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Moonlighting: public service and private practice

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We study job incentives in moonlighting, when public-service physicians may refer patients to their private practices. Some doctors in the public system are dedicated, and behave sincerely, but others—the moonlighters—are utility maximizers. Allowing moonlighting always enhances aggregate consumer welfare, but equilibrium public-care quality may increase or decrease; if quality increases, moonlighting improves each consumer's expected utility. Unregulated moonlighting may reduce consumer welfare as a result of adverse behavioral reactions, such as moonlighters shirking more and dedicated doctors abandoning their sincere behavior. Price regulation in the private market limits such adverse behaviors in the public system and improves consumer welfare.

1. Introduction

■ Many goods are produced in both the public and private sectors. Workers who produce these goods may also work in both sectors. Perhaps health care is the prime example of mixed private-public provision: physicians often work in both sectors, and may self-refer patients in the public system to their private practices.[1] We use the term "moonlighting" to describe dual public-private job participation.[2] In this article, we examine the effects of moonlighting on service

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[1] According to the United Kingdom Monopolies and Mergers Commission, in 1994 more than 60% of physicians employed by the National Health Services also worked in the private sector. In Germany (and many other countries), physicians based in public hospitals can admit private patients, collect fees, and then reimburse the public hospital (Rickman and McGuire, 1999).

[2] Workers having many jobs is, of course, common. Our interest here is only when one of these jobs is in the public service.

quality, price, and consumer welfare in both the public and private sectors. We also analyze when and how government regulation in the moonlighting market may enhance welfare.

Our research focuses on dual job incentives in the mixed economy, where workers may participate in both the public and private markets. Because of its importance,[3] and for clearer exposition, we primarily focus on the physician market and doctors' self-referrals from the public to the private sector. Our research methodology is general and can be applied to situations such as public law enforcement officers working for private security firms or consumers; public school teachers offering private tutoring services or working for private test preparation firms (such as Princeton or Kaplan); and academics in public (and private) universities consulting for private firms (and the government).

It is often argued that moonlighting should be regulated or prohibited. There seems to be a presumption that allowing physicians to moonlight will hurt services in the public sector. Economists are usually quick to point out that allowing a market to operate generally enhances welfare. For example, if moonlighting is allowed, physicians can be expected to provide faster and higher-quality services in the private sector; consumers who are willing to pay for these superior services will opt out of the public system. Critics argue, however, that moonlighters may cut back on quality for patients in the public sector and doctors who choose not to moonlight may also cut back on quality. When a public system lacks incentive instruments, this adverse reaction presents an unmitigated problem.

Two sets of questions must be addressed in the above argument. First, for those against moonlighting, if incentives in the public sector are weak, why are moonlighters expected to provide good services there when they are *not* allowed to moonlight? That is, why would allowing moonlighting *suddenly* make quality in the public sector worse? Second, for those on the other side of the argument, will moonlighting enhance consumer welfare when there could be losses in the public sector?

Our view is that modelling moonlighting requires an adaptation of the standard incentive-based methodology. Besides the differences in incentives between the public and private sectors, there is also a difference between the market participants. Even when it is allowed, not every physician chooses to moonlight. We introduce a group of physicians called the "dedicated doctors." They are dedicated in the sense that they provide high-quality service in the public sector despite the lack of incentives; they may also reject moonlighting opportunities.[4]

The presence of the dedicated doctors allows us to understand why health-care quality in the public sector is not necessarily extremely poor. Moreover, if moonlighting makes some of these dedicated doctors change their position and become moonlighters, then there will be an adverse effect on the quality in the public sector. Worrying about quality degradation in the public sector is indeed a legitimate concern, even when moonlighters provide poor quality there in the first place. A second reason for fearing quality deterioration should also be considered. Moonlighters may decide to reduce quality in the public sector even more than if they were not allowed to moonlight. In either of these two circumstances, moonlighting leads to adverse behavior in the public sector.

How is consumer welfare affected by moonlighting? Despite the adverse behavioral reactions created by moonlighting, welfare may be enhanced when the private market is regulated. Suppose that the magnitude of these adverse reactions by physicians is positively related to the extent and profitability of moonlighting in the private market. More opportunities in the private market may lure more dedicated doctors to moonlight; these opportunities may also induce moonlighters to shirk more in the public system. Restricting moonlighting will limit its negative effects; reducing

[3] A recent newsletter from the Health Economics and Financing Programme at the London School of Hygiene and Tropical Medicine (2003) reported on "moonlighting physicians."

[4] Robert Frank documented wage differentials among jobs that have different moral concerns. Apparently, workers are willing to "trade pay or other desired working conditions in exchange for additional opportunities to help others on the job" (Frank, 1996, pp. 2–3).

the scope of moonlighting, on the other hand, limits private market efficiency. We show that a price ceiling on moonlighting in the private market enhances overall consumer welfare. The ceiling reduces some surplus in the private market, but controls the quality deterioration in the public system by a larger order of magnitude.

These intuitions and results are derived from a basic model of moonlighting in a mixed economy. We consider a set of consumers going through the public system in order to obtain health-care services. When they are matched with the dedicated doctors in the public system, they receive services there at a fixed, nominal fee. When they are matched with the moonlighters, they may be referred out of the public system if moonlighting is allowed. When a moonlighter and a consumer decide to use the private market, we use a Nash bargaining solution to describe that outcome, which prescribes a quality and a price for the health-care service.

We postulate that the regulator in the public sector has weaker incentive instruments than the private sector. As a benchmark for comparison, we let contracts in the private sector be fully efficient. In the public system, only limited punishments can be imposed on physicians. Furthermore, the actual quality is only observed when the regulator performs a costly audit. Because of the higher contract enforcement cost in the public sector, opportunistic moonlighters may shirk and earn information rent.

Despite the superior incentive efficiency in the private sector, a government would like to maintain a public system. The private health-service providers only supply to consumers who are willing to pay. We assume in the model that some consumers are poor, and have no access to the private market. Although the government might prefer to pay a direct transfer to poor consumers, verifying that in fact consumers spend it on health services may be infeasible. Also, frequent income and wealth monitoring of poor consumers may be very costly. Therefore, a public sector exists primarily to help these poor consumers, but is also available to all consumers.

We first compare the regimes where moonlighting is allowed and where it is not; we defer behavioral reactions from dedicated doctors and moonlighters until later in the article. The basic model generates some expected results and some that are surprising. First, without behavioral reactions, allowing moonlighting does increase aggregate consumer welfare. Consumers who opt out of the public system are willing to pay a higher price for a higher quality. The quality that is implemented in the public system, however, may become higher or lower when moonlighting is allowed.

Why may the quality in the public system increase or decrease if moonlighting is allowed—even when there is no behavioral reaction? When moonlighting is allowed, some moonlighters will opt out of the public sector. This reduces the contract enforcement cost, and tends to raise the equilibrium quality in the public sector. However, efficiency is higher in the private sector. So when moonlighting is allowed, the regulator does want to channel some consumers from the public sector to the private. This requires the regulator to implement a lower quality in the public sector. The two opposing effects imply that the quality in the public sector may rise or fall.

As a robustness check, we consider the effect of asymmetric information on the basic model.[5] Asymmetric information may limit the volume of trade. Nevertheless, consumers always have the option of remaining in the public system. Should they decide to use a moonlighter in an equilibrium, they must expect to gain from the decision. The expected gain from trade drives the improvement in consumer welfare.

In this article, we assume that incentives are stronger in the private sector than in the public sector. This accords well with reality; in public sectors, work compensation is less variable and termination of employment more difficult. Some justifications for weak incentives in the public sector can be found in Dewatripont, Jewitt, and Tirole (1999). In our context, the public system provides care because poor consumers cannot pay for private services. This is similar to a rationale

[5] In an earlier version, we examined a dynamic model. In this case, consumers can have a credible threat against a moonlighter who offers low quality. As a result, moonlighters may have to offer high quality even if the consumer stays within the public system. Nevertheless, allowing moonlighting always improves welfare.

used by Banerjee (1997) in a different context. More generally, a government may decide to adopt universal provision for equity reasons.

The theoretical literature on dual job incentives in the mixed economy is not extensive. Rickman and McGuire (1999) examine the optimal public reimbursement cost-sharing rule when a physician can supply both public and private services and focus on the issue of whether public and private services are complements or substitutes. Barros and Olivella (2002) analyze a model with a waiting list in the public sector to study a physician's decision to cream-skim. Finally, Gonzalez (2002) presents a model where a physician has an incentive to provide excessive quality in the public sector in order to raise her prestige.

Other papers in the health economics literature have examined the effect of the private market on the waiting list in the public sector. Iversen (1997) considers a dynamic model of rationing by waiting lists and shows that the existence of a private sector can make the list longer. Barros and Martinez-Giralt (2002) use a Hotelling model of oligopoly to study the effect of interaction between public and private health care on quality and cost efficiency. Besley, Hall, and Preston (1998) show empirically that waiting lists in the UK National Health Services are positively associated with private insurance. These papers do not consider job incentives of physicians working in both sectors.

Moonlighting can be seen as a multitask principal-agent problem, where the regulator sets the reimbursement rate in the public sector and may regulate prices and the ability to work in the private sector. Other research in the multitasking agency literature include Holmstrom and Milgrom (1994) in the theory of the firm and Ma (1994) in health care.

The regulation literature has looked at incentives when a regulator may later work in the private sector. In the "revolving door" literature (Che, 1995), the issue is whether the opportunity after tenure will motivate a regulator to invest in a skill for a regulatory agency. The literature has not looked at situations where the regulator can work simultaneously at a government agency and a regulated firm.

Finally, our assumptions on physician behavior build on models originating from the psychology literature. Our hypothesis that some physicians will provide quality without being monitored adopts a behavioral approach that has received much attention recently. Rabin (1993) develops a formal game-theoretic model on fairness. Alger and Ma (2003) propose that some agents are honest and truthfully reveal information to the principal.

In the next section, we present the basic model and analyze it in Section 3. Then in Section 4 we study the moonlighting regime. The effect of private information is discussed in Section 5. We introduce behavioral changes of moonlighters and dedicated doctors in Section 6, and then draw some conclusions.

2. The model

■ There are three groups of players: one set of consumers, and two sets of doctors. Each consumer would like to receive one unit of health service. As discussed in the Introduction, we assume that some consumers are poor, and therefore cash constrained and unable to pay for health-care services. For ease of exposition, we assume that half the consumers are cash constrained, and the remaining half are not. We sometimes call them poor and rich consumers.[6]

We assume that all doctors work in the public system. Our model abstracts away physicians' career decisions; we examine only incentive issues for those physicians whose careers involve the public sector. The two sets of doctors in the public system are the dedicated doctors and the moonlighters. Initially, we assume that the dedicated doctors work only in the public sector. The moonlighters may also work in the private sector, if they are allowed to do so. Whether the moonlighters are allowed to operate in the private market will be determined as a policy choice.

[6] We do not include the possibility of a consumer completely opting out of the public system. This option is usually taken by very rich members of an economy. Our purpose is to study how patients who go through the public system initially may actually end up in the private system.

A physician chooses a quality level to provide to his patient in the public system; a higher quality of health-care services costs more to the physician. Physicians' quality decisions can be monitored. We postulate that monitoring in the public system is less effective than in the private market. This is expressed as two separate assumptions.

First, we assume that a physician's quality choice can be verified at a cost, and that this cost is lower in the private system than in the public system. As a normalization, we let the monitoring cost in the private market be zero, but strictly positive in the public system. Second, in the private market there are sufficient punishments to deter physicians' shirking behaviors, but in the public system, punishments are limited. Again, as a normalization, we assume that in the public system, penalties cannot be levied but only the level of physician reimbursement can change.

Monitoring does appear in practice to be less effective in the public system than in the private market. In our context, consumers do not pay for the services they receive in the public sector; they do if they use the private market. Thus, consumers have stronger incentives to verify qualities when purchasing services in the private market. The only important element in our setup is that there is a significant difference in incentive costs: it costs more (in expected terms) to get a moonlighter to perform some level of quality in the public sector than in the private system. Results in the article should be robust against other ways to specify how this cost is modelled explicitly. For the public system, we model the monitoring of qualities by an audit system, which we will shortly define.

There are D dedicated doctors, M moonlighters, $N/2$ poor consumers, and $N/2$ rich consumers. The above three numbers are normalized so that one doctor can treat one and only one patient. We assume that D, M, and N are fixed parameters, and $N > M + D$ so there is always an excess demand for services.

Let q denote the quality of care. A consumer's benefit from receiving a unit of service or treatment at quality q is vq. Here, the valuation for quality, v, is the realization of a random variable distributed on the strictly positive support $[\underline{v}, \bar{v}]$ with distribution and density functions $F(v)$ and $f(v)$. Consumers' valuations of quality are independently and identically distributed. Each consumer is described by her valuation of a unit of quality. Each consumer knows her own valuation; we will discuss the situations when consumers or physicians are uninformed about the consumers' valuation as a model extension.

For a poor, cash-constrained consumer, vq measures the increment in utility if she receives a unit of health care at quality q. This may be different from her willingness to pay: if a poor consumer is given a sum of money, she may decide (optimally) to purchase something else. We will ignore this issue, as the medical services are provided in kind. For a rich consumer, vq measures her valuation of the unit of care at quality q. Furthermore, if she participates in the private market to obtain this at a price p, then her utility is $vq - p$. A consumer's utility is zero if she does not receive any treatment.

A physician incurs a cost or disutility $c(q)$, a strictly increasing and convex function, when he provides a treatment to a consumer at quality q. A regulator in the public system decides on payments to physicians. Whether a physician is a dedicated doctor or a moonlighter is unknown to the regulator. Payment is based on a report-audit system (to be defined shortly). For convenience, we will use the cost or disutility $c(q)$ to denote a payment, although the regulator can neither directly control the physician's choice of quality nor observe it except through an audit.

The dedicated doctors are altruistic. Their preferences are represented by a linear combination of their own monetary payoffs and patients' benefits subject to nonnegative monetary payoffs. So if a dedicated physician receives a payment T from the regulator after having supplied health care at quality q to a patient with valuation v, his payoff is $T - c(q) + \beta vq$, where β is a big number. Because a dedicated doctor values patient benefit strongly (independent of whether the consumer is rich or poor), he would like to supply a high quality. We impose a nonnegative profit constraint; the dedicated doctor must cover his cost when attempting to satisfy his preferences. Moonlighters are selfish and maximize their own payoffs. Alternatively, moonlighters may be assumed to have the same kind of preferences $T - c(q) + \beta vq$, with β very small.

We now define the extensive form of the basic model. First, the regulator sets a range of reimbursement levels; let this be the interval $[c(\underline{q}), c(\bar{q})]$. The lower value $\underline{q}$ can be interpreted as a minimum acceptable level of quality cost, whereas the higher level $\bar{q}$ is the maximum allowed by the government. We normalize the cost of $c(\underline{q})$ at 0. The regulator also decides whether doctors working in the public system can participate in the private market (moonlighting). Second, each consumer is matched with a dedicated doctor with probability D/N, or with a moonlighter with probability M/N; otherwise, the consumer does not receive any medical service.[7] A consumer's characteristics become known to the matched physician; these include whether the consumer is rich or poor, and the consumer's valuation. Third, a dedicated doctor decides on a treatment quality. A moonlighter decides whether to treat the patient in the public system at some quality level or, if moonlighting is allowed, refer the patient to his private practice. We will describe the subgame played by the moonlighter and the consumer in the private market. Fourth, those physicians who have treated consumers in the public system participate in a report-audit subgame, to be defined next. Finally, upon completion of the audit, payments to physicians are made.

We now describe the report-audit subgame. Formally, this is a subform; the regulator does not observe consumer characteristics, physicians' preferences, or qualities. At this stage, each physician has already performed a treatment at some quality level q in the public system. First, each physician makes a report about his quality q^r, where $q^r \in [\underline{q}, \bar{q}]$. Second, on receiving a report, the regulator decides whether to audit the physician who has made the report. If the regulator decides not to audit the report q^r, then the physician is compensated by $c(q^r)$. If the regulator decides to audit, then it incurs a cost $\gamma > 0$ and the true quality that the physician has supplied becomes known. The reimbursement then becomes $c(q)$. Each physician is allowed to randomize between various reports; likewise, the regulator may randomize on the audit decision. The regulator does not get to commit on the audit rule before physicians choose their qualities or file their reports. The formal model requires sequential rationality of the audit decision.

The audit mechanism of our game captures a few important aspects. First, an audit in the public system is costly. Second, in the public system, limited penalties can be levied on physicians who lie about the qualities they perform. Suppose that a physician performs q but reports $q^r > q$. If he is audited, then he receives a payment $c(q)$, which just compensates for his cost. On the other hand, if he is not audited, he obtains $c(q^r)$, which gives him a rent of $c(q^r) - c(q)$. Third, a physician can report truthfully $q^r = q$ and his cost will be reimbursed.

A poor consumer receives a unit of health care at a quality supplied from a physician, as does a rich consumer who is matched with a dedicated doctor. If moonlighting is permitted, a rich consumer may be offered a private option by a moonlighter. If the consumer refuses the moonlighting offer—the disagreement outcome—she is treated in the public system by the moonlighter. The private-practice option consists of a price-quality pair (p, q), where p is the price the consumer pays the moonlighter and q is the quality of care provided by the moonlighter to the consumer. As we have discussed earlier, contracting in the private market is less costly and (p, q) can be enforced. We use an efficient benchmark in the private sector: the agreement (p, q) is given by a Nash bargaining solution, with the consumer and the moonlighter dividing the surplus over the disagreement outcome in the ratio α and $1 - \alpha$, respectively.

The regulator's welfare index consists of consumer benefit less any payment to physicians and audit costs. The basic analysis centers on the comparison of equilibrium welfare depending on whether moonlighting is allowed or not. We will progressively make the model more complex. We will discuss asymmetric information between doctors and consumers. In a later section, we will change the assumptions on the behavior of dedicated doctors and moonlighters; each type of doctor will be allowed more strategies, and price regulation in the private market will be studied.

[7] This matching process is typical of public health systems in many developing countries; consumers often do not get to choose their own doctors when they seek services from the public sector.

3. Equilibrium quality and welfare when moonlighting is disallowed

■ We begin with the regime where moonlighting is disallowed. First, we derive the dedicated physicians' and moonlighters' equilibrium quality choices. From the report-audit mechanism, the regulator pays a doctor $c(q^r)$ if there is no audit on a report q^r; otherwise, he pays $c(q)$, where q is the actual quality. A dedicated doctor values consumer benefit more strongly than monetary reward. So he will want to provide the highest level of quality as long as he breaks even. He can guarantee a zero profit in the report-audit subgame by simply reporting truthfully any quality that he has chosen. Thus, a dedicated doctor has a dominant strategy: choose quality $\bar{q}$ and then report $\bar{q}$ at the report-audit stage.

A moonlighter also has a dominant strategy when he picks a quality level: the lowest quality $\underline{q}$. There are two possible outcomes after he has made a report. If he is audited, then he gets zero profit no matter which quality he has chosen. If he is not audited, he gets $c(q^r) - c(q)$. In other words, his remuneration is independent of his quality choice. Higher effort is more costly, however. So his best choice of quality is $\underline{q}$. We summarize this by the following.

Lemma 1. The dedicated doctor chooses the maximum quality $\bar{q}$ allowed as a dominant strategy. The moonlighter chooses the minimum acceptable quality $\underline{q}$ as a dominant strategy.

Now we derive the regulator's equilibrium audit policy. Because each dedicated physician picks $\bar{q}$ and reports $\bar{q}$, a report $q^r \neq \bar{q}$ can only be made by a moonlighter. Because the moonlighter always picks quality $\underline{q}$, auditing a report of $q^r \neq \bar{q}$ reduces the reimbursement from $c(q^r)$ to $c(\underline{q}) = 0$. For any $q^r \neq \bar{q}$, the regulator audits if and only if the audit expenditure γ is less than the cost savings $c(q^r)$, or $\gamma < c(q^r)$. In other words, for any $q^r \neq \bar{q}$, the regulator audits only if q^r is higher than a threshold q^a where $c(q^a) = \gamma$.

Consider now the report $q^r = \bar{q}$. Even if all moonlighters always report $\bar{q}$, an audit may not be optimal. Only the moonlighter's payments are reduced, as the dedicated doctors choose effort $\bar{q}$. The probability of auditing a moonlighter is $\frac{M}{D+M}$ and the cost saving is $c(\bar{q})$. Thus, the expected cost saving from an audit is $\frac{M}{D+M}c(\bar{q})$. When all doctors choose $\bar{q}$, an audit is optimal if

$$\gamma \leq \frac{M}{D+M}c(\bar{q}). \tag{1}$$

Define q^b as the quality level when the regulator is indifferent between performing an audit and not if all doctors report q^b. It is implicitly defined by

$$\gamma = \frac{M}{D+M}c(q^b). \tag{2}$$

Thus, for $\bar{q} < q^b$, the regulator never audits report $q^r = \bar{q}$.

Suppose that $q^r = \bar{q} > q^b$. Now we claim that the regulator must audit this report with positive probability less than 1. If the regulator were to audit a report $q^r = \bar{q}$ with probability 1, then each moonlighter would report q^a. Then if each moonlighter were to report q^a, however auditing a report $q^r = \bar{q}$ would be suboptimal. If the regulator were not going to audit a report $q^r = \bar{q}$, then all moonlighters would report q^r. This, however, would not be optimal for the regulator given (2). Thus, we have the following lemma.

Lemma 2. For a given maximum level of allowed quality $\bar{q}$, the regulator's equilibrium audit policy is as follows. Any report in the range $[\underline{q}, q^a]$ is not audited. Any report in the range $(q^a, \bar{q})$ is audited with probability 1. If $\bar{q} < q^b$, the regulator never audits report $\bar{q}$. If $\bar{q} > q^b$, the regulator audits report $\bar{q}$ with positive probability less than 1.

Given the regulator's auditing strategy, a physician's equilibrium strategy is described as follows.

Lemma 3. A moonlighter never reports q^r in the range $[\underline{q}, q^a)$ or $(q^a, \bar{q})$. If $\bar{q} < q^b$, a moonlighter always reports $\bar{q}$. If $\bar{q} > q^b$, a moonlighter randomizes between reporting q^a and $\bar{q}$. A dedicated doctor always reports $\bar{q}$.

If $\bar{q}$ is exactly equal to q^b, there is a continuum of equilibria. Let p be a number in $[0, \frac{D}{D+M}]$. Each p indexes an equilibrium: the regulator audits a report $\bar{q}$ with probability p while each physician always reports $\bar{q}$. The regulator's payoff remains the same for each of these equilibria, while the moonlighter's payoff is decreasing in p.[8]

Consider a given audit cost γ. As the allowed quality increases from q^a, a moonlighter's equilibrium payoff increases until it reaches $c(q^b)$. Then at $\bar{q} = q^b$, the moonlighter's equilibrium payoff becomes a set $[\gamma, c(q^b)]$. Once $\bar{q} > q^b$, a moonlighter's equilibrium payoff is γ.

We now derive the mixing probabilities when $\bar{q} > q^b$. Let θ be the probability that a moonlighter reports $\bar{q}$, and $1 - \theta$ the probability he reports q^a. If the regulator is indifferent between performing an audit or not upon receiving report $q^r = \bar{q}$,

$$\gamma = \frac{\theta M}{D + \theta M} c(\bar{q}). \tag{3}$$

Let ϕ be the probability that the regulator performs an audit upon receiving report $q^r = \bar{q}$, and $1 - \phi$ the complementary probability. If a moonlighter is indifferent between reporting q^a and $\bar{q}$, then

$$c(q^a) = (1 - \phi)c(\bar{q}) \qquad \text{or} \qquad \gamma = (1 - \phi)c(\bar{q}). \tag{4}$$

Solving (3) and (4) for θ and ϕ, we have

$$\theta = \left[\frac{D}{M}\right]\left[\frac{\gamma}{c(\bar{q}) - \gamma}\right] \qquad\qquad \phi = 1 - \frac{\gamma}{c(\bar{q})}.$$

The probability of an audit, ϕ, is increasing in $c(\bar{q})$; a higher maximum reimbursed quality results in more frequent audits. The probability of a moonlighter reporting $\bar{q}$ is increasing in the ratio of dedicated physicians to moonlighters. In equilibrium, the regulator performs a total of $\phi[D + \theta M]$ audits. (Each dedicated physician reports $\bar{q}$, and with probability θ a moonlighter reports $\bar{q}$; these reports are audited with probability ϕ.)

Now, we can derive the regulator's objective function. Consumers' benefits are

$$D \int_{\underline{v}}^{\bar{v}} v\bar{q} f(v)\, dv + M \int_{\underline{v}}^{\bar{v}} v\underline{q} f(v)\, dv,$$

which results from the quality $\bar{q}$ from the dedicated physicians and quality $\underline{q}$ from the moonlighters.

When $\bar{q} > q^b$, audits occur in equilibrium. The total number of audits is $\phi[D + \theta M]$, which results in a cost of $\phi[D + \theta M]\gamma$. Using the values of θ and ϕ computed above, we find that the total audit cost is $D\gamma$, independent of $\bar{q}$. The payments to physicians plus audit cost are $[Dc(\bar{q}) + Mc(q^a)] + D\gamma$ if $\bar{q} > q^b$, which simplifies to

$$Dc(\bar{q}) + [D + M]\gamma.$$

Now, we can put the different contributions to welfare together to obtain the regulator's welfare index. If $\bar{q} \le q^b$, the welfare index that is associated with the continuation equilibrium outcome is

$$D \int_{\underline{v}}^{\bar{v}} v\bar{q} f(v)\, dv + M \int_{\underline{v}}^{\bar{v}} v\underline{q} f(v)\, dv - (D + M)c(\bar{q}) \equiv W^L(\bar{q}). \tag{5}$$

If $\bar{q} > q^b$, then the welfare index is

[8] By the definition of $c(q^b)$ in (2), the regulator is indifferent between auditing and not when all physicians report $\bar{q}$. When the regulator audits with a probability less than $\frac{D}{D+M}$, a moonlighter prefers to report $\bar{q}$ than q^a.

$$D\int_{\underline{v}}^{\bar{v}} v\bar{q} f(v)\,dv + M\int_{\underline{v}}^{\bar{v}} v\underline{q} f(v)\,dv - Dc(\bar{q}) - [D+M]\gamma \equiv W^H(\bar{q}) - [D+M]\gamma. \quad (6)$$

Consider the maximization of the concave functions W^L and W^H on $\bar{q} \geq q^a$ (ignoring the requirement that (5) applies only for $\bar{q} \leq q^b$, and that (6) applies only for $\bar{q} > q^b$). We assume that the value of q^a is sufficiently low that the maxima are achieved at values strictly higher than q^a. Then the following first-order conditions fully characterize the quality levels $\bar{q}^L$ and $\bar{q}^H$ which respectively maximize W^L and W^H on $\bar{q} \geq q^a$:

$$\int_{\underline{v}}^{\bar{v}} vf(v)\,dv = \left[1 + \frac{M}{D}\right] c'(\bar{q}^L), \quad (7)$$

$$\int_{\underline{v}}^{\bar{v}} vf(v)\,dv = c'(\bar{q}^H). \quad (8)$$

Clearly, $\bar{q}^L < \bar{q}^H$ from the convexity of c, and $W^L(\bar{q}^L) < W^H(\bar{q}^H)$. Next, define $\widehat{\gamma}$ by

$$[D+M]\widehat{\gamma} = W^H(\bar{q}^H) - W^L(\bar{q}^L). \quad (9)$$

We now can state the following result on the equilibrium quality when moonlighting is disallowed.

Proposition 1. The equilibrium quality is $\bar{q}^L$ if $\gamma > \widehat{\gamma}$; it is $\bar{q}^H$ if $\gamma < \widehat{\gamma}$. If $\gamma = \widehat{\gamma}$, either $\bar{q}^L$ or $\bar{q}^H$ is an equilibrium. That is, if the audit cost is low, the equilibrium quality chosen by the dedicated doctor is the higher value $\bar{q}^H$ while the regulator audits with a strictly positive probability. On the other hand, if the audit cost is high, the equilibrium quality chosen by the dedicated doctor is the lower value $\bar{q}^L$ while the regulator never audits.

Proof. See the Appendix.

Proposition 1 describes the equilibrium quality level when moonlighting is disallowed. If the audit cost γ is low, the regulator uses the audit mechanism in an equilibrium. In turn, a moonlighter's (expected) payoff is driven down to $c(q^a) = \gamma$; independent of which quality level dedicated physicians provide. Put another way, the use of audits makes the presence of moonlighters equivalent to a fixed cost; see (6). Thus, the equilibrium quality $\bar{q}^H$ is efficient in the sense that the equilibrium quality that the dedicated doctors choose maximizes the weighted average of net consumer surplus. On the other hand, if the audit cost is high, the regulator will not use the mechanism in an equilibrium. Now, implementing a higher quality level from the dedicated doctors requires giving a higher rent to the moonlighters. As a result, the marginal cost of quality becomes higher; see (5). The equilibrium quality level becomes lower compared to the case when audit cost is low.

In the public system, audits are costly, and punishments are limited. So moonlighters cannot be deterred from shirking. The presence of dedicated doctors is very important to the public system: they allow costly quality to be implemented. This benefits consumers, especially those who are poor.

4. Moonlighting equilibrium quality and welfare

■ We now consider equilibria when moonlighting is allowed. When a rich, financially unconstrained consumer with valuation v is matched with a moonlighter, the moonlighter decides whether to offer the consumer the private market option, and the consumer decides whether to accept it. If they agree on opting out, the outcome is a price-quality pair agreement (p, q) determined by the Nash bargaining solution.

The Nash bargaining solution depends on the allocation that maximizes the moonlighter and the consumer joint surplus as well as the disagreement point. The joint surplus is $vq - c(q)$. Let $q(v)$ maximize this joint surplus, and $S(v)$ the maximum surplus:

$$q(v) \equiv \text{argmax}_q \; vq - c(q) \quad \text{and} \quad S(v) \equiv vq(v) - c(q(v)). \tag{10}$$

This surplus is increasing in v, and at a rate $q(v)$ by the Envelope Theorem.

If the moonlighter and the consumer fail to reach an agreement, the consumer will be treated by the moonlighter in the public sector; this is the disagreement point. From the previous section, the moonlighter will choose the minimum quality there. So the disagreement payoff to a consumer is $v\underline{q}$. What is the disagreement payoff to the moonlighter? This is determined by the continuation equilibrium in the report-audit game. Suppose that the regulator has allowed a maximum reimbursement $c(\bar{q})$, and that there are a total of N reports for reimbursements. Of these N reports, D must have been made by the dedicated doctors (who do not work in the private market). The remaining, $N - D \equiv \widetilde{M}$, have been made by moonlighters who have not opted out of public service. The continuation game is then isomorphic to the one in the regime when moonlighting is disallowed if M in that section is now replaced by $\widetilde{M}$.[9]

From the previous section, a continuation equilibrium in the report-audit game has one of two equilibria for a given γ. In the first, when $c(\bar{q})$ is relatively low, the regulator does not audit any report. Each physician reports $c(\bar{q})$ and is reimbursed accordingly. In the second, when $c(\bar{q})$ is relatively high, the regulator audits with a strictly positive probability. Each moonlighter randomizes between reporting $c(q^a)$ and $c(\bar{q})$, and receives an expected payoff γ.[10]

According to the Nash bargaining solution, when their joint surplus is higher than the total disagreement payoff, the moonlighter and the consumer will opt for the private market. So they opt out when either $S(v) > v\underline{q} + c(\bar{q})$ or $S(v) > v\underline{q} + \gamma$. Now define valuation thresholds $\widehat{v}_L$ and $\widehat{v}_H$ by

$$S(\widehat{v}_L) \equiv \widehat{v}_L \, \underline{q} + \gamma \tag{11}$$

and

$$S(\widehat{v}_H) \equiv \widehat{v}_H \underline{q} + c(\bar{q}). \tag{12}$$

These thresholds are well defined because the joint surplus always increases in v faster than the total disagreement payoff. Because $c(\bar{q}) > \gamma$, we have $\widehat{v}_L \le \widehat{v}_H$.

How do the continuation equilibria in the report-audit game change as $\bar{q}$ increases? Suppose $\bar{q}$ is just slightly higher than q^a so that the regulator does not audit in equilibrium. Moonlighters who are matched with rich consumers with valuation $v \ge \widehat{v}_H$ opt for the private market. As $\bar{q}$ increases, but still not sufficiently high to trigger an equilibrium audit, the disagreement point becomes more attractive to the moonlighters. So the number of referrals actually decreases: $\widehat{v}_H$ increases with $\bar{q}$, and $F(\widehat{v}_H)$ increases too. In other words, as $\bar{q}$ increases, $M[0.5 + 0.5F(\widehat{v}_H)] \equiv \widetilde{M}$ increases, and the regulator receives more reports.

As $\bar{q}$ increases, an audit becomes more and more attractive to the regulator. When $\bar{q}$ reaches a certain level, then an audit becomes an optimal response. The critical quality q^c that triggers an audit is given by

$$\frac{\widetilde{M}}{D + \widetilde{M}} c(q^c) = \frac{M[0.5 + 0.5F(\widehat{v}_H)]}{D + M[0.5 + 0.5F(\widehat{v}_H)]} c(q^c) = \gamma, \tag{13}$$

where $S(\widehat{v}_H) \equiv \widehat{v}_H \underline{q} + c(q^c)$. (Equation (13) has a unique solution in q^c because the left-hand side of (13) is increasing in q^c.) When $\bar{q}$ is higher than this critical level, the regulator will audit with a positive probability in equilibrium. Here, the moonlighter's disagreement payment is only

[9] Because we have a continuum of physicians, a single moonlighter's referral decision cannot change the equilibrium history.

[10] We ignore the degenerate case when the values of $\bar{q}$ and γ imply a continuum of equilibria where moonlighters always report q^c and the regulator can use any auditing probability from 0 to $\phi(\bar{q}) = 1 - \frac{\gamma}{c(\bar{q})}$.

$\gamma < c(q^c)$, and those rich consumers with valuations above $\widehat{v}_L$ will agree to opt out of the public system.[11] We summarize the above in the following.

Lemma 4. Consider a subgame defined by the regulator's maximum allowed reimbursement $c(\bar{q})$. In a continuation equilibrium, if $\bar{q} < q^c$ (defined in (13)), the regulator does not audit. A moonlighter refers to the private market those rich consumers with valuations higher than $\widehat{v}_H$ (defined in (12)). If $\bar{q} > q^c$, the regulator audits with a strictly positive probability. A moonlighter who serves a consumer in the public system randomizes between reporting q^a and $\bar{q}$, and refers to the private market those rich consumers with valuations higher than $\widehat{v}_L$ (defined in (11)).

For $v > \widehat{v}_i, i = L, H$, the Nash bargaining solution yields the efficient quality $q(v)$ and a price $p(v)$. The consumer's utility is $vq(v) - p(v)$, and the moonlighter's utility is $p(v) - c(q(v))$. The price $p(v)$ determines the split of the surplus above the disagreement point utilities in the ratio α to $1 - \alpha$ for the consumer and the moonlighter, respectively.

For a given γ, we can now write down the consumer welfare index under moonlighting. When $\bar{q} \leq q^c$ (when the regulator does not audit a report in equilibrium), the welfare index in the continuation equilibrium is

$$D \int_{\underline{v}}^{\bar{v}} v\bar{q} f(v)\, dv + M \int_{\underline{v}}^{\bar{v}} v\underline{q} f(v)\, dv + \frac{M}{2} \int_{\widehat{v}_H}^{\bar{v}} \alpha[S(v) - v\underline{q} - c(\bar{q})] f(v)\, dv - \left[D + \frac{M}{2}[1 + F(\widehat{v}_H)]\right] c(\bar{q}), \tag{14}$$

where $\widehat{v}_H$ satisfies (12). The integrals describe, respectively, utilities of consumers matched with dedicated doctors, the base utilities of consumers matched with moonlighters, and the increment over the base utility when moonlighters refer rich consumers to the private market (which is the fraction α of the efficient surplus over the total disagreement payoffs). The last term is the total expenditure in the public system.

The consumer welfare when $\bar{q} > q^c$ (when the regulator audits with positive probability) in the continuation equilibrium is

$$D \int_{\underline{v}}^{\bar{v}} v\bar{q} f(v)\, dv + M \int_{\underline{v}}^{\bar{v}} v\underline{q} f(v)\, dv + \frac{M}{2} \left[\int_{\widehat{v}_L}^{\bar{v}} \alpha[S(v) - v\underline{q} - \gamma] f(v)\, dv\right] - \left[Dc(\bar{q}) + \frac{M}{2}[1 + F(\widehat{v}_L)]\gamma\right] - \gamma D, \tag{15}$$

where $\widehat{v}_L$ satisfies (11). The terms in the above have the analogous interpretation. Let $\bar{q}_M^L$ maximize (14) subject to $\bar{q} \leq q^c$, and $\bar{q}_M^H$ maximize (15) subject to $\bar{q} > q^c$. We can now state a result that corresponds to parts of Proposition 1.

Proposition 2. There exists $\widetilde{\gamma}$ such that

(i) If $\gamma > \widetilde{\gamma}$ or the audit cost is sufficiently high, the regulator does not audit a report, and the equilibrium quality is $\bar{q}_M^L$.
(ii) If $\gamma < \widetilde{\gamma}$ or the audit cost is sufficiently low, the regulator audits a report with a positive probability, and the equilibrium quality is $\bar{q}_M^H$.

Proof. See the Appendix.

We now characterize the properties of the equilibrium quality under moonlighting. To do this, we relate (14) and (15) with their counterparts under the regime when moonlighting is banned. After rearranging terms, we can rewrite (14) as

$$W^L(\bar{q}) + \frac{M}{2} \int_{\widehat{v}_H}^{\bar{v}} [\alpha[S(v) - v\underline{q}] + (1 - \alpha)c(\bar{q})] f(v)\, dv, \tag{16}$$

[11] Actually, as $\bar{q}$ increases beyond q^c from below, there is a discontinuous decrease in the number of reports.

where $W^L(\bar{q})$, given by (5), is the welfare index when the regulator does not audit in equilibrium in the regime where moonlighting is banned. Next, we express (15) as

$$W^H(\bar{q}) - (D + M)\gamma + \frac{M}{2}\int_{\widehat{v}_L}^{\bar{v}} [\alpha[S(v) - v\underline{q}] + (1 - \alpha)\gamma] f(v)\, dv, \tag{17}$$

where $W^H(\bar{q})$, given by (6), is the welfare index when the regulator audits in equilibrium in the regime where moonlighting is banned. The value of $\widetilde{\gamma}$ may be obtained by equating the maximized values of (16) and (17).

We can use these indexes to compare the equilibrium welfare across the two regimes, as follows.

Proposition 3. The equilibrium welfare must increase when moonlighting is allowed.

Proof. We show that for any given maximum allowed quality $\bar{q}$, the continuation equilibrium welfare must increase if moonlighting is allowed. It follows that the equilibrium welfare must be higher under moonlighting.

First, observe that for any given $\bar{q}$, the expression in (16) is higher than (5); they correspond to the continuation equilibrium welfare levels when the regulator does not audit in equilibrium. Similarly, the expression in (17) is higher than (6); they correspond to the continuation equilibrium welfare levels when the regulator audits in equilibrium. So if, for a given $\bar{q}$, the continuation equilibrium involves no change in equilibrium regulator audit strategy when the ban on moonlighting is lifted, equilibrium welfare increases.

It remains to consider cases where equilibrium audit strategies are switched. Suppose that for a given $\bar{q}$, the regulator audits in a continuation equilibrium when moonlighting is banned, but does not audit when the ban is lifted. The quality choice by dedicated physicians and moonlighters who serve consumers in the public system in the moonlighting regime remains the same as before moonlighting is allowed. Under moonlighting there are gains due to Nash bargaining from referrals to the private sector. The regulator not auditing a report is a cost saving. So the welfare index increases.

Finally, for a given $\bar{q}$, there does not exist a case of the regulator not performing an audit in a continuation equilibrium when moonlighting is banned but does so under moonlighting. This is because the regulator always receives fewer reports from moonlighters when moonlighting is allowed. With fewer reports from moonlighters, the regulator still will not audit when moonlighting is allowed. *Q.E.D.*

The proof of Proposition 3 uses a fixed maximum allowed quality level to illustrate the welfare improvement due to moonlighting. For any given $\bar{q}$, there are actually two potential efficiency gains when moonlighting is allowed. First, some moonlighters no longer work in the public sector, so payment of either γ or $c(\bar{q})$ to them (in exchange for their performing only $\underline{q}$) is unnecessary; this is a cost-saving effect. To see this formally, just consider the case of $\alpha = 0$; all incremental surplus in the private sector is now appropriated by moonlighters. The difference between (16) and (5) is now only the cost savings; similarly for the comparison between (17) and (6). We call this the cost-saving gain.

Second, when consumers and moonlighters contract in the private system, they reach an efficient quality level relative to the consumer's valuation. This is reflected in the increment of efficient surplus $S(v)$ over the disagreement payoffs. Consumers get a fraction α of this increment, and this accounts for those terms that involve α in either (16) or (17). We call this the surplus gain.

The two thresholds $\widetilde{\gamma}$ and $\widehat{\gamma}$ cannot be ranked generally. So allowing moonlighting may actually lead to the regulator auditing in equilibrium, or vice versa. Nor can the equilibrium allowed quality level across the regimes be ranked generally. In other words, the quality provided by dedicated physicians in the public sector may increase or decrease when moonlighting is allowed. Proposition 3 guarantees, however, that the aggregate consumer welfare must increase when moonlighting is allowed, even when those consumers who continue to get services in the public sector may be hurt.

When moonlighting is allowed, the regulator will oftentimes adjust the maximum allowed quality. The cost-saving and surplus gains are both affected by a change in $\bar{q}$. Consumers do not pay for services in the public system. So there is the classical moral hazard problem. Getting more (rich) consumers to the private market allows the realization of the surplus gain. To induce more consumers to leave the public system, the regulator must reduce $\bar{q}$ to implement a lower $\widehat{v}_H$.[12] On the other hand, the cost-saving gain lowers the marginal cost of implementing a given $\bar{q}$; this tends to raise the equilibrium $\bar{q}$.

Furthermore, raising $\bar{q}$ also has the effect of hurting the consumer's utility from the Nash bargaining outcome in those equilibria where the regulator does not audit reports. The consumer gets a fraction of the surplus over the disagreement point. A higher $\bar{q}$ gives a higher disagreement payoff to the moonlighter. So a higher $\bar{q}$ will indirectly lower the welfare index.

Because of these mixed effects of $\bar{q}$ on the consumer welfare index, the equilibrium quality may either increase or decrease when moonlighting is allowed. If the dedicated physician's equilibrium quality actually falls when moonlighting is allowed, those consumers who remain in the public sector become worse off. On the other hand, if $\bar{q}$ is raised as a result of moonlighting, all consumers are better off than without moonlighting.

The expression in (17) is concave in $\bar{q}$. In fact, $\bar{q}^H_M$ is given by $\int_{\underline{v}}^{\bar{v}} vf(v)\,dv = c'(\bar{q}^H_M)$, exactly the same as the equilibrium quality in the non-moonlighting regime when the audit cost is sufficiently low.[13] We can state the following result (proof omitted).

Proposition 4. Suppose that $\gamma < \min\{\widehat{\gamma}, \widetilde{\gamma}\}$; then allowing moonlighting does not change the equilibrium quality $\bar{q}^H_M = \bar{q}^H$. Because the dedicated physicians' equilibrium quality remains unchanged, all consumers have higher expected utility when moonlighting is allowed.[14]

We stated earlier that one of the goals of the public system is to provide health services to poor consumers. The public system, while providing care to the poor, cannot tailor quality levels to particular consumers. So there may be some tradeoff to consider if it is to be compared to a completely private system. The analysis of a completely private system is out of the scope of the current article. However, we can offer some comparison that is based on the equilibria of the moonlighting regime.

We do not fully model how consumers and doctors interact in a purely private market. Instead, we retain many of the properties of the moonlighting regime and offer a sufficient condition so that a public system helping the poor, despite its imperfection, is better than a fully efficient private market that only provides for the rich. To this end, we assume that if there were a private market, all rich consumers would be randomly matched to doctors and would be treated (there being more doctors than rich consumers). We assume the same preferences: dedicated physicians provide efficient qualities at cost, whereas moonlighters provide efficient qualities and keep part of the surplus, as in the moonlighting regime in this section.

The welfare that results from such a private system is

$$0.5N\left[\frac{D}{D+M}\int_{\underline{v}}^{\bar{v}} S(v)f(v)\,dv + \frac{M}{D+M}\int_{\underline{v}}^{\bar{v}} \alpha S(v)f(v)\,dv\right]. \qquad (18)$$

These terms result from the half of all N consumers being randomly matched with dedicated physicians and moonlighters. Each physician generates a surplus $S(v)$; dedicated physicians are only reimbursed for the cost, whereas moonlighters keep $(1-\alpha)$ of the surplus. The following condition specifies that welfare in the purely private market is lower than the public system with moonlighting.

[12] Note that $\widehat{v}_L$ is independent of $\bar{q}$.

[13] The expression in (16) is not necessarily concave in $\bar{q}$ even when $W^L(\bar{q})$ is. So, the first-order condition will be necessary for an interior maximum but may not be sufficient for the characterization of $\bar{q}^L_M$.

[14] The expectation of consumer's utility is taken before each is matched to any physician.

Condition (C0). The equilibrium welfare of public system with moonlighting, expression (14) evaluated at $\bar{q}_M^L$ when $\gamma > \widetilde{\gamma}$ or expression (15) evaluated at $\bar{q}_M^H$ when $\gamma < \widetilde{\gamma}$, achieves a higher welfare than the welfare in the pure private market in (18).

Condition (C0) likely holds when either α or γ is small. We have based the comparison on a population of an equal mix of rich and poor consumers; clearly, if there were more poor consumers, Condition (C0) would hold more often.

5. Private information and moonlighting

■ We have assumed that when the consumer meets with a moonlighter, they share the same information. Nevertheless, when a moonlighter and a consumer negotiate under asymmetric information, must moonlighting increase welfare? We consider two alternative asymmetric information situations. First, only consumers know their true valuations of quality. Second, a moonlighter knows the consumer's valuation, and only a fraction of consumers are informed of their own valuations. Both are plausible assumptions. In the first case, consumers' valuations may be related to how much treatment could improve their daily lives, which moonlighters may not know. In the second scenario, doctors have expert knowledge and information about consumers' illness; through diagnosis, doctors gain private information about the value of treatment. Although consumers also learn about the diagnosis, some may not fully understand and do not know their valuations

We now define the extensive form. Under each of the informational assumptions, the moonlighter makes an offer of a price-quality pair (or a menu of such pairs), which the consumer may accept or reject. If there is an acceptance, the treatment is provided by the moonlighter in the private sector under the terms of the offer. If there is a rejection, the moonlighter treats the consumer in the public system at the minimum quality $\underline{q}$, while the consumer incurs no cost.

Now we argue that consumer welfare becomes higher when moonlighting is allowed. The key to the argument is a consumer's option of rejecting the moonlighter's offer. Suppose that consumers' valuations are their own private information. A moonlighter's offer of price and quality will lead to either acceptance or rejection. A higher price leads to a higher profit but a lower likelihood of acceptance; conversely, a higher quality leads to a lower profit but a higher likelihood of acceptance. The moonlighter finds the optimal tradeoff to maximize his expected profit. Reacting against any moonlighter's offer optimally, a consumer must be better off accepting the moonlighter's offer than staying in the public system.

Next, suppose that the moonlighter learns a consumer's valuation, but the consumer may be uninformed. Consider an equilibrium.[15] Here, an uninformed consumer must infer the moonlighter's private information given the moonlighter's price-quality offer (or menu of offers). In an equilibrium, the consumer must not be mistaken about the moonlighter's strategy. For example, in an equilibrium, a moonlighter may make some offer of price and quality if and only if the consumer's valuation is above a certain threshold. Assuming this moonlighter strategy, the consumer infers that her valuation must be above the threshold, compares the expected utilities of remaining in the public system and opting out, and chooses among them optimally. If the consumer participates in moonlighting in an equilibrium, she must become better off.

To see that moonlighting must raise consumer welfare under either of these informational regimes, again use the fact that the regulator can maintain the same equilibrium $\bar{q}$ as when moonlighting is banned. Whenever a consumer and a moonlighter mutually agree to opt out of the public system in an equilibrium, there must be some mutually beneficial expected gain, and both must be better off. When the maximum quality remains unchanged, those consumers who remain in the public system are not made worse off. Welfare must increase in any equilibrium.

[15] There may be multiple equilibria. Our argument applies to each of them. There may also be trivial equilibria in which the moonlighting market is inactive, but our point is not to rank all equilibria when moonlighting is allowed.

6. Physician reactions and price regulation

■ We have depicted moonlighting simply as permitting a physician in a public facility to refer a consumer for treatment in a private setting. Nevertheless, moonlighting may bring more complex effects, a worry that appears in policy discussions. In this section, we consider two such effects: shirking by moonlighters and adverse reactions by dedicated doctors. We then introduce price regulation in the private market as a policy counteracting these effects. In this section, for expositional reasons, we assume for the main part of the analysis that the auditing costs are sufficiently high so that audits are never performed in equilibrium. If auditing costs were low so that audits would be performed, then the regulator would use the audit as an extra instrument to control physician behavior, but, as we argue later, this would not change the qualitative results that price controls in the private market improve consumer surplus.

□ **Shirking by moonlighters.** In the basic model, when a moonlighter treats a consumer in the public system, he always chooses a minimum quality level. So far we have assumed that this remains a moonlighter's quality provision when moonlighting is allowed. Now, we let the moonlighter reduce this quality level when moonlighting is allowed. This may simply be a "crowding-out" effect. To save time and energy for the private market, a moonlighter may decide to reduce the quality in the public sector. Formally, this effect can be studied by lowering the level of $\underline{q}$ once moonlighting is allowed; we call this shirking in the public sector by moonlighters.

Our concern is not to measure the extent of shirking so that moonlighting becomes undesirable. Nor do we find it very important to install another margin for a moonlighter's choice of shirking which reflects precisely his cost-benefit tradeoff. Rather, we are interested in exploring the use of price regulation in the private market to limit shirking in the public sector. It is enough for our purpose to assume that the extent of shirking is directly related to the potential moonlighting profit. For example, when moonlighting is permitted, a moonlighter will work harder in the private market when profit opportunities there are higher. As a result, he will shirk more in the public sector, hurting consumers there.

We consider a price-ceiling regulation: let $\bar{p}$ be the maximum price for health treatment in the private sector. When a moonlighter and a consumer agree to a treatment in the private market, they agree on the quality but the price cannot be higher than $\bar{p}$. We assume that the range of the price ceiling is $[c(\underline{q}), \widehat{p}]$, where $\widehat{p}$ is the highest price under the Nash bargaining solution between a (rich) consumer and a moonlighter when there is no restriction in the private market.[16] Any price ceiling in the assumed range will restrict the Nash bargaining between a moonlighter and a consumer. The lower the price ceiling, the less freedom there is for private contracting.

We assume that a moonlighter shirks by an amount $\sigma(\bar{p})$ when the price ceiling is $\bar{p}$, where the shirking function σ is strictly increasing for any $\bar{p}$ in $[c(\underline{q}), \widehat{p}]$, with $\sigma(c(\underline{q})) = 0$.[17] For a given price ceiling $\bar{p}$ in the private sector, a moonlighter provides services at the public sector at quality $\underline{q} - \sigma(\bar{p})$. Again, the increasing shirking function captures the idea that the moonlighter's opportunity cost of providing services in the public sector increases when there is more flexibility for private contracting.

Now we study moonlighting equilibria when prices in the private market must not exceed the ceiling. We begin by modifying the Nash bargaining solution. As before, if a moonlighter and a consumer fail to agree on a contract for private service, the moonlighter will provide service in the public sector. Now, the quality of this service will be $\underline{q} - \sigma(\bar{p})$. At the disagreement point, the moonlighter's payoff is $c(\bar{q}) - c(\underline{q} - \sigma(\bar{p})) \equiv D_m$, while the consumer's is $v(\underline{q} - \sigma(\bar{p})) \equiv D_c$. If there is an agreement, the moonlighter provides treatment at quality q at price $p \leq \bar{p}$. The

[16] Note that we suppress $\widehat{p}$ dependence on $\bar{q}$.

[17] It may also be convex, but our analysis does not rely on this.

Nash bargaining outcome (p, q) is characterized by the solution of the following maximization program:

$$\max_{p,q} \ \alpha \ln(vq - p - D_c) + (1 - \alpha) \ln\{p - c(q) - D_m\} \tag{19}$$

subject to $p \leq \bar{p}$. The following presents the Nash bargaining outcomes.

Lemma 5. For low values of v, the price ceiling does not bind, and the quality is efficient: $v = c'(q)$; the quality is increasing in v. For those values of v higher than a threshold, the price ceiling binds, and the quality becomes inefficiently low: $v > c'(q)$; the quality is decreasing in v beyond the threshold.

Proof. See the Appendix.

When the value of v is low, consumers and moonlighters will not be restricted by the price ceiling $\bar{p}$; the price to split the surplus from the efficient quality ($v = c'(q)$) is below $\bar{p}$. As the value of v increases, the efficient quality and the price both rise. Beyond some threshold, the price ceiling becomes binding: the price must not rise above $\bar{p}$ even for higher values of v. Nevertheless, a higher value of v implies a bigger surplus—even when q remains constant. The Nash bargaining solution insists on splitting the surplus (above the disagreement point) in a fixed ratio. So the value of q in the agreement must begin to fall so that the moonlighter's utility, $\bar{p} - c(q)$, may increase.[18]

Once the price ceiling binds, the extent of inefficiency is increasing in v. The lower the ceiling, the more likely the moonlighter will supply inefficient quality to consumers in the private market. On the other hand, a lower price ceiling implies less shirking in the public market. This is the tradeoff that a price ceiling introduces.

We can describe the consumer surplus given a price ceiling $\bar{p}$. There will be two consumer thresholds, v^1 and v^2 with $v^1 < v^2$. Consumers will be offered a private-practice option if and only if their valuations are higher than v^1. For those consumers with $v \geq v^1$, there are two possibilities. If their valuations are not very high, $v < v^2$, the price ceiling does not bind, and they receive efficient quality from moonlighters in the private market. If their valuations are higher than v^2, they receive an inefficient quality from the moonlighters, given by (A2) from the Appendix. We will use $CS(v)$ to denote the consumer surplus in the private market for those consumers with v in $[v^1, v^2]$, and $\overline{CS}(v)$ to denote the consumer surplus for $v > v^2$. The consumer surplus under moonlighting is

$$\begin{aligned} &D \int_{\underline{v}}^{\bar{v}} (v\bar{q} - c(\bar{q})) f(v)\, dv + \frac{M}{2} \int_{\underline{v}}^{\bar{v}} (v(\underline{q} - \sigma(\bar{p})) - c(\bar{q})) f(v)\, dv \\ &+ \frac{M}{2} \left[\int_{\underline{v}}^{v^1} (v(\underline{q} - \sigma(\bar{p})) - c(\bar{q})) f(v)\, dv + \int_{v^1}^{v^2} CS(v) f(v)\, dv + \int_{v^2}^{\bar{v}} \overline{CS}(v) f(v)\, dv \right]. \end{aligned} \tag{20}$$

In the above expression, the first two terms refer to the welfare from dedicated doctors and from moonlighters providing quality $\underline{q} - \sigma(\bar{p})$ to poor consumers, while the terms in brackets list the welfare from moonlighters treating rich consumers in the public and private sectors, respectively.

The imposition of the price ceiling represents an intermediate institution of the two polar regimes where the moonlighting practice is completely banned and where it is uncontrolled. If the price ceiling is high, moonlighters freely contract with consumers in the private market, resulting in high efficiency there, but this implies a high level of shirking by moonlighters in the public sector. If the price ceiling is low, moonlighters do not find it very worthwhile to participate in the private market, but the level of shirking in the public system will be minimal.

[18] Consumers with high v will not prefer to forgo the private market opportunity even when they receive inefficient quality from moonlighters. The reason is that the total surplus is increasing in v and the moonlighters receive only a fraction of the incremental surplus.

An optimal choice of the price ceiling balances the inefficiency in the quality for consumers with high valuations against the lower quality received by rich consumers with lower valuations and the poor who are treated by moonlighters in the public sector. We use an envelope argument to establish that an optimal price ceiling will be in the interior of $[c(\underline{q}), \widehat{p}]$. At $\bar{p} = \widehat{p}$, contracting in the private market is unlimited. Consider reducing the price ceiling $\bar{p}$ from $\widehat{p}$ by an infinitesimal amount. This will only affect the consumers with the highest valuations; these consumers, according to the Nash bargaining solution, receive the efficient quality level. After the reduction in the price ceiling, these consumers will receive a slightly lower quality, but this will be a second-order loss. On the other hand, a lower price ceiling reduces shirking for all consumers who receive treatment in the public sector by moonlighters. This is a first-order gain. As a result, total welfare in (20) improves. A sufficient condition for an effective price ceiling is $F(\widehat{v}_H)\sigma'(\widehat{p}) > f(\bar{v})[CS(\bar{v}) - \overline{CS}(\bar{v})]$. This condition is satisfied, as $CS(\bar{v}) - \overline{CS}(\bar{v})$ is infinitesimal at the highest effective price ceiling.

When auditing costs are low, an audit will be used with positive probability by the regulator, and the results are qualitatively similar. In the private market, the moonlighter's disagreement utility does not change with the price ceiling. Let the regulator maintain the same maximum allowed reimbursement in the public sector $c(\bar{q})$. Thus, only consumers who meet moonlighters are affected: those with the highest valuation suffer a second-order loss as before, when the price ceiling is reduced from $\widehat{p}$; all consumers who use the private sector benefit from a first-order gain as a result of an increase in their disagreement utility; all consumers who are treated in the public sector also receive a first-order gain as a result of the reduction in shirking. The total auditing cost remains the same. Thus, we have the following result.

Proposition 5. Suppose moonlighters may shirk by lowering quality below $\underline{q}$, and the amount of shirking is directly related to the maximum price they can charge in the private sector. There exists a price ceiling $\bar{p}$ in the private market such that consumer surplus is higher than when either moonlighting is banned or moonlighting is allowed without any binding price restriction.

□ **Adverse reaction by dedicated doctors.** Moonlighting may affect dedicated doctors' behavior. Seeing that some colleagues earn more money from private practice, a dedicated doctor may feel unappreciated. The dissatisfaction may lead him to refuse to perform the recommended quality. We model the adverse reaction by postulating that a fraction η of dedicated doctors become moonlighters; they provide quality $\underline{q}$ in the public sector, and self-refer consumers to the private sector.[19] As in the previous subsection, we consider price regulation and assume that the dedicated doctors' defection rate $\eta(\bar{p})$ is nondecreasing in the price ceiling $\bar{p}$ for the private market. This assumption can be motivated as in the previous subsection: profit opportunities in the private sector are "temptations" that lure dedicated doctors to consider moonlighting. These profit opportunities in the private sector are rising in the price ceiling and falling in the recommended quality in the public sector.

We assume $\eta(\widehat{p}) = 1$; if there is no effective price ceiling, all dedicated doctors become moonlighters. We make this assumption for expositional ease; we only need a sufficiently high percentage of dedicated doctors becoming moonlighters. Below we will make assumptions about the defection rate of dedicated doctors for low price ceilings. We believe that when the private market is constrained by a low price ceiling, there will be a very small defection rate among dedicated doctors. The profit opportunity in the private market is lower with a low price ceiling, and dedicated doctors have little temptation to become moonlighters.

[19] An alternative assumption is that a fraction of dedicated doctors choose to act like moonlighters in the public system but do not practice in the private sector. The qualitative results are the same as with the approach that we use.

Consumer welfare in this case is

$$[1-\eta(\bar{p})]D\int_{\underline{v}}^{\bar{v}}(v\bar{q}-c(\bar{q}))f(v)\,dv+\left[\frac{M+\eta(\bar{p})D}{2}\right]\left[\int_{v^1}^{v^2}CS(v)f(v)\,dv+\int_{v^2}^{\bar{v}}\overline{CS}(v)f(v)\,dv\right]$$
$$+\left[\frac{M+\eta(\bar{p})D}{2}\right]\left[\int_{\underline{v}}^{v^1}(v\underline{q}-c(\bar{q}))f(v)\,dv+\int_{\underline{v}}^{\bar{v}}(v\underline{q}-c(\bar{q}))f(v)\,dv\right].$$

In this expression, only $1-\eta(\bar{p})$ of the dedicated doctors provide services at the recommended quality level; this accounts for the first term. The next terms are the consumer surplus in the private and the public sectors generated by the moonlighters and those dedicated doctors who have become moonlighters.

We now argue that an effective price ceiling improves consumer welfare. If the price ceiling is set at $\widehat{p}$, by assumption, all dedicated doctors become moonlighters. So all poor consumers receive the minimum quality, as do those rich consumers with low valuations. We now impose a condition such that $\widehat{p}$ will not be a chosen price ceiling. This condition says that consumer surplus is decreasing in the proportion of moonlighters; that is, if we replace a dedicated doctor by a moonlighter, the equilibrium consumer surplus falls. A sufficient condition for this to hold occurs when the share of the surplus in the private market gained by a consumer, α, is small. The welfare expressions (14) and (15) can be used to verify this; simply replace D by $D-\epsilon$, and M by $M+\epsilon$ in these expressions. Then partially differentiate with respect to ϵ. We state this assumption as follows.

Condition (C1). The equilibrium welfare of a moonlighting regime in a public system consisting of $M+D$ moonlighters and no dedicated physicians is less than a banned moonlighting regime in a public system consisting of D dedicated physicians and M moonlighters.

By Condition (C1), the welfare of an unrestricted moonlighting regime from a public system consisting of $M+D$ moonlighters is less than that of a banned moonlighting regime from a public system having M moonlighters and D dedicated doctors. Therefore, the regulator will not set a price ceiling so high that all dedicated physicians have defected to become moonlighters.

Consider the lowest price ceiling that allows the moonlighting market to operate.[20] This price ceiling, denoted $\bar{p}_L$, will be above $c(\bar{q})$ (when auditing does not occur in equilibrium), and allows consumers with the highest valuation to contract with a moonlighter for a service in the private sector. We now state as follows.

Condition (C2). In the moonlighting regime, equilibrium consumer surplus is increasing at the price ceiling that just shuts down the private market. The mathematical equivalent is

$$0.5[M+\eta'(\bar{p}_L)D]f(\bar{v})\left[\overline{CS}(\bar{v})+c(\bar{q})\right]>\eta'(\bar{p}_L)D\int_{\underline{v}}^{\bar{v}}v(\bar{q}-\underline{q})f(v)\,dv. \tag{21}$$

In (21), the marginal gain from raising price ceilings is the probability that a moonlighter matches with a rich consumer with the highest valuation, $0.5[M+\eta'(\bar{p}_L)D]f(\bar{v})$, multiplied by the sum of consumer surplus and cost savings, $\overline{CS}(\bar{v})+c(\bar{q})$. There is a loss when a dedicated doctor becomes a moonlighter: he performs the service at $\underline{q}$ instead of $\bar{q}$. The marginal expected loss when the price ceiling is raised from $\bar{p}_L$ is given by the right-hand side of (21). When Condition (C2) holds, the regulator does not impose a price ceiling below $\bar{p}_L$ to shut down moonlighting; Condition (C2) is sufficient, but not necessary. Inequality (21) is satisfied when η' tends to 0 as $\bar{p}$ tends to $\bar{p}_L$ from above; that is, as the price ceiling is raised, the dedicated

[20] This price ceiling generally depends on the maximum allowed reimbursement level $c(\bar{q})$, which we will keep constant here.

doctors must not become moonlighters at a very fast rate. As before, similar arguments hold when auditing occurs in equilibrium.

In summary, we have the following.

Proposition 6. Suppose that dedicated doctors may react to moonlighting adversely by reducing quality in their public service and by participating in moonlighting, and that the percentage of dedicated doctors who react adversely is nondecreasing in the price ceiling in the private market. Under Conditions (C1) and (C2), an effective price ceiling results in a higher consumer surplus than when moonlighting is allowed without any price is restricted or banned.

7. Concluding remarks

■ We have analyzed a model where some physicians may refer patients in the public system to their private practice. These moonlighters provide minimal quality when they treat patients in the public system. Not all physicians moonlight, however; dedicated doctors provide good service in the public system. We showed that absent behavioral reactions, unregulated moonlighting raises aggregate consumer welfare. Moonlighting may have an ambiguous effect on qualities in the public system; some consumers may become worse off when they are treated in the public system as a result of physician moonlighting. Our results are based on the gains from trade in the private market. Asymmetric information considerations do not alter these results. If there are adverse behavioral reactions by physicians, setting a price ceiling in the private sector improves welfare by mitigating these reactions, even though it reduces the efficiency of the moonlighting option.

Physicians in our model exhibit various behaviors; in reality, the range of these behaviors can be even wider. For example, when moonlighting is allowed, some dedicated doctors may choose not to moonlight, but still reduce the quality in the public sector; or they may moonlight but continue to provide good quality in the public system. Our main qualitative features would hold under each of these reactions.

We can use the model as a framework to study creaming problems. Although we have concentrated on quality efficiency issues, cost variations have been ignored. Physicians' referring less costly patients to their private clinics may well be among the consequences of moonlighting. Referrals can also occur in the opposite direction. A moonlighter who sees a patient in his private practice may refer her to the public system because her treatment cost is too high. Selection of patients and the distribution of their costs across the public and private sectors can be examined.

Our framework can be used to study other issues. First, moonlighting may also change the total physician supply; some doctors may quit the public service altogether. We may also consider how moonlighters compete with other physicians who only work in the private sector. Our modelling approach can accommodate these considerations. It would be interesting to analyze a general equilibrium model of private and public sectors. Second, while we have considered price ceilings in the private sector, moonlighting restrictions may come from maximum quantities of private services that can be performed over a period of time. Alternatively, physicians may be limited by a maximum income they can earn through moonlighting. Finally, we have not considered complementary inputs (such as nurses and medical supplies) and technologies. In some countries, technology in the public sector is thought to be superior to the private sector; complementary inputs may also be better there. On the other hand, waiting time in the public system is longer. Opting out of the private market may result in shorter waiting times but treatment protocols with less complementary services. Moonlighting lets consumers and physicians explore tradeoffs in different dimensions.

Our idea here highlights the incentive perspective when public and private sectors interact.[21] It also hints at a potential role for the public sector as a workplace to attract dedicated workers.

[21] Ma (2004) considers how public rationing may increase private incentives for cost efficiency.

Integrating these ideas in a model for the public sector may be interesting. Besley and Ghatak (2005) examine some of these issues.

As we have commented in the Introduction, the theoretical literature on dual job incentives in the mixed economy is small. We have studied referral and quality questions. We hope that other researchers will find our model useful for thinking about other questions concerning moonlighting in the mixed economy.

Appendix

■ Proofs of Propositions 1–2 and Lemma 5 follow.

Proof of Proposition 1. First, for any q, we have $W^L(q) = W^H(q) - Mc(q)$. From the definitions of $\bar{q}^L, \bar{q}^H$, and $\widehat{\gamma}$, $W^H(\bar{q}^H) - [D + M]\gamma < W^L(\bar{q}^L)$ if and only if $\gamma > \widehat{\gamma}$.

Now suppose that $\gamma > \widehat{\gamma}$; we show that in fact $\bar{q}^L < q^b$, and hence indeed $W^L(\bar{q}^L)$ is the maximum welfare index. If $\gamma > \widehat{\gamma}$,

$$\gamma > \frac{W^H(\bar{q}^H) - W^L(\bar{q}^L)}{D + M}.$$

From the definition of q^b, and $\gamma > \widehat{\gamma}$, we have

$$\frac{M}{D + M}c(q^b) = \gamma > \frac{W^H(\bar{q}^H) - W^L(\bar{q}^L)}{D + M}.$$

From $W^L(\bar{q}^L) = W^H(\bar{q}^L) - Mc(\bar{q}^L)$, the last expression simplifies to

$$\frac{M}{D + M}\left[c(q^b) - c(\bar{q}^L)\right] > \frac{W^H(\bar{q}^H) - W^H(\bar{q}^L)}{D + M} \geq 0,$$

where the last inequality follows from the definition of $\bar{q}^H$. Hence we have $\bar{q}^L < q^b$. We conclude that $\bar{q}^L$ maximizes the welfare when $\gamma > \widehat{\gamma}$.

Now consider $\gamma < \widehat{\gamma}$; we have $W^H(\bar{q}^H) - [D + M]\gamma > W^L(\bar{q}^L)$. From the definition of q^b, we have

$$\frac{M}{D + M}c(q^b) = \gamma < \frac{W^H(\bar{q}^H) - W^L(\bar{q}^L)}{D + M}.$$

From $W^H(\bar{q}^H) = W^L(\bar{q}^H) + Mc(\bar{q}^H)$, the last expression simplifies to

$$0 \leq \frac{W^L(\bar{q}^L) - W^L(\bar{q}^H)}{D + M} < \frac{M}{D + M}[c(\bar{q}^H) - c(q^b)],$$

where the first inequality follows from the definition of $\bar{q}^L$. Hence we have $\bar{q}^H > q^b$. We conclude that $\bar{q}^H$ maximizes the welfare when $\gamma < \widehat{\gamma}$. *Q.E.D.*

Proof of Proposition 2. First, the expression in (15) is strictly decreasing in γ. This is because from (11) we know that $\widehat{v}_L$ is increasing in γ, whereas the partial derivatives of (15) with respect to $\widehat{v}_L$ and γ are both negative. Furthermore, observe that the value of $\bar{q}^H_M$ does not depend on γ: in (15) $\bar{q}$ is separable from γ. So the optimized value of (15) is strictly decreasing in γ.

Second, the expression in (14) is independent of γ. The definition of $\widehat{v}_H$ in (12) is also independent of γ. So the value of γ only determines the constraint set: $\bar{q} \leq q^c$. From (13), we can show that q^c is increasing in γ. So as γ falls, the constrained set becomes smaller. So the optimized value of (14) is nondecreasing in γ.

Combining the above properties of the maximized values of (14) and (15), we know that as γ decreases from a high value, eventually the maximized value of (15) must overtake that of (14). Once this happens, the ranking will remain because of the monotonicity of (14) and (15) in γ. *Q.E.D.*

Proof of Lemma 5. The properties of the Nash bargaining solution for low values of v follow directly from those properties of the solution when there is no price ceiling. To derive the properties when the ceiling binds, consider now the Kuhn-Tucker conditions with respect to p and q, respectively:

$$\frac{-\alpha}{vq - \bar{p} - D_c} + \frac{1 - \alpha}{\bar{p} - c(q) - D_m} > 0 \tag{A1}$$

$$\frac{\alpha v}{vq - \bar{p} - D_c} - \frac{(1 - \alpha)c'(q)}{\bar{p} - c(q) - D_m} = 0. \tag{A2}$$

The inequality (A1) comes from the binding price ceiling $\bar{p}$; the equality (A2) describes the Nash bargaining solution for q. Combining these two yields the inequality $v > c'(q)$. To see that the Nash bargaining solution prescribes a q decreasing in v in this range, observe that the cross-partial derivative of the objective function (19) with respect to q and v is negative.

This can be confirmed by differentiating the left-hand side of (A2) (which is the derivative of (19) with respect to q) with respect to v to obtain

$$\frac{-\alpha(\bar{p} + D_c)}{(vq - \bar{p} - D_c)^2} < 0.$$

So an increase in v will decrease q. *Q.E.D.*

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