3$	29.8 22.5 22.5	26.3 26.3 20.8	23.8 23.8 19.6	26.3 20.8 26.3	23.8 24.1 24.1	21.9 21.9 22.5	23.8 19.6 23.8	21.9 22.5 21.9	20.4 20.4 20.4