GATEKEEPING IN HEALTH CARE

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Abstract

We study the competitive effects of restricting direct access to secondary care by gatekeeping, focusing on the informational role of general practitioners (GPs). In the secondary care market there are two hospitals choosing quality and specialisation. Patients, who are ex ante uninformed, can consult a GP to receive an (imperfect) diagnosis and obtain information about the secondary care market. We show that hospital competition is amplified by higher GP attendance but dampened by improved diagnosing accuracy. Therefore, compulsory gatekeeping may result in excessive quality competition and too much specialisation, unless the mismatch costs and the diagnosing accuracy are sufficiently high. Second-best price regulation makes direct regulation of GP consultation redundant, but will generally not implement first-best.

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1 Introduction

The UK and the Scandinavian countries are examples of countries where general practitioners (GPs) have a gatekeeping role in the health care system. Patients do not have direct access to secondary care. They need a referral from their (primary care) GP to get access to a hospital or a specialist.[1] In the US, several health maintenance organisations (HMOs) also practice gatekeeping. Recently, however, some HMOs have relaxed the restrictions on access to specialists (see, e.g., Ferris et al., 2001). In Germany, patients need a referral to get access to a hospital and it has been on the political agenda to also restrict direct access to specialist care by giving GPs a gatekeeper role. The current paper contributes to the discussion on gatekeeping by analysing the competition effects that arise when GPs are equipped with a gatekeeping role.

In general, there are two main arguments for introducing gatekeeping in health care markets (see Scott, 2000). First, it is usually claimed that gatekeepers contribute to cost control by reducing 'unnecessary' interventions.[2] Second, it is argued that secondary care is used more efficiently since 'GPs usually have better information than patients about the quality of care available from secondary care providers' (Scott, 2000, p. 1177). In the present paper we focus on the second argument, highlighting the fact that making this information available to patients changes the nature of competition between secondary care providers, which in turn affects the social desirability of gatekeeping.

As pointed out in a seminal paper by Arrow (1963), uncertainty and various informational problems make health care markets distinctly different from most other markets. The present paper stresses the importance of non-price competition between health care providers, as well as the role of imperfect information in the relationship between patients and providers. Building on the familiar model of Hotelling (1929), we consider a secondary care market with two providers (hospitals). In order to attract patients (and obtain third party payments) the hospitals have two strategic variables at their disposal:

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[1] In Sweden, though, individuals have direct access to hospital outpatient care, but still need a referral if hospitalisation is required.

[2] Although this is a common argument for restricting access to secondary care, the empirical evidence that gatekeeping actually contributes to lower health care expenditures seems to be scarce (see, e.g., Barros, 1998).

location and quality of care. We refer to location as the specialisation or service mix at a hospital, though it may also be interpreted in geographical terms. Thus, hospitals engage in non-price competition in terms of both horizontal and vertical differentiation of services.

The major aim of the paper is to highlight the informational role of GP gatekeepers in secondary care markets. We assume that patients are ex ante uniformed about their specific diagnosis and the exact characteristics of the hospitals. Thus, if they access secondary care providers directly, their choices may be subject to substantial errors. First, a patient may end up in a poor match, i.e., he may choose the hospital that is less able to cure his disease. Second, he may decide to go to the hospital that provides the lower quality of care. To reduce the risk of choosing the 'wrong' hospital, patients may therefore (at some costs) consult a GP first. The GPs are informed agents (middlemen) and convey accurate information about hospital characteristics, i.e., quality and specialisation. They also give attending patients a noisy diagnosis. Thus, the GPs are imperfect agents in the sense that diagnosing accuracy is not perfect.[3] When deciding whether to consult a GP or to approach a hospital directly, patients weigh the consulting costs against the reduction in (expected) mismatch costs due to better information.

The analysis is focused on two basic questions. (i) How does GP gatekeeping affect hospitals' incentives to specialise and to invest in quality? (ii) Is strict gatekeeping – i.e., no access to secondary care without a GP referral – socially desirable? The answers to these two questions are closely connected. Concerning the first question, we show that a higher GP attendance rate amplifies quality competition and induces the hospitals to specialise their services. The former is explained by the fact that informed patients are sensitive to quality differences, while uninformed patients are not. The latter is due the fact that hospitals can dampen quality competition by specialising their services.[4]

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[3] Diagnosing accuracy may be determined by several factors like a GP's skills, a GP's effort, a patient's disease type, etc. The physician agency literature analyses in detail strategic reasons for GPs to make false reports or to exercise inappropriate levels of effort (see McGuire, 2000, for an overview). Below we discuss the part of this literature which is relevant for gatekeeping.

[4] A completely analogical feature is present in the location-price game by D'Aspremont et al. (1979), where firms differentiate (specialise) to soften price competition. Like in their paper, the dampening-of-competition effect dominates the countervailing market-expanding effect of locating closer to your rival. For a more detailed discussion, see Brekke et al. (2005).

Interestingly, the other information variable – diagnosing accuracy – has the exact opposite effect. When diagnosing accuracy is low, patients attending a GP put a larger weight on quality differences than hospital specialisations, since the probability of a wrong diagnosis is high. As a consequence, improved diagnosing accuracy tends to weaken quality competition and, in turn, the corresponding incentives for specialisation. However, improved diagnosing accuracy also increases the benefit of consulting a GP, leading to higher GP attendance, which, in turn, increases hospital competition. Thus, when the patients' decision of whether or not to attend a GP is endogenised, the latter (indirect) effect of improved diagnosing accuracy on hospital competition tends to counteract the former (direct) effect.[5]

Regarding the second question, we show that strict gatekeeping is detrimental to welfare unless mismatch costs and diagnosing accuracy are sufficiently high. The reason is that both low mismatch costs and low diagnosing accuracy trigger hospital competition. Since higher GP attendance has the same directional effect on competition, as explained above, strict gatekeeping tightens hospital competition even further. As a consequence, hospitals engage in excessive competition, resulting in too high quality and too much specialisation from a welfare perspective.[6] However, if second-best price regulation is available, there is no scope for direct regulation of GP attendance. Thus, the treatment price is a sufficient instrument to induce second-best optimal quality and specialisation of hospital care. Finally, we characterise the second-best equilibrium, showing that first-best is generally not achievable for the regulator.

The paper relates to both the general literature on spatial competition and the literature on (imperfect) competition in health care markets. The interaction between quality and location choices has been investigated by Economides (1989) under price competi-

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[5] In our specific model, with linear GP consultation costs, these two effects exactly offset, so that equilibrium hospital specialisation and quality provision are unaffected by the degree of diagnosing accuracy. However, under (enforced or *de facto*) strict gatekeeping, where every patient attends a GP before receiving secondary care, the indirect effect is eliminated and improved diagnosing accuracy will dampen hospital competition.

[6] This result is related to Dranove et al. (2003), who empirically analyse whether public disclosure of patient health outcomes at the level of the individual physician or hospital ('report cards') is beneficial to patients and social welfare. They find that report cards led to both selection behaviour by providers and improved matching of patients with hospitals. However, on net this led to higher levels of resource use and to worse health outcomes (for sicker patients).

tion and Brekke et al. (2005) under price regulation.[7] The present paper contributes to this literature by introducing imperfect information into the framework. As previously mentioned, we find that the hospitals' incentives to differentiate services crucially depend on the degree of information in the market. In particular, we find that the presence of uninformed consumers tend to soften the incentives for horizontal differentiation. In this respect our findings are in the spirit of Bester (1998), who shows that quality competition may induce minimum differentiation–i.e., agglomeration at the market centre–when consumers are uncertain about product quality and use observed prices to ascertain the quality of goods.

The paper also relates to the more general literature on transparency in imperfectly competitive markets.[8] Increased transparency on the consumer side of the market typically leads to intensified price competition and thus to a more socially desirable market outcome. Our paper contributes to this literature by analysing the effects of improved transparency in markets that are characterised by *non-price competition*. In this case, more intense competition between firms does not necessarily improve social welfare. Improved market transparency consequently has ambiguous welfare effects.[9]

Finally, our paper complements the multi-task agency literature on the economics of general practice, e.g., Garcia Mariñoso and Jelovac (2003), Malcomson (2004) and González (2004). These papers focus on the dual nature of GP activity, namely, on diagnosing patients and treating or referring them. Optimal payment systems are derived that, at the same time, induce GPs to exert diagnosis effort and give incentives for efficient referral or treatment decisions, i.e., GP treatment for low severity diagnoses and

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[7]Two other related papers applied to the primary care market are Gravelle (1999) and Nuscheler (2003). Both papers address the issue of competition between physicians by investigating the interaction between quality and location choices when prices are regulated. They apply a circular model with attention directed towards entry of physicians into the market, so the focus of these papers is clearly quite different from ours. Calem and Rizzo (1995) also analyse horizontal and vertical differentiation of hospitals. However, in contrast to our paper, they neither consider price regulation nor gatekeeping.

[8]See, e.g., Varian (1980), Burdett and Judd (1983), Lommerud and Sørgard (2003), Schultz (2004, 2005).

[9]Another related paper in this strand of the literature is Baye and Morgan (2001), who analyse the competition effects of information gatekeepers on the Internet, where such gatekeepers create a market for price information by charging fees to firms that advertise prices and to consumers who access the list of advertised prices.

referral for high severity diagnoses.[10] This also refers to the second gain of gatekeeping: coordination of care improves since patients more appropriately treated by a GP are screened out through costly diagnosing of all patients. On the other hand, as Malcomson (2004) points out, patients who would not otherwise have been referred, may be referred after being subject to costly diagnosis. Again, health care is used more efficiently. In our paper, GPs are – on the one hand – perfect agents in the sense that they truthfully convey the information about the secondary care market that they have, but – on the other hand – imperfect agents in the sense that diagnosing is noisy. Although we consider diagnosing accuracy to be exogenous, it can, in fact, be seen as a result of an incentive contract like the ones derived in the above cited papers. Instead of analysing whether or not a patient should be referred to a hospital, we consider that all patients will be referred and concentrate on the improved matching of patients to hospitals through gatekeeping GPs.[11] Although important for the social desirability of gatekeeping, this has not been analysed before. Moreover, we explicitly model the secondary care sector and introduce imperfect competition, and thereby significantly advance the literature. We demonstrate that the information acquired through gatekeeping affects competition amongst secondary care providers and that this may generate – so far neglected – (adverse) effects of such a system.

The remainder of the paper is organised as follows. The basic framework is presented in Section 2. In Section 3, we analyse hospitals' incentives for specialisation and quality investments for a given GP attendance rate. In Section 4, we endogenise the GP attendance rate and characterise the corresponding specialisation-quality-consultation equilibrium. Section 5 is devoted to welfare effects of gatekeeping and regulation of GP attendance, as well as second-best price regulation. Finally, in Section 6 we provide some concluding remarks.

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[10] Given the optimal contracts, the question of whether a gatekeeping system dominates free access to secondary care is analysed. Without going into details here, the results are ambiguous.

[11] In the agency literature cited above, high severity patients finally end up with a specialist as GPs are assumed to be unable to cure these patients. In this sense, our analysis deals with matching of high severity patients to specialists or hospitals.

2 The model

There is a continuum of patients with mass 1 distributed uniformly along the Hotelling line $S = [0, 1]$. The location of a patient is denoted $z \in S$ and is associated with the disease he suffers from. A disease z can be seen as a realisation of a random variable Z which is uniformly distributed on S. All patients need one medical treatment to be cured. There are two health care providers – henceforth called hospitals – both able to cure all diseases. However, they are differentiated with respect to the disease they are best able to cure. Specialisation of a hospital is denoted x_i, $i = 1, 2$. In order to facilitate the analysis, we assume that the hospitals are confined to separate halves of the disease space S with respect to specialisations, so that $x_1 \in \left[0, \frac{1}{2}\right]$ and $x_2 \in \left[\frac{1}{2}, 1\right]$.

In addition to specialisation, there is a second strategic variable used by the hospitals to attract patients, namely the quality of care $q_i \in [0, \overline{q}]$, $i = 1, 2$. Quality costs are assumed to be symmetric and quadratic, kq_i^2, where $k > 0$. Placing an upper bound $\overline{q}$ on quality investments is a (crude) way of capturing that it is insurmountably costly to increase quality beyond a certain level.[12] Quality costs are considered to be fixed, i.e., they are independent of how many patients are actually treated.[13] This implies that quality has the characteristics of a public good at each hospital. Examples of such quality investments are the cost of searching for and hiring more qualified medical staff, additional training of existing medical staff, and investments in improved hospital facilities, which can be related to both medical machinery and non-medical facilities such as room standard.[14] Without loss of generality, other fixed costs are set to zero. Marginal production costs are assumed to be constant and equal to zero. This cost structure stresses the importance of fixed costs, which seems reasonable for the hospital market.

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[12] We can, for instance, think of $\overline{q}$ as the best (state-of-the-art) technology or medical procedure available in the market. Thus, increasing quality above this level is not possible.

[13] The assumption of production-independent quality costs is widely used in the literature on quality competition in health care markets (see, e.g., Calem and Rizzo, 1995; Lyon, 1999; Gravelle and Masiero, 2000; Barros and Martinez-Giralt, 2002).

[14] Including variable quality costs would obviously imply a more general quality cost structure. However, since prices are fixed in our model, variable quality costs would only weaken the incentives for investing in quality. It can readily be verified that this only complicates the analysis without providing any qualitatively different results. Interested readers may consult Ma and Burgess (1993) for the case of fixed locations or contact the authors for the case of endogenous locations.

The price for one treatment is denoted $p \geq 0$ and is set by some regulatory authority.[15] The expected profit of hospital i is given by

$$\Pi_i = pD_i - kq_i^2, \tag{1}$$

where D_i is expected demand for hospital i treatment.

A patient's (ex-post) utility when going to hospital i is given by

$$u_i^z = v + q_i - p - t(z - x_i)^2. \tag{2}$$

The maximum gross willingness to pay for hospital treatment, v, is assumed to be sufficiently large for the entire market to be covered. Thereby, we preclude monopoly and kink equilibria and concentrate on competitive ones.[16] Notice that this assumption essentially means that all patients have access to hospital or specialist care, which seems reasonable, at least for developed countries (without waiting lists). The last term measures the mismatch costs incurred when treated by hospital $i = 1, 2$. The parameter $t > 0$ determines the importance of mismatch costs relative to the quality of care. Of course, mismatch costs would be zero if the patient suffers exactly from the disease for which the hospital he attends is specialised. Mismatch costs are assumed to be quadratically increasing in distance.

Patients are ex ante uninformed about both their own diagnosis and the qualities and specialisations of hospitals. They only know v, the distribution of Z, and that hospital treatment is required, but they cannot observe x_i, q_i, and z. For uninformed patients, secondary care is an experience good, and the ex-post utility given by (2) can only be learned through actual consumption. However, patients can obtain more information ex ante by consulting a GP before accessing the hospital market. We assume that a GP will convey accurate information about the secondary care market, i.e., hospitals' qualities and specialisations, and give the attending patient a diagnosis, i.e., a location on S. This

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[15]All results we derive also hold for constant marginal costs $MC > 0$. Let $\widetilde{p}$ denote the mill price, then the mark-up is given by $p = \widetilde{p} - MC$.

[16]In a circular model, Economides (1993) and Nuscheler (2003) make similar assumptions, whereas Salop (1979) and Gravelle (1999) study monopoly and kink equilibria in detail.

diagnosis is noisy, though. We assume that the GP will provide the correct diagnosis with an exogenous probability $\delta < 1$, which we henceforth term 'diagnosing accuracy'. We then make the simplifying assumption that incorrect diagnoses – that occur with probability $(1 - \delta)$ – are uniformly distributed on S.[17] Both the probability of a correct diagnosis and the distribution of incorrect diagnoses are common knowledge. Thus, the GP is a perfect agent in the sense that all information is truthfully conveyed to those patients consulting the GP, but an imperfect agent in the sense that diagnosing accuracy is not perfect.

Realistically, there are some individual costs associated with attending a GP to obtain information. To incorporate this, we assume cost heterogeneity with respect to GP consultation, where $y \in [0, 1]$ denotes the cost type of a patient. The associated costs are then assumed to be ay, where $a > 0$. This heterogeneity can simply be justified by an opportunity cost argument, e.g., by varying time costs due to different wage earning abilities. There are no other (direct) costs of gatekeeping. To simplify the analysis we assume that patient types are uniformly distributed on the disease space S. As a result, patients are uniformly distributed on the unit square with the disease (or diagnosis) on one axis and cost type on the other. The share of patients choosing to obtain information through GP consultation is denoted by λ.

The available regulatory instruments for a social planner are assumed to be λ and p, while hospital quality as well as hospital specialisation are not verifiable in a contractual sense.[18] Regarding regulation on λ, it is – in theory – possible to imagine that the regulator can influence the amount of information available to patients in the market through several different means. We will, however, focus on what is probably the most realistic regulatory instrument, namely introducing a strict gatekeeping regime, where all patients are required to consult a GP before seeking secondary care. Thus, the scope for regulating λ is restricted to setting $\lambda = 1$.

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[17] This assumption eases the presentation of results, while still preserving the relevant features of imperfect diagnosing. It may be more realistic to assume that the densities of incorrect diagnoses are higher in the neighbourhood of the true location of a patient. Note, however, that the masspoint at the true location in fact approximates such a density.

[18] This assumption is appropriate as the quality of care is, in general, difficult to measure. To some extent the regulator may be able to control hospital specialisations. We capture this by restricting specialisation choices of hospitals to their respective halves of the unit interval.

The effect of GP gatekeeping to the market for secondary care is analysed in a 5-stage game:

1. The regulator sets her available regulatory variables. These are one or both of p and λ. Regulation on the latter variable is restricted to setting $\lambda = 1$.

2. The hospitals simultaneously decide on their specialisations, $x_1 \in \left[0, \frac{1}{2}\right]$ and $x_2 \in \left[\frac{1}{2}, 1\right]$.

3. The hospitals simultaneously set their quality levels $q_1 \in [0, \overline{q}]$ and $q_2 \in [0, \overline{q}]$.

4. Patients choose whether to consult a gatekeeping general practitioner and obtain accurate information about x_i and q_i, and a diagnosis with accuracy $\delta < 1$.

5. All patients demand secondary care treatment.

The sequential structure of the game is argued by the different degree of irreversibility of strategic decisions. Clearly, the decision of whether to consult a gatekeeping GP and/or which hospital to go to is the most flexible decision to be taken in the entire game. Changing quality or specialisation requires more effort and investment. In both cases it may be necessary to replace some medical machinery and/or have the current staff undergo significant training, or even hire new staff. Although it may sometimes be hard to distinguish between quality investments and a change of specialisation, it seems logically consistent to assert that hospitals first decide what to produce (their service or speciality mix), and then determine the quality of services.[19] This sequential structure is common in models that combine horizontal and vertical differentiation (see, e.g., Economides, 1989; Calem and Rizzo, 1995; Bester, 1998; Gravelle, 1999).

That the regulator can determine λ and p at the beginning of the game essentially means that we consider commitment power on her side. This assumption is, of course, crucial as in most sequential games. With respect to λ, this can easily be justified since introducing a strict gatekeeping system (i.e., setting $\lambda = 1$) must be regarded as a major reform of the health care system. This may be less clear with the price. As in Brekke et al.

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[19]Calem and Rizzo (1995) discuss this in some more detail.

(2005) and Nuscheler (2003) there will be an incentive to reoptimise after specialisations have been chosen. Nevertheless, since commitment is valuable for the regulator, one could argue that she should be able to obtain such commitment power, either through reputation or by creating institutional mechanisms that makes it costly, or otherwise difficult, to change the regulated price.[20] In any case, since price regulation is not the major focus of the present paper, we will concentrate on the full commitment case.

Although we have a game of imperfect information (the fraction $1 - \lambda$ of the population is uninformed about hospital quality, hospital specialisation and about their own disease; the fraction $\lambda(1 - \delta)$ receives accurate quality and specialisation information but a wrong diagnosis), subgame perfection is the appropriate solution concept. We solve the game by backward induction, starting with the demand for hospital care. Hospitals then play their sequential specialisation-quality game for a given value of λ. This yields reaction functions $x_i^*(\lambda)$ and $q_i^*(\lambda)$ for $i = 1, 2$. This game is analysed in Section 3.

As hospitals have no means to 'signal' their characteristics, neither specialisations nor qualities are observed by patients, although hospitals move before patients decide about whether to consult a GP (and obtain information) or not. Therefore, patients have to decide on GP consultation for given values of the hospitals' strategic variables. So, in a game-theoretic sense, consultation decisions are simultaneous to the specialisation-quality game. A reaction function $\lambda^*(x_1, x_2, q_1, q_2)$ results, and the equilibrium of the specialisation-quality-consultation subgame is then, as usual, the intersection of the reaction functions where actions are mutually best responses. This subgame is analysed in Section 4.

The solution of the full game is relegated to Section 5, where social welfare and price regulation is investigated.

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[20] The assumption that a regulator can credibly commit to a given price (or, more generally, a given transfer) is extensively applied in the literature, see e.g., Ma and Burgess (1993), Wolinsky (1997) and Beitia (2003).

3 Hospital specialisation and quality

3.1 The demand for secondary care

A share $1 - \lambda$ of the population does not consult a GP, and thus remains uninformed about the actual quality levels and about specialisations. Moreover, these patients do not know the exact disease they suffer from. To make a decision about which hospital to approach, patients have to evaluate their expected utility of attending each hospital. As the game is fully symmetric and since hospitals have no means to signal their characteristics, we adopt the standard tie-breaking rule where both hospitals receive half of the uninformed patients, $(1 - \lambda)/2$. Any other tie-breaking rule would yield qualitatively similar results. As we concentrate on symmetric equilibria, we also impose symmetry here.

The residual fraction of the population, λ, consults a GP and obtains (perfect) information about hospital characteristics. These patients are responsive to quality investments and specialisation decisions, since both strategic variables are observed. Furthermore, the patients consulting a GP receive an imperfect diagnosis. The probability of getting a correct diagnosis is δ and is uniformly distributed on S. If a patient receives a diagnosis z, the probability that he actually suffers from disease z is δ. With the remaining probability, $1 - \delta$, z is just a draw from the uniform distribution over the unit interval S. Thus, the expected utility of hospital i treatment, for a patient who has received a diagnosis z, is given by

$$Eu_i^z = v + q_i - \delta t \left(z - x_i\right)^2 - (1 - \delta) t \int_0^1 \left(s - x_i\right)^2 ds. \tag{3}$$

As long as $\delta > 0$, there exists a unique diagnosis, $\overline{z}$, such that a patient who receives this diagnosis is, in expectation, indifferent between the two hospitals. This diagnosis is found by solving $Eu_1^z = Eu_2^z$ for z, yielding

$$\overline{z} = \frac{1}{2} + \frac{q_1 - q_2}{2t\delta \left(x_2 - x_1\right)} - \frac{\left(1 - x_1 - x_2\right)}{2\delta}. \tag{4}$$

The expected demand for hospital 1 from GP-patients is then given by the expected number of patients who receive a diagnosis $z \leq \overline{z}$. Since both true and incorrect diagnoses are uniformly distributed on S, and diagnosing accuracy is the same for all locations,

the reported diagnosis is also uniformly distributed on S, implying that the probability of receiving a diagnosis $z \leq \overline{z}$ is $\overline{z}$. Thus, overall expected demand for hospital 1 is $D_1 = \lambda \overline{z} + (1 - \lambda)/2$, while hospital 2 expects to receive the residual demand $D_2 = 1 - D_1 = \lambda (1 - \overline{z}) + (1 - \lambda)/2$.

3.2 Quality competition

For given locations and given GP attendance, optimal quality investments are found by inserting demand derived above into the profit function (1) and optimising with respect to q_i. We assume that $\delta > \frac{1}{2}$. For this case, we show in the Appendix that, if $\overline{q}$ is not too high, a unique pure strategy equilibrium in the quality subgame exists for all $p > 0$ and $\lambda > 0$, and for all locations $x_1 \in \left[0, \frac{1}{2}\right]$ and $x_2 \in \left[\frac{1}{2}, 1\right]$. This equilibrium is given by

$$q_i^* (\Delta; \lambda, p) = \min \left(\frac{p\lambda}{4tk\delta\Delta}, \overline{q} \right), \quad i = 1, 2, \tag{5}$$

where $\Delta := x_2 - x_1$. We see that equilibrium quality levels in the interior solution are always symmetric and depend only on the distance between hospitals' locations. This is due to the absence of price competition, where quality investments have a market expanding effect which, due to the uniform distribution of patients, does not depend on absolute locations. An immediate implication is that optimal specialisations will be characterised by some certain distance and not by absolute locations.

Assuming an interior solution, the comparative static results are mostly straightforward. Less product differentiation (lower Δ) will intensify quality competition, i.e., competition is intense when products are close substitutes. Furthermore, patients are more responsive to quality improvements when mismatch costs are small, implying that t is a measure of competition intensity. Not very surprisingly, an increase in the quality cost parameter k has an adverse effect on quality provision. The better medical treatments are paid, the higher are the benefits of capturing market from the competitor. At this stage of the game the only means of competition is the quality of care, and thus hospitals will improve their quality as a response to an increase in p.

The degree of information in the market is captured by the two parameters λ and δ. A

higher GP attendance (λ) leads to increased quality provision. This is quite intuitive, since more patients obtain information about hospital qualities and thus become responsive to possible quality differences between the hospitals. Improved diagnosing accuracy, on the other hand, has the opposite effect, which might seem a bit surprising at first glance.[21] The underlying mechanism is that lower diagnosing accuracy makes hospital quality a relatively stronger signal for an imperfectly informed patient. If a patient is less certain about his own location, and thus about the expected mismatch costs of attending each hospital, he will attach more weight to hospital quality in making the decision of which hospital to approach for treatment. In other words, improved diagnosing accuracy means that information about hospital specialisation becomes more valuable for the patient. All else equal, a higher value of δ thus reduces the degree of competition in the market and leads to lower quality provision in equilibrium.

3.3 Specialisation

At this stage of the game hospitals decide on their specialisation, taking, for a given λ, the effects on quality competition and demand into account. We look for a symmetric equilibrium in pure strategies. Inserting the optimal quality levels in the interior solution into hospital 1's profit function, we obtain the following partial derivative with respect to x_1:

$$\frac{\partial \Pi_1}{\partial x_1} = p\lambda \left(\frac{1}{2\delta} - \frac{p\lambda}{8\Delta^3 kt^2 \delta^2} \right). \tag{6}$$

As already mentioned, setting $\partial \Pi_1 / \partial x_1 = 0$ only yields Δ^*. There exists a continuum of locations fulfilling $x_2 - x_1 = \Delta^*$. Imposing symmetry leads to a unique equilibrium, given by[22]

$$x_1^* (\lambda, p) = \frac{1}{2} (1 - \Delta^*) \text{ and } x_2^* (\lambda, p) = \frac{1}{2} (1 + \Delta^*), \tag{7}$$

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[21]Remember that patients receive perfect information about qualities and specialisations, while diagnosis information is imperfect.

[22]It is easily shown that the second-order conditions are met. Moreover, note that symmetry always implies $x_1 + x_2 = 1$.

where

$$\Delta^* (\lambda, p) = \left(\frac{p\lambda}{4t^2 k\delta} \right)^{\frac{1}{3}}. \tag{8}$$

In addition, there are two possible corner solutions. If differentiation incentives are very strong, the hospitals will locate at the endpoints, i.e., $\Delta^* = 1$. On the other hand, if the upper bound on quality is sufficiently low, the locations given by (7)-(8) will induce a corner solution, $q_i = \overline{q}$, in the ensuing quality subgame. In this case, the equilibrium in the location game is a corner solution where both hospitals locate at the midpoint, i.e., $\Delta^* = 0$. In the following, we focus on the interior equilibrium given by (7)-(8).[23]

The hospitals' location incentives are governed by two opposing forces. *Ceteris paribus*, each hospital can obtain a larger share of the market by moving closer to its rival. On the other hand, closer locations imply that quality competition is intensified, as can be seen from equation (5).

Consider an increase in the treatment price p. This will strengthen the market share effect, since hospitals now receive a higher mark-up on each treatment. However, a price increase also means that quality competition is amplified. From (8) we see that the latter effect always dominates: a higher price implies that hospitals aim at dampening the resulting increase in quality competition by locating further apart.

A similar mechanism determines the relationship between GP attendance and locations. More informed patients will result in stronger quality competition, and hospitals will respond by differentiating more.[24] A social planner thus faces a trade-off when setting the price or taking measures to improve information in the market. The improved quality has to be weighed against the change in aggregate mismatch costs.

Like in the quality subgame, increased information about the secondary care market through higher GP attendance and improved diagnosing accuracy yield opposite incentives for hospital competition. Since improved diagnosing accuracy *reduces* the intensity of

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[23]In the specialisation equilibrium given by (7) and (8), each hospital might also have an incentive to deviate by locating at the midpoint, if such a relocation induces a corner solution in the quality subgame. It can easily be shown that such a deviation is not profitable unless $\overline{q}$ is sufficiently low. We rule out this possibility by assumption.

[24]This result is clearly dependent on the mode of competition. If we allow the firms (hospitals) to compete on prices, and not qualities, the opposite result would apply (cf. Schultz, 2004).

quality competition, hospitals choose to differentiate less.

We have already identified the mismatch cost parameter t as a measure of competition intensity. A low t boosts quality provision and – to dampen this effect – hospitals locate further apart. Finally, an increase in the quality cost parameter k reduces quality competition, resulting in less product differentiation. When inserting (8) into (5) we obtain the equilibrium quality levels of the game:

$$q^{*}\left(\lambda,p\right)=\left(\frac{p^{2}\lambda^{2}}{16tk^{2}\delta^{2}}\right)^{\frac{1}{3}}. \tag{9}$$

The following Proposition summarises the comparative statics results:

Proposition 1 *The best responses of the specialisation-quality game are both increasing in treatment price and GP consultation, and decreasing in mismatch costs, quality costs and diagnosing accuracy.*

4   GP consultation

In the previous section we derived the equilibrium of the specialisation-quality game for a given value of λ, and equations (7), (8) and (9) show the respective best response functions of the hospitals. To solve the game we now have to derive the best response of patients to any given level of Δ and q. This is done by letting patients make the choice of whether or not to consult a GP to obtain more information, based on an assessment of expected benefits and costs.

When deciding whether to approach a (randomly chosen) hospital directly or to consult a GP first, a patient has to weigh the costs of going to a GP against the benefits. As the game is common knowledge, patients know that hospitals provide the same quality. Moreover, the quality received is independent of whether a GP was consulted or not and therefore the consultation decision is independent of qualities. Determining the (individual) benefits of gatekeeping, and thereby the best response $\lambda^{*}(\Delta)$, simply requires ascertaining the reduction in expected mismatch costs for every degree of product differentiation, Δ, in the market. To simplify the analysis we assume that patients know

that the equilibrium will be symmetric, i.e., that hospitals locate equidistantly from the market centre, but on opposite sides.

For a given degree of differentiation, Δ, expected mismatch costs for a patient who directly approaches a hospital are

$$M_0 = \frac{t}{2} \int_0^1 \left(z - \frac{1}{2} (1 - \Delta) \right)^2 dz + \frac{t}{2} \int_0^1 \left(z - \frac{1}{2} (1 + \Delta) \right)^2 dz. \qquad (10)$$

The first term of equation (10) measures the expected mismatch costs when approaching hospital 1 weighted with the probability that this hospital will actually be chosen (which, applying our tie-breaking rule, is 1/2). Expected mismatch costs are calculated over the entire disease space, since patients are unaware of their actual diagnosis. Accordingly, the second term measures the expected mismatch costs when consulting hospital 2, weighted with 1/2. When consulting a GP first, expected mismatch costs are reduced to

$$M_{GP} = t \int_0^{\frac{1}{2}} \left(\delta \left(z - \frac{1}{2} (1 - \Delta) \right)^2 + (1 - \delta) \int_0^1 \left(s - \frac{1}{2} (1 - \Delta) \right)^2 ds \right) dz \qquad (11)$$

$$+ t \int_{\frac{1}{2}}^1 \left(\delta \left(z - \frac{1}{2} (1 + \Delta) \right)^2 + (1 - \delta) \int_0^1 \left(s - \frac{1}{2} (1 + \Delta) \right)^2 ds \right) dz.$$

Through GP consultation the patient obtains a diagnosis z and seeks treatment of hospital 1 whenever $z \in \left[0, \frac{1}{2} \right]$. The associated expected mismatch costs are given by the first line of equation (11). With probability δ the diagnosis z is correct and the corresponding mismatch costs are given by the first term of the integrand (of the outer integral). With the remaining probability $1 - \delta$ the diagnosis z is false. The true disease may be at any point of the unit interval and every disease is equally likely. The resulting mismatch costs are given by the second term, i.e., by the inner integral. If $z \in \left(\frac{1}{2}, 1 \right]$, the patient chooses treatment of hospital 2 and, in expectation, incurs the second line as mismatch costs. The expected benefit of gatekeeping is thus

$$B := M_0 - M_{GP} = \frac{t \delta \Delta}{4}. \qquad (12)$$

The best response $\lambda^*(\Delta)$ is now obtained by equating the expected benefits of gatekeeping

to its actual costs, $t\delta\Delta/4 = a\lambda$, and solving for λ, yielding

$$\lambda^*(\Delta) = \frac{t\delta\Delta}{4a}. \tag{13}$$

The comparative static results are intuitive. The higher consulting cost (a), the lower the share of patients actually attending a GP for consultation. The benefits of gate-keeping are increasing in mismatch costs, since more costs may be avoided by obtaining information. Expected mismatch costs are determined by three different factors. For any given positive distance between the hospitals, these costs are obviously increasing in the mismatch cost parameter (t) and decreasing in the diagnosing accuracy (δ). In addition, expected mismatch costs are increasing in the degree of horizontal differentiation. The further apart the hospitals are located, the more costly, in terms of mismatch costs, to attend the 'wrong' hospital.

Let us now turn to the solution of the game. Equations (8) and (13) define the two reaction functions which determine the equilibrium attendance rate and differentiation, λ^* and Δ^*, so that the level of GP attendance is the best response to hospital specialisations, and vice versa. Assuming an interior solution for hospital differentiation and GP attendance, the equilibrium values of Δ and λ are found by simultaneously solving (8) and (13), yielding

$$\Delta^*(p) = \frac{1}{4}\left(\frac{p}{tka}\right)^{\frac{1}{2}}, \tag{14}$$

$$\lambda^*(p) = \frac{\delta}{16}\left(\frac{pt}{ka^3}\right)^{\frac{1}{2}}. \tag{15}$$

The corresponding quality levels are obtained by substituting equation (15) into (9), yielding[25]

$$q^*(p) = \frac{p}{16ak}. \tag{16}$$

We are now ready to state the comparative static results of the specialisation-quality-consultation subgame:

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[25]Of course, $\Delta = \lambda = q = 0$ also is an equilibrium of the game, though not a very realistic one. Moreover, this equilibrium immediately disappears when there is an arbitrarily small (but positive) fraction of informed patients and, in this sense, the equilibrium is 'unstable'. We therefore concentrate on the equilibrium given in equations (14) to (16).

Proposition 2 *The specialisation-quality-consultation equilibrium has the following comparative static properties:*

(i) GP attendance is increasing in treatment price, mismatch costs and diagnosing accuracy, and decreasing in quality and attendance costs;

(ii) hospital differentiation is increasing in treatment price, decreasing in mismatch, attendance and quality costs, and independent of diagnosing accuracy;

(iii) hospital quality is increasing in treatment price, decreasing in attendance and quality costs, and independent of mismatch costs and diagnosing accuracy.

Several of these effects are quite intuitive. The share of the population attending a GP increases in the mismatch cost, t, as this drives up the benefits of gatekeeping. It also increases in the treatment price. This is an indirect effect stemming from specialisation. Price increases boost quality competition and, to dampen this effect, hospitals aim at reducing the substitutability of their services, increasing the benefits of gatekeeping. Obviously, λ^* is a decreasing function of a. The higher the disutility incurred by consulting a GP, the lower the share of patients who actually consult one. This reduces the competitive pressure in the hospital market, leading to less differentiation and a lower supply of quality. Equilibrium GP attendance is also increasing in the diagnosing accuracy, δ, since improved accuracy reduces expected mismatch costs and thus increases the benefits of GP gatekeeping. Finally, an increase in the quality cost parameter, k, reduces quality competition and thereby differentiation incentives. This, in turn, reduces the benefits of gatekeeping, leading to a lower GP attendance in equilibrium.

There are also some effects that are less obvious. We see that the mismatch costs parameter t has no effect on equilibrium hospital quality. With exogenous GP attendance, patients were more responsive to quality investments at lower values of t, amplifying quality competition. With endogenous GP attendance, however, this effect is counteracted by the consultation effect. A lower t reduces the benefits of gatekeeping, resulting in lower GP attendance and thus a less competitive market. With linear costs of GP consultation these two effects exactly offset. Interestingly, we also see that equilibrium hospital specialisation and quality provision are not affected by diagnosing accuracy, δ. For a given level of GP attendance, we know that higher diagnosing accuracy *reduces* the degree of

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competition in the market, with lower quality provision and less differentiation (direct effect). However, a higher diagnosing accuracy also increases the value of information obtained by attending a GP, leading to higher GP attendance, which, in turn, *increases* the degree of hospital competition (indirect effect). Thus, when the decision of whether or not to attend a GP is taken into account, the indirect effect of improved diagnosing accuracy on hospital competition tends to counteract the direct effect. In our specific model, with linear GP consultation costs, these two effects exactly offset. Obviously, the indirect effect is eliminated if consultation costs are so low that all patients choose to consult a GP before accessing the hospital market. In this case, the equilibrium is a corner solution with $\lambda^* = 1$, where improved diagnosing accuracy dampens competition between secondary care providers.

5 Regulation and welfare

Consider a social planner who aims at maximising social welfare, defined as the sum of consumers' and producers' surpluses net of any government expenditures.[26] Imposing symmetry, and noting that aggregate GP consultation costs are $a \int_0^\lambda s \, ds = \frac{1}{2} a \lambda^2$, expected social welfare is given by

$$W = v + q(1 - 2kq) - [(1 - \lambda) M_0 + \lambda M_{GP}] - \frac{1}{2} a \lambda^2,$$

or, when substituting for M_0 and M_{GP} from equations (10) and (11),

$$W = v + q(1 - 2kq) - \frac{t}{12} [1 - 3\Delta (\lambda \delta - \Delta)] - \frac{1}{2} a \lambda^2. \tag{17}$$

The interpretation of (17) is straightforward. In addition to the gross utility of hospital treatment (1. term), expected social welfare consists of the social net benefit of quality provision (2. term) net of expected aggregate mismatch costs (3. term) and aggregate GP consultation costs (4. term).

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[26]If we interpret p as a per treatment or per patient reimbursement from a government agency, we implicitly assume that the third party (i.e., the regulator) is able to raise the necessary funds in a non-distortionary manner.

5.1 The first-best optimum

It is constructive to start out by considering the first-best solution, where the regulator can choose Δ, q, and λ directly. The first-order conditions are given by

$$\Delta^{fb} = \frac{\lambda\delta}{2}, \ q^{fb} = \frac{1}{4k}, \ \text{and} \ \lambda^{fb} = \frac{t\delta\Delta}{4a}. \tag{18}$$

First-best quality is found by equating marginal benefits and marginal costs of quality provision, and the solution is independent of specialisation and GP attendance.

Considering first-best specialisations, for given levels of λ and δ, the regulator faces the following trade-off: on the one hand, mismatch costs incurred by the fully informed patients (share $\lambda\delta$) are minimised when hospitals locate symmetrically with a distance $\Delta = \frac{1}{2}$. These locations are optimal if the entire population is fully informed ($\lambda\delta = 1$). On the other hand, as the fully uninformed patients (share $1-\lambda$) choose a provider randomly and the partially informed received a wrong diagnosis (share $\lambda(1 - \delta)$), their mismatch costs are minimised when hospitals do not differentiate their services at all ($\Delta = 0$) and locate at the market centre. These locations are optimal if there is no disease information acquired ($\lambda\delta = 0$). Balancing these two opposing effects leads to an optimal hospital differentiation $\Delta^{fb} \in \left[0, \frac{1}{2}\right]$.

On the other hand, for a given degree of differentiation, optimal GP attendance increases in hospital differentiation and in the mismatch cost parameter t. An increase in either Δ or t increases the mismatch costs that can be avoided by seeing a GP, and thus the benefits of gatekeeping. When the diagnosing accuracy is high, mismatch costs are reduced with a higher probability, making a GP visit more attractive. Obviously, when consulting costs are large, the social planner would prefer that fewer patients are approaching a GP. The complete characterisation of the first-best solution is as follows:

Proposition 3 *The first-best efficient solution has quality $q^{fb} = \frac{1}{4k}$ and*

(i) $\lambda^{fb} = 0$ and $\Delta^{fb} = 0$ for $t\delta^2 < 8a$,

(ii) $\lambda^{fb} \in [0, 1]$ and $\Delta^{fb} = \frac{\lambda^{fb}\delta}{2}$ for $t\delta^2 = 8a$, and

(iii) $\lambda^{fb} = 1$ and $\Delta^{fb} = \frac{\delta}{2}$ for $t\delta^2 > 8a$.

Proof. The first-best solution in (i) is an interior solution where both first-order conditions, $\Delta^{fb} = \frac{\lambda \delta}{2}$ and $\lambda^{fb} = \frac{t \delta \Delta}{4a}$, are satisfied. As λ is restricted to the unit interval there are situations where $\lambda^{fb} = \frac{t \delta \Delta}{4a}$ does not hold, i.e., when parameters are such that λ exceeds one. Inserting $\Delta = \frac{\lambda \delta}{2}$ into (17) and differentiating yields $\frac{\partial W}{\partial \lambda} = \frac{\lambda}{8} \left(t \delta^2 - 8a \right)$. For $t \delta^2 > 8a$ the regulator sets λ to its maximum, $\lambda^{fb} = 1$, and $\Delta^{fb} = \frac{\delta}{2}$. The regulator is indifferent between all feasible values of λ when $t \delta^2 = 8a$. ∎

The characteristics of the first-best solution can be explained by comparing the costs of a gatekeeping system to its benefits. The term $t \delta^2$ relates to the benefits of such a system, while $8a$ relates to its costs. The benefits are higher if more mismatch costs can be saved by acquiring information. Of course, these benefits are positively related to the mismatch cost parameter t. Benefits are also increasing in diagnosing accuracy, since the unnecessary mismatch costs are saved with higher probability. In case (i) of the proposition, where the benefits of gatekeeping are small compared to its costs ($t \delta^2 < 8a$), the social planner prefers a situation without any information in the market ($\lambda = 0$). In this case, aggregate mismatch costs are minimised when both firms do not differentiate and agglomerate at the market centre. On the other hand, in case (iii), where the benefits of gatekeeping are high compared to its costs ($t \delta^2 > 8a$), the social planner wants maximum market transparency ($\lambda = 1$). Efficient specialisation is then $\delta/2$, which is (for imperfect diagnosing) smaller than $1/2$, reflecting the regulator's trade-off as described above. The intermediate case (ii) is a knife-edge result.

5.2   Regulation of GP attendance

Once quality and specialisation are not directly contractible, the regulator must use the available regulatory instruments, p and/or λ, to balance several different considerations, and the first-best optimum is, in general, not attainable. In this subsection we consider the case of an exogenously given treatment price p, which may or may not be at the optimal second-best level, and see if and when the regulator has any incentives to regulate GP attendance. As previously argued, regulation on λ realistically amounts to making GP consultation compulsory by introducing a strict gatekeeping system, i.e., setting $\lambda = 1$.

Comparing (13) and (18) we see that, for a given degree of hospital differentiation,

private and social incentives for GP attendance coincide. So why should a regulator distort GP consultation? The reason is that hospital specialisations in the 'laissez-faire' equilibrium, given by (14), do not necessarily produce a socially optimal degree of differentiation. Moreover, quality provision may be inefficient. It may therefore be desirable to make GP attendance compulsory, in order to affect both hospital specialisations and quality investments in a socially desirable direction, even if this means that GP attendance costs increase beyond the socially (and privately) optimal level. In order to investigate the regulator's incentives to introduce a strict gatekeeping regime, we have to evaluate social welfare with, respectively, voluntary and compulsory GP consultation.

With *voluntary GP consultation*, expected social welfare is found by inserting the equilibrium expressions for $\Delta^*(p)$, $\lambda^*(p)$ and $q^*(p)$ from (14)-(16) into the welfare function (17), yielding

$$W^*(p) = v - \frac{t}{12} + \frac{(24a - 4p + t\delta^2)\, p}{512ka^2}. \tag{19}$$

If the regulator enforces *compulsory GP consultation*, expected social welfare is found by setting $\lambda = 1$ in the equilibrium expressions for $\Delta^*(\lambda, p)$ and $q^*(\lambda, p)$ in (8) and (9), and substituting into the welfare function (17), yielding

$$W^*(p)|_{\lambda=1} = v - \frac{t}{12} - \frac{a}{2} + \frac{1}{16}\left[2\left(\frac{2t\delta^2 p}{k}\right)^{\frac{1}{3}} + 3\left(\frac{4p^2}{k^2 t\delta^2}\right)^{\frac{1}{3}} - 4\left(\frac{2p^4}{kt^2\delta^4}\right)^{\frac{1}{3}} \right]. \tag{20}$$

Whether or not an introduction of a strict gatekeeping system is (for a given price) socially desirable is then determined by the sign of the difference between (19) and (20). Since it is not feasible to characterise this difference analytically, we resort to simulations.

In Tables 1 and 2 we present numerical examples of the effects of strict gatekeeping, focusing on the key parameters t and δ. For the remaining parameters of the model we assume $v = 1$, $p = 0.5$, $k = 0.5$ and $a = 0.25$. Before we turn to the interpretation of the tables, note that first-best quality provision is $q^{fb} = 0.5$. Moreover, from the first order conditions for the first-best, given in (18), we know that, for a given share of informed patients, mismatch costs are minimised when differentiation is $\Delta = \lambda\delta/2$. The characterisation of the first-best optimum shows that a strict gatekeeping system is efficient whenever $t\delta^2 > 8a$ (see Proposition 3). In our example, this is the case for $\delta = 0.9$

and $t = 2.5$ or $t = 3.0$ (highlighted by ** in Table 2).

Table 1: Voluntary GP consultation

t	Low accuracy: $\delta = 0.6$					High accuracy: $\delta = 0.9$				
	λ^*	q^*	Δ^*	$\lambda^*\delta/2$	W^*	λ^*	q^*	Δ^*	$\lambda^*\delta/2$	W^*
1.0	0.30	0.25	0.50	0.09	1.053	0.45	0.25	0.50	0.20	1.067
1.5	0.37	0.25	0.41	0.11	1.017	0.55	0.25	0.41	0.25	1.038
2.0	0.42	0.25	0.35	0.13	0.981	0.64	0.25	0.35	0.29	1.009
2.5	0.47	0.25	0.32	0.14	0.945	0.71	0.25	0.32	0.32	0.980
3.0	0.52	0.25	0.29	0.16	0.909	0.78	0.25	0.29	0.35	0.951

Assumptions: $v = 1$, $p = 0.5$, $k = 0.5$, $a = 0.25$

Table 2: Compulsory GP consultation

t	Low accuracy: $\delta = 0.6$					High accuracy: $\delta = 0.9$				
	λ	q^*	Δ^*	$\lambda\delta/2$	W^*	λ	q^*	Δ^*	$\lambda\delta/2$	W^*
1.0	1.00	0.56	0.75	0.30	1.011	1.00	0.43	0.65	0.45	**1.077**
1.5	1.00	0.49	0.57	0.30	1.006	1.00	0.37	0.50	0.45	**1.059**
2.0	1.00	0.44	0.47	0.30	**0.986**	1.00	0.34	0.41	0.45	**1.033**
2.5	1.00	0.41	0.41	0.30	**0.958**	1.00**	0.31	0.35	0.45	**1.003**
3.0	1.00	0.39	0.36	0.30	**0.927**	1.00**	0.30	0.31	0.45	**0.971**

Assumptions: $v = 1$, $p = 0.5$, $k = 0.5$, $a = 0.25$

Notes: Bold numbers indicate that compulsory gatekeeping improves social welfare; ** means $\lambda^{fb} = 1$, otherwise $\lambda^{fb} = 0$.

Let us first concentrate on a low diagnosing accuracy ($\delta = 0.6$) and investigate the role of the mismatch cost parameter t. With voluntary GP attendance (Table 1), higher mismatch costs dampen incentives for quality competition, leading to less differentiation in equilibrium. Since an increase in t directly increases the benefits of gatekeeping, more patients will consult a GP and, as a result, the incentives to invest in quality improve. In our model these two opposing effects exactly offset so that equilibrium quality provision remains unchanged. Compared to the first-best solution, quality is too low and there is

excessive differentiation for the given degree of information in the market ($\Delta^* > \lambda^* \delta / 2$). The bold numbers in Table 2 reveal that compulsory gatekeeping is socially desirable for $t = 2.0, 2.5, 3.0$ but not for $t = 1.0, 1.5$. The intuition is clearly traceable, but perhaps not immediately obvious.[27] For low values of t, quality competition is tight. Since there is no consultation effect that softens quality competition (λ is fixed to 1), there is excessive quality competition (for $t = 1.0$) and excessive product differentiation. Thus, for sufficiently strong competitive effects the introduction of compulsory gatekeeping lowers social welfare. For high values of t, on the other hand, compulsory gatekeeping makes quality move in direction of the first-best. As the competitive effects are relatively moderate, the impact on product differentiation is small. It is difficult to assess the contribution of product differentiation to social welfare, since the efficient benchmark $\lambda^* \delta / 2$ changes with the introduction of compulsory gatekeeping. In our example, mismatch costs are reduced for all values of t and the reduction is larger for higher values of t. For $t = 3.0$ we get close to the efficient degree of specialisation.

Let us now turn to the effect of diagnosing accuracy δ on the desirability of gatekeeping. The comparative static analysis of the voluntary gatekeeping equilibrium, shown in equations (14)-(16), demonstrated that δ only affects equilibrium GP consultation but not quality and specialisation (see also Table 1). The inefficiency in both variables is independent of δ and, in principle, an introduction of compulsory gatekeeping can, via the competition effect, improve the outcome. As already discussed above, the competition effect can be very strong for low values of t such that, for a low diagnosing accuracy, excessive quality provision and too much differentiation make compulsory gatekeeping socially harmful. However, from our analysis of the specialisation-quality game we know that, for a given λ, an increase in diagnosing accuracy reduces the competitive pressure and thereby quality and differentiation incentives. The competitive effects of introducing strict gatekeeping are thus smaller for higher levels of diagnosing accuracy. Therefore, compulsory gatekeeping is more likely to be beneficial for small values of t when δ is high. From our example in Table 2 we see that compulsory gatekeeping is socially beneficial for

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[27]The most obvious intuition is maybe the following: for high mismatch cost parameters the benefits of gatekeeping are high, so compulsory gatekeeping is likely to be desirable. This intuition, however, is wrong, since social and private incentives to see a GP coincide.

all reported values of t when $\delta = 0.9$, whereas it is not when $\delta = 0.6$.

Finally, note that compulsory gatekeeping is beneficial in 8 cases while the first-best optimum yields strict gatekeeping in only two of these cases. This confirms our general intuition that it can pay off to distort GP consultation in order to improve on the other endogenous variables.

5.3   Price regulation

The above results hinge on the assumption that the treatment price is exogenous. We will now relax this assumption and assume that the regulator is able also to use the price as a regulatory instrument in an optimal way. Assuming second-best price regulation, the following result obtains:

Proposition 4 *With second-best price regulation and endogenous GP consultation decisions, there is no scope for direct regulation of GP attendance.*

Proof. Inserting (8) and (9) into (17) yields a welfare function $W(p, \lambda)$. By defining $\widehat{p} := p\lambda$ we can define a new welfare function $\widehat{W}(\widehat{p}, \lambda) := W(\Delta^*(\widehat{p}), q^*(\widehat{p}), \lambda)$. Maximising $W(p, \lambda)$ with respect to p and λ is then equivalent to maximising $\widehat{W}(\widehat{p}, \lambda)$ with respect to $\widehat{p}$ and λ. Taking the partial derivative with respect to λ yields

$$\frac{\partial \widehat{W}(\widehat{p}, \lambda)}{\partial \lambda} = -a\lambda + \frac{t\delta}{4}\Delta^*(\widehat{p}). \tag{21}$$

By comparing (18) and (21) we see that social and private incentives for GP attendance coincide for every given value of Δ. The regulator can then use $\widehat{p}$ to induce the optimal (second-best) levels of q and Δ and let patients choose the socially optimal level of GP attendance themselves. ∎

When second-best pricing is available, there is no longer any need to use strict gatekeeping as a regulatory mechanism to induce socially more desirable hospital differentiation and quality provision. From (8) and (9) we know that p and λ have identical effects on equilibrium differentiation and quality provision. Thus, by using the price instrument properly, the regulator can induce exactly the same specialisation-quality outcome for any

given value of λ. Consider an increase in the share of informed patients in the market. The resulting effects – stronger quality competition and larger differentiation – can be exactly offset by reducing the price accordingly. If the regulator uses the price instrument to induce second-best differentiation and quality provision, an optimal trade-off between expected mismatch cost reductions and consultation costs will secure the socially optimal level of GP attendance. And this is exactly the trade-off that patients make themselves in the described game.

We now derive the second-best pricing policy where the regulator optimally trades off inefficiencies along three dimensions: quality, specialisation and GP attendance. We study the efficiency properties of the resulting equilibrium and also ask when second-best price regulation will lead to a *de facto* strict gatekeeping system, where all patients choose to consult a GP before demanding secondary care.[28]

Optimal price regulation can imply two possible regimes in this model. If the regulator sets the price sufficiently high, the ensuing equilibrium outcome in the specialisation-quality game will be a corner solution with $q = \overline{q}$ and $\Delta = 0$. Equilibrium GP attendance is then $\lambda = 0$. Alternatively, the regulator can induce an interior solution, i.e., $q < \overline{q}$, by setting a sufficiently low price. It is easily shown that a corner solution is socially preferable only if $\overline{q}$ is very small, and we rule out this possibility by assumption, focusing instead on the interior solution.[29] Maximising (19) with respect to p yields the following second-best treatment price:

$$p^{sb} = 3a + \frac{1}{8}t\delta^2. \tag{22}$$

Perhaps the most interesting feature is that the optimal price is increasing in diagnosing accuracy, although δ does not affect quality and specialisations in equilibrium. The reason is that higher diagnosing accuracy increases the optimal degree of hospital

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[28]Compared to the first-best outcome, given in Proposition 3, λ^* will – in interior solutions – be inefficient. Then the trade-off is indeed along three dimensions. Since λ^* is efficient for any given specialisation, one may also argue that the trade-off is along two dimensions only.

[29]It is straightforward to show that the regulator will never induce a corner solution if

$$\frac{\left(24a + t\delta^2\right)^2}{8192ka^2} + \overline{q}\left(2k\overline{q} - 1\right) > 0.$$

differentiation, from a welfare perspective. This reflects the trade-off between minimising mismatch costs for fully informed patients, requiring $\Delta = \frac{1}{2}$, and minimising expected mismatch costs for uninformed patients, requiring $\Delta = 0$. A higher diagnosing accuracy increases the degree of information about hospital specialisations in the market, implying that the socially optimal specialisations move further away from the market centre. The regulator must then stimulate more differentiation by increasing the treatment price.

The effects of the consultation and mismatch cost parameters a and t are more straightforward. An increase in either type of cost dampens hospital competition, leading to less differentiation and lower quality provision, effects that can by counteracted by increasing p.

From the price given in (22), the following equilibrium outcome obtains:

$$\Delta^{sb} = \frac{1}{4} \left[\frac{1}{k} \left(\frac{3}{t} + \frac{\delta^2}{8a} \right) \right]^{\frac{1}{2}}, \; q^{sb} = \frac{3}{16k} + \frac{t\delta^2}{128ak}, \text{ and } \lambda^{sb} = \frac{\delta}{64} \left(\frac{2t \left(24a + t\delta^2 \right)}{a^3 k} \right)^{\frac{1}{2}}. \quad (23)$$

It is straightforward to show that second-best pricing yields an interior solution with respect to GP attendance for a subset of the parameter values, defined by $k > \overline{k}$, where

$$\overline{k} := \frac{t\delta^2 \left(24a + t\delta^2 \right)}{2048a^3}.$$

Thus, if $k \leq \overline{k}$ we have a corner solution with $\lambda^{sb} = 1$. Given that $\partial \overline{k} / \partial t > 0$, $\partial \overline{k} / \partial \delta > 0$ and $\partial \overline{k} / \partial a < 0$, the following result obtains:

Proposition 5 *Second-best price regulation implies a de facto strict gatekeeping regime ($\lambda^{sb} = 1$) if quality costs or GP consulting costs are sufficiently small, or if mismatch costs are sufficiently high. Higher diagnosing accuracy makes $\lambda^{sb} = 1$ the outcome for a larger set of parameter values.*

The intuition is quite straightforward and follows from the previous analysis and discussion. A higher t increases expected mismatch costs, which makes GP gatekeeping more desirable. Lower costs of quality provision (k) have the same kind of effect, since it leads to more differentiation in the hospital market. The expected reduction in mismatch costs through GP consultation is increasing in diagnosing accuracy, making gatekeeping more

desirable for higher levels of δ. Finally, a lower GP consulting cost (a) obviously means that more patients consult a GP to obtain information.

For the final part of the analysis, we will focus on interior solutions, implying that GP attendance is generally inefficient, compared with the first-best solution.[30] The efficiency properties of the second-best interior solution are summarised as follows:

Proposition 6 *The second-best (interior) solution of the specialisation-quality-consultation game has the following efficiency properties:*

(i) for $t\delta^2 < 8a$, there is too much differentiation given λ^{sb}, and too low quality provision;

(ii) for $t\delta^2 = 8a$, differentiation is first-best given λ^{sb} and first-best quality is implemented;

(iii) for $t\delta^2 > 8a$, there is insufficient differentiation given λ^{sb}, and too high quality provision.

Proof. First-best specialisation, conditional on the share of GP-patients, requires $\Delta^{fb} = \lambda\delta/2$. From (23) we find that

$$\Delta^{sb} - \lambda^{sb}\delta/2 = \frac{1}{128a}\sqrt{\frac{48a + 2t\delta^2}{akt}}\left(8a - t\delta^2\right) > (<) \, 0 \quad if \quad t\delta^2 < (>) \, 8a.$$

First-best quality is given by $q^{fb} = \frac{1}{4k}$. From (23) we have

$$q^{sb} - q^{fb} = \frac{t\delta^2 - 8a}{128ka} < (>) \, 0 \quad if \quad t\delta^2 < (>) \, 8a.$$

∎

The first observation worth making from Proposition 6 is that the first-best outcome with respect to both hospital differentiation and quality provision is – apart from the knife-edge case (ii) – never achieved. This should not be too surprising, though, since the regulator has more policy goals than regulatory instruments.

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[30] For a discussion of optimal price regulation under complete information, i.e., where $\lambda\delta = 1$, see Brekke et al. (2005).

To see the intuition for the general efficiency characteristics of the second-best equilibrium, consider regimes (i) and (iii), where the benefits of gatekeeping are either low or high compared to its costs. Note first that an interior solution with respect to GP attendance requires that GP consultation costs are sufficiently high. From (16) we know that a high value of a implies that quality provision will be relatively low in equilibrium. If, in addition, mismatch costs and/or diagnosing accuracy are relatively low, the value and/or the probability of obtaining information will be small and, consequently, GP attendance will be low in equilibrium. Since the first-best efficient level of quality provision is independent of mismatch costs, this implies that social welfare is maximised at a low degree of differentiation. In this case, $t\delta^2 < 8a$, the price that yields first-best differentiation is not high enough to generate efficient quality provision. Thus, higher quality can only be obtained at the expense of excessive differentiation, and these considerations are optimally traded off at a price which yields under-provision of quality and too much differentiation.

On the other hand, if mismatch costs are high, the first-best level of differentiation will be higher – closer to $\delta/2$ – due to higher GP attendance. In this case, $t\delta^2 > 8a$, the optimal degree of differentiation is obtained at a price that yields over-provision of quality. Consequently, optimal regulation implies accepting a less than optimal degree of differentiation in order to avoid too much over-investment in quality.

6   Concluding remarks

Equipping GPs with a gatekeeper role in the health care system is a major issue in the debate on health care reforms. Among politicians, the conventional wisdom is that gatekeeping contributes to cost control. This is somewhat surprising since evidence is lacking, as was demonstrated in an empirical study by Barros (1998). As GPs are usually better informed than patients about the characteristics of the secondary health care market, e.g., about quality and specialisation of hospitals, matching of patients to hospitals may be improved by gatekeeping. However, this argument neglects the potential competitive effects in the hospital market. We have presented a model that analyses the competitive

effects of gatekeeping in the presence of hospital non-price competition.

While prices were regulated, we allowed for competition in specialisation and quality. We found that when the price is exogenously given, strict gatekeeping may reduce social welfare, especially if mismatch costs and diagnosing accuracy are both sufficiently low. In this case, making it compulsory to attend a GP before receiving secondary care will boost competition to such an extent that excessive hospital specialisation and quality occur. This raises doubts about whether gatekeeping improves efficiency. Things change dramatically when allowing for second-best price regulation. In this case, we showed that there is no scope for direct regulation of GP attendance, since consultation decisions of patients are the same as what a social planner would implement. A *de facto* strict gatekeeping regime arises endogenously if the benefits of gatekeeping are sufficiently high (improved matching outweighs the potentially negative competitive effects) compared to its costs. Finally, we considered the (interior) second-best equilibrium, showing that the solution, in general, will be characterised by inefficient levels of quality, specialisation and GP attendance, depending on the relative values of mismatch costs, consultation costs and the diagnosing accuracy.

The analysis demonstrates that efficiency gains that are usually attributed to GP gatekeeping cannot be taken for granted when the secondary care sector is endogenised and non-price competition amongst providers is considered. In the short run, efficiency gains may indeed be obtained by better matches. However, quality provision may still be inefficient. In the long run, hospitals will adjust their specialisation so that differentiation increases, which might counteract the positive short run effect.

Appendix. Equilibrium in the quality subgame

In this Appendix we show that the pure strategy equilibrium of the quality subgame is indeed given by equation (5) if the upper bound on quality, $\overline{q}$, is not too high. Consider first an interior solution, $q_1^* = q_2^* < \overline{q}$. The profit of hospital 1 is then given by

$$\Pi_1\left(p,\lambda\right) = \frac{p}{2}\left(1 - \frac{\lambda}{\delta}\left(1 - x_1 - x_2 + \frac{q_1^*}{2t\Delta}\right)\right), \tag{A1}$$

where $\Delta := x_2 - x_1$. Let us now check for possible profitable deviations for hospital 1. An obvious implication from the first-order conditions is that a deviation implying $\overline{z} \in (0, 1)$ is never profitable. Thus, any possibly profitable deviation must imply that the deviating hospital serves only the completely uninformed patients, i.e., $\overline{z} = 0$. Optimal deviation is thus to set $q_1 = 0$ and receive a payoff

$$\widehat{\Pi}_1 (p, \lambda) = \frac{(1 - \lambda) p}{2}. \tag{A2}$$

Deviation is not profitable if $\Phi_1 (p, \lambda) := \Pi_1 (p, \lambda) - \widehat{\Pi}_1 (p, \lambda) > 0$, where Φ_1 can be expressed as

$$\Phi_1 (p, \lambda) = \frac{p\lambda}{2} \left[1 - \frac{1}{\delta} \left(1 - x_1 - x_2 + \frac{q_1^*}{2t\Delta} \right) \right]. \tag{A3}$$

Let us now study the properties of Φ_1: Since for $p = 0$ both profits are zero, $\Pi_1(0, \lambda) = \widehat{\Pi}_1 (0, \lambda) = 0$, we have $\Phi_1 (0, \lambda) = 0$. So, not surprisingly, there is no incentive to deviate when the price is zero. The first and second order partial derivative with respect to p are

$$\frac{\partial \Phi_1 (p, \lambda)}{\partial p} = \frac{\lambda}{2\delta} (x_1 + x_2 + \delta - 1) + \frac{\lambda q_1^*}{4t\delta\Delta} \frac{\delta - 1}{\delta}, \tag{A4}$$

$$\frac{\partial^2 \Phi_1 (p, \lambda)}{\partial p^2} = -\frac{\lambda^2}{8kt^2\delta^2\Delta^2} < 0. \tag{A5}$$

The second term of (A4) is negative as long as $p > 0$ and $\delta < 1$. Thus, for deviation to be unprofitable for small values of p we need to have

$$\lim_{p \to 0} \frac{\partial \Phi_1 (p, \lambda)}{\partial p} = \frac{(x_1 + x_2 + \delta - 1) \lambda}{2\delta} > 0. \tag{A6}$$

It is easy to show that inequality (A6) holds for all $x_1 \in \left[0, \frac{1}{2} \right]$ and $x_2 \in \left[\frac{1}{2}, 1 \right]$ if $\delta > \frac{1}{2}$. Thus, if $\delta > \frac{1}{2}$, there exists a sufficiently low value of p such that deviation is not profitable. The concavity of Φ_1, shown in equation (A5), demonstrates that deviation may well be (and will be) profitable for sufficiently high values of p. In the next paragraph we define the upper bound for quality, $\overline{q}$, such that this will never happen.

Now consider a corner solution. Due to the first-order conditions, where quality incentives depend on relative, but not absolute, locations, the corner solution must also be

symmetric; $q_1^* = q_2^* = \overline{q}$. In this case, the profit of hospital 1 is given by

$$\Pi_1\left(p, \lambda, \overline{q}\right) = \frac{p}{2}\left(1 - \frac{\lambda\left(1 - x_1 - x_2\right)}{\delta}\right) - k\overline{q}^2. \tag{A7}$$

Optimal deviation profits are still given by (A2), implying

$$\Phi_1\left(p, \lambda, \overline{q}\right) = \frac{\lambda p}{2}\left(1 - \frac{\left(1 - x_1 - x_2\right)}{\delta}\right) - k\overline{q}^2, \tag{A8}$$

where $\frac{\partial\Phi(p,\lambda,\overline{q})}{\partial p} > 0$ and $\frac{\partial\Phi(p,\lambda,\overline{q})}{\lambda} > 0$.

From (5) we know that the interior solution, $q_i^*(p, \lambda)$, is monotonically increasing in p and λ. Now define $\overline{p}$ and $\overline{q}$ such that $q_i^*\left(\overline{p}, 1\right) = \overline{q}$ and $\Phi_1\left(\overline{p}, 1\right) \geq 0$. Then we know that $\Phi_1\left(p, \lambda\right) \geq 0$ for $p \leq \overline{p}$ (if $\delta > 1/2$) and $\Phi_1\left(p, \lambda, \overline{q}\right) \geq 0$ for $p > \overline{p}$ (by proper definition of $\overline{q}$). It follows that, if $\delta > \frac{1}{2}$, a pure strategy equilibrium exists for all p and λ, and all locations $x_1 \in \left[0, \frac{1}{2}\right]$ and $x_2 \in \left[\frac{1}{2}, 1\right]$. This equilibrium is given by (5).

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Symbols in order of appearance in the text

$S = [0,1]$	Disease set
$z \in S$	Disease
$Z \sim U(S)$	A disease is random, uniform distribution on S
$x_1 \in \left[0, \frac{1}{2}\right], x_2 \in \left[\frac{1}{2}, 1\right]$	Specialisation of provider 1 and 2, respectively
$q_i \in [0, \overline{q}], i = 1,2$	Quality of secondary care of provider i
$k > 0$	Quality cost parameter
$p \geq 0$	Price per treatment or patient
$\Pi_i, i = 1,2$	Profit of provider i
$D_i, i = 1,2$	Demand for treatment at provider i
$u_i^z, i = 1,2$	Utility to patient z when receiving treatment from provider i
$v > 0$	Quality independent willingness to pay for secondary care treatment
$t > 0$	Mismatch cost parameter
$\delta \in (0,1)$	GP diagnosing accuracy (probability of correct diagnosis)
$y \in [0,1]$	Consultation cost type of a patient
$a > 0$	Consultation cost parameter
$\lambda \in [0,1]$	GP attendance rate (share of patients consulting a GP)
$\overline{z}$	Disease of the GP attending patient who is indifferent between providers
$\Delta := x_2 - x_1$	Degree of product differentiation
M_0	Expected mismatch costs with direct access
M_{GP}	Expected mismatch costs with GP attendance
$B := M_0 - M_{GP}$	Benefits of consulting a gatekeeping GP
W	Social welfare function
index "fb"	stands for "first best optimum"
index "sb"	stands for "second best optimum"

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