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Spatial Competition Across Borders: The Role of Patients' Mobility and Institutional Settings

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Abstract: Health care systems rely on geographical boundaries that secure financial stability and adequate planning. Quality differences across regions often arise for efficiency reasons, causing patient flows if mobility is free. In this paper, a theoretical spatial competition model is developed to study the role of patients' mobility on quality setting and to draw policy implications on its use as an instrument to reduce disparities, in a setting where regions differ in efficiency, costs, and market structure. From the analysis, it emerges that the institutional setting matters and a trade-off may appear between equity (in terms of quality difference across patients) and welfare (finding an allocation that maximizes social benefits). In a centralized setting, it is optimal to regulate mobility and increase the quality gap, while allowing free mobility calls for a refined quality setting, in which, depending on a balance between costs and benefits, the quality gap may be either increased or decreased. In decentralization the gap is generally lower, compared to centralization: the different consideration of benefits from local quality provision results in higher quality levels where the market structure is vertically integrated.

Keywords: cross-border patients' mobility; spatial competition; centralized vs. decentralized provision

JEL Classification: C72; I18; I11; H42

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1. Introduction

Health care may be considered a merit good, i.e., a private good that a government wants to be made accessible to a wider audience than those that would be able to pay for its provision, because of paternalistic reasons (Schnellenbach, 2012). Solidarity plays a crucial role, since one of the important features of health care financing is to redistribute income from the rich to the poor. Redistribution is developed along two lines: (a) at patient (individual) level through a system of (possibly) means tested prices that allow anybody to afford care; (b) at geographical/regional level if income across regions is unevenly distributed. The second feature is particularly important in the study of patients' mobility, since health care systems rely on geographical boundaries that are necessary to secure financial stability and to ensure adequate planning of health care infrastructure and capacity. This is true both at national level (where in several countries the organization of health care has been devolved to lower government tiers) and at supranational level, such as the EU community.

In this context, it is important to take into consideration the differences in the organizational structure for the market of health care across regions or countries, where both integrated and separated systems coexist—and compete. For example, while the UK Government has advocated for most of the functions that concern the organization and financing of health care, this not the prevalent model: in several countries in Europe (e.g., Austria, Denmark, Germany, Sweden, Italy, and Spain) and across the world (e.g., Australia and China) devolution is a well established feature (Adolph et al., 2012; Biggs & Cook, 2019; Chen & Liu, 2023; Costa-Font & Perdikis, 2020). In order to reconcile local autonomy with equity, several health care systems foresee instruments such as equalization grants, competition, and cross-border patients' mobility.

Fiscal equalization grants are a popular instrument to redistribute resources across jurisdictions. For example, in the OECD area (OECD, 2013), they represent about 50% of intergovernmental grants, about 2.5% of GDP. Equalization grants may take country-specific forms (Dougherty & Forman, 2021; Slavinskaite, 2020), which influence lower level decisions related to both expenditure and tax effort and quality of care, but they are not the only instrument that concerns health care provision.

In fact, quality differences may not only arise from income disparities, but also because of different levels of efficiency; the introduction of competition among providers and cross-border patients' mobility should in principle allow to reduce gaps. However, both the theoretical and the empirical literature do not seem to agree on this conclusion. Competition may reduce or increase quality according to several factors, ranging from the number and types of providers, their objectives, the type of competition—on price or on quality (see, e.g., Levaggi and Levaggi (2020, 2024); Siciliani (2018); Siciliani et al. (2017)).

The variety of models used and the differences in the institutional setting considered means that the literature is not able to offer an unambiguous answer as per the effects of these instruments. For example, while Gaynor and Town (2011) and Gaynor et al. (2015) show that competition is beneficial, Guccio et al. (2024) demonstrate that, while it may improve efficiency, the effect on quality is not clear-cut if providers have asymmetric objectives and location is not uniform.

The same is true for patients' mobility. In Brekke et al. (2014b), regions differ in quality efficiency and the authors show that cross-border patients' mobility may be beneficial for both patients from high and low skill regions, as in the classical Heckscher–Ohlin model of international trade, but this result does not extend to settings where regions also differ in income (Brekke et al., 2016).

Andritsos and Tang (2014) show that cross-border patients' mobility may improve welfare only if some conditions are met, but in general its welfare effects are not clear-cut. Also, mixed effects on waiting times and reimbursement rates, and the uneven distribution of costs between regions have to be taken into consideration (Andritsos & Tang, 2013). Besides, Aiura (2019) shows that with progressive taxes, patients' mobility may reduce welfare. However, if the level of vertical integration in health care provision varies across regions, different results may be obtained (Bisceglia et al., 2018). As for the empirical evidence, quality gaps appear to be related to the size of the income difference (Balia et al., 2020; Perna et al., 2022; Piedra-Peña, 2022; Yuan et al., 2023) and patients' mobility has in some cases produced a drain of resources from poor to rich regions (Berta et al., 2021; Carnazza et al., 2024).

From a policy point of view, it is then interesting to answer the following questions: Is patients' mobility beneficial? If so, under which conditions? Do institutional and market settings matter in this choice? The organization of health care may be quite different both at regional and country level (Costa-Font & Perdikis, 2020; Oliver & Mossialos, 2005; Siciliani et al., 2017) and the same is true for the market structure. This issue is relevant both at national and super-national level. For example, at the EU level, a large debate has followed the introduction of the Directive on Patients Mobility (European Parliament and Council,

2011) which in actual fact does not leave patients as much leeway as some would hope (Frischhut & Levaggi, 2015).

In this paper, we investigate the role of patients' mobility in the choice of quality levels, in settings with either decentralized or centralized decision making, in an environment where patients' mobility is free or is regulated and the institutional setting as per the organization of health care is different across regions. The framework we develop allows us to capture the most important features of actual health care systems, with a richer, high skill region where provision is separated and a poorer, low skill region where provision is vertically integrated. We show that a trade-off may emerge between equity and efficiency. Patients' mobility improves welfare, but this does not always mean that quality increases or that the quality gap shrinks. When mobility is allowed, the institutional setting matters: in a decentralized setting and with the organization of health care that is different across jurisdictions, in a high skill region, quality responds to patients' mobility through the price received for incoming patients, while in a low skill one, quality may increase or decrease, depending on a balance between costs and benefits, with the latter option more likely to happen. When a central planner is responsible for decisions on quality, regulation of mobility is optimal for the maximization of total welfare, even with an increased quality gap. If mobility is free, the gap may be enlarged or reduced, depending on the difference between overall costs and benefits. Compared to decentralization, the quality difference is usually higher: if the goal is to maximize total welfare, only total consumer surplus is taken into consideration and the benefit from local quality provision in the low skill region has less influence on decisions.

The paper is organized as follows: in Section 2, we present the model and in Section 3 the outset with no patients' mobility across regions. The outcomes of free mobility (Section 4) and regulated mobility (Section 5), both in centralization and decentralization are then derived and compared; a discussion of the results and conclusions close the paper.

2. The Model

As discussed in the introduction, patients' mobility occurs in a framework where decisions on quality of care are taken by authorities located in different regions/countries, where the organisation of the internal market may be asymmetric (Toth, 2020). In fact, hospital ownership varies among jurisdictions, both at national and international level, with private hospitals being profit maximizing entities that use quality to compete for patients and public ones that pursue different objectives and are directly run by the regulator (Paris et al., 2010). In this paper, we propose a stylized model of quality competition in a spatial environment that is split between two regions A and B (that can either belong to the same country or not), each having two hospitals and where the organization of provision is different. We build a Hotelling competition model (Hotelling, 1929) and assume a spatial configuration à la Salop (Salop, 1979), where a mass of patients (which is normalized to 1) is uniformly distributed on a circle of unit circumference.[1] As in Bisceglia et al. (2018), patients located on the upper semicircle belong to Region A, while the remaining consumers belong to Region B and the market is served by four health care providers (hospitals), two in each region, which are exogenously and uniformly distributed at locations l_j, $j = 1, \ldots, 4$ with l_1, l_2 in Region A and l_3, l_4 in Region B (see Figure 1).

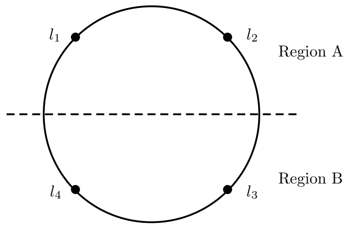

Figure 1. Spatial configuration.

We assume that the net utility of individuals located on the circle at x that access care at l_j is:

$$U_j(x) = v + \beta q_j - m\, d(x, l_j), \tag{1}$$

where v is the intrinsic utility of hospital care, $q_j \geq 0$ is the quality offered by provider j, $\beta > 0$ is marginal utility of quality so that βq_j is the monetary equivalent gain derived from the treatment and the term $m\, d(x, l_j)$ is a mismatch cost, linear in the distance $d(x, l_j)$ from x to l_j. It is assumed that v is high enough to make the market fully covered. The "traveling" cost $m\, d(x, l_j)$ also comprises search costs, which are often noteworthy in case patients choose to be treated outside their region of residence.

Users located at x sitting between l_j and l_k choose their preferred provider by comparing $U_j(x)$ and $U_k(x)$. The location x_{jk} of the indifferent patient is:

$$v + \beta\, q_j - m\, d\Big(x_{jk}, l_j\Big) = v + \beta\, q_k - m\left(\frac{1}{4} - d\Big(x_{jk}, l_j\Big)\right),$$

thus

$$d\Big(x_{jk}, l_j\Big) = \frac{1}{8} + \frac{\beta}{2m}\,(q_j - q_k). \tag{2}$$

As in Brekke et al. (2014b), we assume that only a fraction z of the patients is willing (if allowed) to travel to a provider in the neighboring region if the quality gap is sufficiently high, while, due to personal characteristics (e.g., age, health literacy or other medical/personal conditions), a share $1 - z$ of patients always seeks treatment from the local provider.

We assume that the cost of providing health care has the same structure in the two Regions and is linear in the number of treatments and quadratic in quality. Marginal costs are however region-dependent, thus in general the monetary cost of supplying D treatments of quality q in Region i is written as:

$$C_i(D, q) = c_i D + \frac{1}{2}\theta_i q^2, \quad i = A, B. \tag{3}$$

In an unregulated competition setting with free mobility, each provider faces both "internal" (from the other hospital in the same region) and "external" competition (from the hospital located in the other region). Demand for hospital j will therefore be written as the sum of $D_{j,int}$ and $D_{j,ext}$, where the latter equals the number of external patients treated by provider j, or is zero in case no patient moves from the neighboring region to provider j.

In contrast to other literature (Bisceglia et al., 2018, 2019; Brekke et al., 2014b, 2016), we assume that the organization of the internal market in the two regions is different: in Region A, it is market oriented, the two hospitals are privately owned and set their quality level to maximize profit, while the regulator sets a reimbursement for treatments to resident patients. In Region B, the health care system is instead vertically integrated: the purchaser is responsible for both provision and quality setting. In case of patients moving cross border to access care, a price p is paid for them from the outgoing region. In both regions, expenditure is financed through general linear income taxation. Region A thus represents the situation of a jurisdiction where provision is separated (as e.g., in Germany and The Netherlands), while Region B illustrates the case of a public health care system (as e.g., in Denmark and Sweden). In Region A, for a a given reimbursement p_A and a price p, the providers' profit obtained by delivering a treatment of quality q_j is:

$$\Pi_j = (p_A - c_A)D_{j,int} + (p - c_A)D_{j,ext} - \frac{1}{2}\theta_A q_j^2, \quad j = 1, 2. \tag{4}$$

Denoting by r_A the income in Region A and by t_A the (proportional) tax rate, if U_A is the total utility derived from treatment by resident patients and $\Pi_A = \Pi_1 + \Pi_2$ is the total profit of private providers, the social welfare function in Region A is:

$$W_A = r_A\,(1 - t_A) + U_A + \Pi_A. \tag{5}$$

In the internal market for healthcare in Region A, the regulator acts as a Stackelberg leader and sets the value of p_A to maximize W_A, taking into account the reaction function of the two providers that set quality by competing in a non-cooperative game.

In Region B there is no separation between the regulator and the provider; the social welfare function is:

$$W_B = r_B\,(1 - t_B) + U_B - \frac{w_B}{2}(D_{3,int} + D_{4,int})^2 \tag{6}$$

where r_B is the total income in Region B, t_B the (proportional) tax rate, U_B the total utility derived from treatment by patients residing in Region B and the last term takes into account the possible presence ($w_B \geq 0$) of an additional non-monetary cost in providing the service, e.g., due to the administrative effort in coordinating hospital provision. The quality q_B is equal for the two access points and is set by the regulator to maximize social welfare.

The regulators in the two regions simultaneously act to set the desired level of quality and the presence of mobility makes their choices interdependent. The equilibrium quantities p_A^* and q_B^* are the solutions of a spatial competition game where for a given exogenous price $p \geq c_A$ the objective of the regulator in A is:

$$\max_{p_A} \; W_A \quad \text{s.t.} \begin{cases} p_A \geq c_A, \\ t_A r_A = p_A(D_{1,int} + D_{2,int}) + p(D_{3,ext} + D_{4,ext}), \\ \Pi_j \geq 0,\; j = 1, 2, \end{cases} \tag{7}$$

while that of the regulator in B is:

$$\max_{q_B} \; W_B \quad \text{s.t.} \begin{cases} q_B \geq 0, \\ t_B r_B = c_B(D_{3,int} + D_{4,int}) + \theta_B\, q_B^2, \\ \qquad\qquad + p(D_{1,ext} + D_{2,ext} - (D_{3,ext} + D_{4,ext})). \end{cases} \tag{8}$$

We assume that Region A is richer, i.e., $r_A > r_B$, and has a superior/more efficient technology for providing health care quality, i.e., $\theta_A < \theta_B$. In what follows, we will therefore refer to Region A and Region B as the high-skill and low-skill region, respectively.

3. Mobility Is Not Allowed

Let us start by considering a setting where mobility is not allowed, that in our framework can be equivalently described by the condition $z = 0$. In this case, decisions on quality in the different regions are not interdependent and the equilibrium solution is the following:

Proposition 1. *Let $z = 0$ and $\theta_A \geq \frac{\beta^2}{4m}$; then in equilibrium $q_1 = q_2 = q_A$ and the quantities solving the optimization problem in Section 2 are:*

$$p_A^{nm} = c_A + \frac{m}{2}, \tag{9}$$

$$q_A^{nm} = \frac{\beta}{4\theta_A}, \tag{10}$$

$$q_B^{nm} = \frac{\beta}{4\theta_B}. \tag{11}$$

Proof. In fact, from (2) and (4), the profit function of the two providers in Region A is:

$$\Pi_j = (p_A - c_A)\left(\frac{1}{4} + \frac{\beta}{2m}(q_j - q_{-j})\right) - \frac{1}{2}\theta_A q_j^2, \quad j = 1,2, \ -j = 2,1$$

where q_{-j} is the quality set by the other local competitor. For a given reimbursement p_A, the two qualities are symmetric:

$$q_1 = q_2 = \frac{\beta}{2m\theta_A}(p_A - c_A) =: q_A$$

and the optimal p_A is the solution of the problem:

$$\max_{p_A \geq c_A} \left(r_A(1 - t_A) + 4\int_0^{\frac{1}{8}} (\beta\, q_A - m\, s + v)\, \mathrm{d}s + \frac{1}{2}(p_A - c_A) - \theta_A\, q_A^2 \right)$$
$$\text{s.t.} \quad t_A r_A = p_A \frac{1}{2}, \quad q_A = \frac{\beta}{2m\theta_A}(p_A - c_A), \quad \frac{1}{4}(p_A - c_A) - \frac{\theta_A}{2} q_A^2 \geq 0.$$

The objective function is concave and the solution in (9) and (10) is found by solving the FOC; the condition $\theta_A \geq \frac{\beta^2}{4m}$ assures that the profit for private hospitals is non negative.

In Region B, the maximization problem is written as:

$$\max_{q_B \geq 0} \left(r_B\,(1 - t_B) + 4\int_0^{\frac{1}{8}} (\beta\, q_B - m\, s + v)\, \mathrm{d}s - \frac{w_B}{8} \right)$$
$$\text{s.t.} \quad t_B r_B = \frac{c_B}{2} + \theta_B q_B^2$$

and by standard calculations the solution is the one in (11). □

Quality in the two regions is set to the point where the marginal benefit matches the marginal cost. In fact, quality is increasing in β, the marginal utility of quality, and decreasing in the marginal cost $\theta_A(\theta_B)$ to produce it. Price, as in any spatial competition model, is made up of the unitary cost and a mark-up that depends on the level of competitiveness in the market, which in turn depends on travel costs and the number of competitors (Barro, 2024).

Note that the quality depends on the level of the region's efficiency: since by hypothesis $\theta_A < \theta_B$, quality is higher in the high-skill region and a quality gap emerges. In order to reduce it and improve welfare, the literature suggests to use patients mobility. In what follows, we study how this instrument may work under different institutional settings (centralized vs. decentralized) and we will also show under which conditions regulation—in terms of some measures to control the flow—may be beneficial from a welfare point of view.

4. Free Mobility

In this section, we analyze the outcomes in terms of quality of allowing free mobility of patients, under different institutional settings. As seen in Section 3, when $z = 0$, a quality gap exists between the two regions. By continuity, at least for small values of z, allowing for mobility creates a flow of patients from Region B to Region A; the subsequent analysis is carried out for a general case with the same flow direction. We first consider a scenario, where, given the setting in Section 2, a utilitarian policy maker chooses the quality of each provider by optimizing the sum of the two welfare functions. We then compare the results with a decentralized setting, where quality is set at regional level.

4.1. Centralized Decision Making

Let us consider a setting where mobility is free, that is, patients are allowed to choose their preferred provider based on the net utility difference. Health care is organized at local level as described in Section 2, but qualities q_A, q_B are set by a central planner by optimizing total welfare. From (2) and (4), the profit function of providers in Region A is:

$$\Pi_j = (p_A - c_A)\left(\frac{1}{4} + \frac{\beta}{2m}(q_j - q_{-j})\right) + (p - c_A)\frac{z\beta}{2m}(q_j - q_B) - \frac{1}{2}\theta_A q_j^2,$$

for $j = 1, 2, \ -j = 2, 1$. Thus, given p_A and p, it is $q_1 = q_2 = q_A$ with

$$q_A = \frac{\beta}{2m\theta_A}(p_A - c_A + z(p - c_A)). \tag{12}$$

From Equations (1)–(6), we have

$$\begin{aligned} W_A &= r_A(1 - t_A) + 4\int_0^{\frac{1}{8}}(v + \beta q_A - m\,s)\mathrm{d}s \\ &\quad + \frac{1}{2}(p_A - c_A) + \frac{z\beta}{m}(p - c_A)(q_A - q_B) - \theta_A q_A^2 \end{aligned} \tag{13}$$

$$\begin{aligned} W_B &= r_B(1 - t_B) - \frac{w_B}{2}\left(\frac{1}{2} - \frac{z\beta}{m}(q_A - q_B)\right)^2 + 4\int_0^{\frac{1}{8}}(v + \beta q_B - m\,s)\mathrm{d}s \\ &\quad + 2z\int_{\frac{1}{8} - \frac{z\beta}{2m}(q_A - q_B)}^{\frac{1}{8}}\left(\beta(q_A - q_B) - m\left(\frac{1}{4} - 2s\right)\right)\mathrm{d}s \end{aligned} \tag{14}$$

and the optimization problem is written as:

$$\max_{p_A, q_B}(W_A + W_B) \quad \text{s.t.} \begin{cases} p_A \geq c_A, \\ \Pi_j \geq 0,\ j = 1, 2, \\ q_B \geq 0, \\ 0 \leq q_A - q_B \leq \frac{m}{4\beta}, \\ q_A = \frac{\beta}{2m\theta_A}(p_A - c_A + z(p - c_A)), \\ t_A r_A = p_A \frac{1}{2}, \\ t_B r_B = c_B\left(\frac{1}{2} - \frac{z\beta}{m}(q_A - q_B)\right) + \theta_B\, q_B^2 + p\frac{z\beta}{m}(q_A - q_B). \end{cases} \tag{15}$$

Proposition 2. *Define* $d_B = \dfrac{\beta^2 z}{m^2}(w_B z - m)$ *and suppose that* $\theta_A \geq \frac{\beta^2}{4m}$*. For* $z > 0$*, if the conditions:*

$$2\theta_A + d_B > 0, \quad 2\theta_A\theta_B + d_B(\theta_A + \theta_B) > 0 \tag{16}$$

and

$$
\begin{aligned}
c_A - c_B - \frac{w_B}{2} &> \frac{m}{2z} \, max\left\{ -\frac{\theta_A + d_B}{\theta_A}, \frac{2\beta^2(\theta_B - \theta_A) - m(2\theta_A\theta_B + d_B(\theta_A + \theta_B))}{2\beta^2(\theta_A + \theta_B)} \right\} \\
c_A - c_B - \frac{w_B}{2} &< \frac{m}{2z} \frac{\theta_B - \theta_A}{\theta_A + \theta_B}
\end{aligned} \tag{17}
$$

are satisfied, the problem in (15) *admits the following unique internal solution:*

$$
\begin{aligned}
p^C_{A,fm} &= c_A + \frac{m}{2} - z\left(p - c_A + \frac{2\theta_A\theta_B}{2\theta_A\theta_B + d_B(\theta_A + \theta_B)}\left(c_A - c_B - \frac{w_B}{2} + \frac{m\,d_B}{4z}\frac{\theta_B - \theta_A}{\theta_A\theta_B}\right)\right) \\
q^C_{A,fm} &= \frac{\beta}{4\theta_A} - \frac{z\beta\theta_B}{m(2\theta_A\theta_B + d_B(\theta_A + \theta_B))}\left(c_A - c_B - \frac{w_B}{2} + \frac{m\,d_B}{4z}\frac{\theta_B - \theta_A}{\theta_A\theta_B}\right) \\
q^C_{B,fm} &= \frac{\beta}{4\theta_B} + \frac{z\beta\theta_A}{m(2\theta_A\theta_B + d_B(\theta_A + \theta_B))}\left(c_A - c_B - \frac{w_B}{2} + \frac{m\,d_B}{4z}\frac{\theta_B - \theta_A}{\theta_A\theta_B}\right)
\end{aligned} \tag{18}
$$

which is feasible under the restriction

$$
c_A \le p \le c_A + \frac{2m\theta_A}{z\beta}\, q^C_{A,fm} \min\left\{1, \frac{m - \beta q^C_{A,fm}}{m - 2\beta(q^C_{A,fm} - q^C_{B,fm})}\right\}. \tag{19}
$$

Proof. From (13) and (14), the Hessian matrix of the objective function is

$$
\begin{bmatrix}
-\frac{\beta^2}{4m^2\theta_A^2}(2\theta_A + d_B) & \frac{\beta}{2m\theta_A}d_B \\
\frac{\beta}{2m\theta_A}d_B & -(2\theta_B + d_B)
\end{bmatrix}
$$

and the conditions in (16) assure that $W_A + W_B$ is concave. The system of FOCs admits the unique solution in (18), which satisfies the equality $\theta_A q^C_{A,fm} + \theta_B q^C_{B,fm} = \frac{\beta}{2}$. The constraints $0 < q_B < q_A < q_B + \frac{m}{4\beta}$ can be restated as $\max\left\{0, \frac{2\beta^2 - m\theta_A}{4\beta(\theta_A+\theta_B)}\right\} < q^C_{B,fm} < \frac{\beta}{2(\theta_A+\theta_B)}$ and thus on the conditions on the size of $c_A - c_B - \frac{w_B}{2}$ in (17). By (16), the interval of values in (17) is always non void. Total welfare and the optimal qualities do not depend on p, but affect p_A and the profit of private providers; these satisfy the required feasibility conditions under the constraint on p in (19). In fact, the profit of private providers in Region A is

$$
\frac{1}{2}(p^C_{A,fm} - c_A) + \frac{z\beta}{m}(q^C_{A,fm} - q^C_{B,fm})(p - c_A) - \theta_A q^C_{A,fm},
$$

its derivative with respect to p is $\frac{z\beta}{m}\left(q^C_{A,fm} - q^C_{B,fm} - \frac{m}{2\beta}\right) < 0$ and the profit is non negative for $p \le c_A + \frac{2m\theta_A}{z\beta}\frac{q^C_{A,fm}(m - q^C_{A,fm})}{m - 2\beta(q^C_{A,fm} - q^C_{B,fm})}$. Taking into account that $p^C_{A,fm} = c_A + \frac{2m\theta_A}{\beta}q^C_{A,fm} - z(p - c_A)$, the upper bound on p in (19) is found. Note that for $p = c_A$, the profit amounts to $\beta\theta_A(m - \beta q^C_{A,fm})q^C_{A,fm}$ and is lowest for the lowest value of $c_A - c_B - \frac{w_B}{2}$. Obviously, if the latter is the threshold for the positivity of $q^C_{B,fm}$, the quantity is positive, while inserting the threshold that insures $q^C_{A,fm} - q^C_{B,fm} < \frac{m}{4\beta}$ the value is $\frac{m(4\theta_A + 3\theta_B) - 2\beta^2}{4\beta(\theta_A + \theta_B)}$, which is positivve under the condition $\theta_A \ge \frac{\beta^2}{4m}$ needed for the feasibility of the case $z = 0$. This assures that the interval of feasible values for p in (19) is non void. □

As a first observation, note that at the limit for z tending to zero, conditions on the parameters in Proposition 2 are either trivially satisfied or not needed, while substituting $z = 0$ in the optimal quantities in (18) gives those of the no mobility case in Proposition 1.

The reimbursement paid to providers in Region A for domestic patients is the sum of the no mobility one in (9) (the first two terms) and a term whose sign depends both on p

and on whether the quality in A should be increased or decreased with respect to the no mobility case. It is in fact important to remember that while in Region B quality can be imposed to providers, in Region A quality is set by private providers and p_A is used as an indirect instrument.

The second interesting observation is that quality in the high skill region may be increased or decreased with respect to no mobility according to whether welfare maximization implies a higher or a lower quality gap between the two regions. In other words, if the objective is to maximize total welfare, mobility does not generally imply higher quality levels and a lower quality gap. The conditions to promote mobility depend on the balance between costs and benefits that the patients' choice involves. In fact, from (18) if[2]

$$c_A - c_B < \frac{w_B}{2} - \frac{m\,d_B}{4z}\frac{\theta_B - \theta_A}{\theta_A \theta_B} = \frac{w_B}{2} + \frac{\beta}{m}(m - w_B z)(q_A^{nm} - q_B^{nm}) \tag{20}$$

with mobility, it is optimal to increase quality in Region A and decrease it in Region B, thus to enlarge the quality gap between the two and increase the size of patients that move cross border to access care—and the converse in the opposite case. In fact, the term $c_A - c_B$ represents the difference in unit costs between the two Regions, while the term on the right-hand side in (20) represents the marginal effect of a change in the quality gap in Region B, calculated at the quality difference with no mobility. In practice, increasing q_A over q_A^{nm} increases mobility and this is optimal if the benefits from mobility (increased consumer utility and decreased disutility) experienced in Region B outweigh the related costs.

4.2. Decentralized Decision Making

Let us now turn to a different institutional setting with free mobility, where quality decision is decentralized and set at regional level in a game between the two Regions A and B. Given the reaction function (12) and Equations (13) and (14) for any given p the goal of the regulator in Region A is:

$$\max_{p_A} W_A \quad \text{s.t.} \begin{cases} p_A \geq c_A, \\ q_A = \frac{\beta}{2m\theta_A}(p_A - c_A + z(p - c_A)), \\ t_A r_A = p_A \frac{1}{2} \end{cases}$$

and that of the regulator in Region B is:

$$\max_{q_B} W_B \quad \text{s.t.} \begin{cases} q_B \geq 0, \\ t_B r_B = c_B\left(\frac{1}{2} - \frac{z\beta}{m}(q_A - q_B)\right) + \theta_B q_B^2, + p\frac{z\beta}{m}(q_A - q_B). \end{cases}$$

subject to the constraints $\Pi_j \geq 0$, $j = 1, 2$ and $0 \leq q_A - q_B \leq \frac{m}{4\beta}$.

Proposition 3. *Let $\theta_A \geq \frac{\beta^2}{4m}$ and $z > 0$. If $2\theta_A + d_B > 0$ and*

$$c_A - c_B - \frac{w_B}{2} > \frac{m}{2z}\max\left\{-\frac{m}{2\beta^2}(2\theta_A + d_B), \frac{\theta_B - \theta_A}{\theta_A} - \frac{m}{2\beta^2}(2\theta_B + d_B)\right\} \tag{21}$$

the following equilibrium quantities in decentralization with free mobility:

$$\begin{aligned} p^D_{A,fm} &= c_A + \frac{m}{2}, \\ q^D_{A,fm} &= \frac{\beta}{4\theta_A} + \frac{z\beta}{2m\theta_A}(p - c_A), \\ q^D_{B,fm} &= \frac{\beta}{4\theta_B} + \frac{z\,\beta}{m(2\theta_B + d_B)}\left(c_A - c_B - \frac{w_B}{2} + \frac{m d_B(\theta_B - \theta_A)}{4z\theta_A\theta_B} + \frac{2\theta_A + d_B}{2\theta_A}(p - c_A)\right). \end{aligned} \tag{22}$$

are viable if the following constraints apply on the price p

$$\begin{aligned} p &> c_A - \frac{m}{2z} + \max\left\{-\frac{2\theta_A}{2\theta_A + d_B}\left(c_A - c_B - \frac{w_B}{2}\right), \frac{\theta_A}{\theta_B - \theta_A}\left(c_A - c_B - \frac{w_B}{2}\right)\right\} \\ p &< c_A - \frac{m}{2z} + \frac{\theta_A}{\theta_B - \theta_A}\left(c_A - c_B - \frac{w_B}{2}\right) + \frac{m^2\theta_A}{4z\beta^2}\frac{2\theta_B + d_B}{\theta_B - \theta_A}. \end{aligned} \tag{23}$$

when the resulting profit for private providers is non negative.

Proof. Due to the separation between regulator and provider in the market structure for Region A, quality q_A depends on mobility only through the price p. Region B instead reacts to the quality setting of Region A, due to vertical integration in the provision. Since

$$\begin{aligned} \frac{\mathrm{d}W_A}{\mathrm{d}q_A} &= \frac{\beta}{2} - \frac{\beta}{m}(p_A - c_A) \\ \frac{\mathrm{d}W_B}{\mathrm{d}q_B} &= \frac{\beta}{2} - 2\theta_B q_B + \frac{z\beta}{m}\left(p - c_B - w_B\left(\frac{1}{2} - \frac{z\beta}{m}(q_A - q_B)\right) - \beta(q_A - q_B)\right) \end{aligned}$$

the welfare function W_B is concave if $2\theta_B + d_B > 0$ and the optimal values for reimbursement and qualities given in (22) are readily found from the FOCs. Quality $q^D_{B,fm}$ is increasing in p if $2\theta_A + d_B > 0$ and, in this case, the conditions $0 < q^D_{B,fm} < q^D_{A,fm} < q^D_{B,fm} + \frac{m}{4\beta}$ are restated as the constraints on p in the statement. The interval of viable values for the price is non void under the restriction (21).

In this case, profit is a quadratic function of the price p, with negative derivative at $p = c_A$. Thus, there exists a maximum price for which the profit is non negative (the conditions on the parameters assure that in the case of no mobility this is true). This could impose, depending on the parameters, a further restriction to (23). □

The price for citizens in Region A is the same as per the no mobility case, while the quality depends on the price set for cross-border patients. However, since price should allow to cover at least the marginal cost ($p \geq c_A$), quality q_A is at least equal to the no mobility case and is increasing in both p and z. In Region B, the effect of mobility on quality is less straightforward. In fact, quality q_B can be higher or lower according to a condition similar to the one for the centralized setting, with the addition of a non negative term that depends on the price that B has to pay to A in addition to marginal costs.

Note that under the conditions in Proposition 3, both qualities are increasing in p, but quality in Region A reacts at a higher rate than quality in B, thus the gap increases with p. Using for simplicity the notation $\Delta q = q_A - q_B$, we have:

$$\Delta q^D_{FM} = \Delta q^{nm} + \frac{z\beta(\theta_B - \theta_A)}{m\theta_A(2\theta_B + d_B)}(p - c_A) - \frac{z\beta\left(c_A - c_B - \frac{w_B}{2} + \frac{m d_B(\theta_B - \theta_A)}{4z\theta_A\theta_B}\right)}{m\theta_A(2\theta_B + d_B)}$$

and

$$\Delta q^C_{FM} - \Delta q^D_{FM} = -\frac{2z\beta\theta_B^2\left(c_A - c_B - \frac{w_B}{2} + \frac{md_B(\theta_B-\theta_A)}{4z\theta_A\theta_B}\right)}{m\theta_A(2\theta_B + d_B)(2\theta_A\theta_B + d_B(\theta_A + \theta_B))} - \frac{z\beta(\theta_B - \theta_A)}{m\theta_A(2\theta_B + d_B)}(p - c_A)$$

Since the outcome depends on the price, let us analyze in more detail a few cases. Let us start with a price equal to the marginal cost c_A.

Corollary 1. *Let* $\theta_A \geq \frac{\beta^2}{4m}$, $2\theta_A + d_B > 0$, $2\theta_A\theta_B + d_B(\theta_A + \theta_B) > 0$, $m\theta_A\theta_B > \beta^2(\theta_A - \theta_A)$ *and*

$$c_A - c_B - \frac{w_B}{2} > \frac{m}{2z}\, max\left\{-\frac{\theta_A + d_B}{\theta_A}, \frac{\theta_B - \theta_A}{\theta_A + \theta_B} - \frac{m(2\theta_A\theta_B + d_B(\theta_A + \theta_B)}{2\beta^2(\theta_A + \theta_B)}, -\frac{2\theta_A + d_B}{2\theta_A}\right\}$$
$$c_A - c_B - \frac{w_B}{2} < \frac{m}{2z}\frac{\theta_B - \theta_A}{\theta_A + \theta_B}.$$

Then for $p = c_A$

$$c_A - c_B - \tfrac{w_B}{2} < -\tfrac{m}{4z}\tfrac{d_B(\theta_B-\theta_A)}{\theta_A\theta_B} : \begin{cases} q^D_{A,fm} = q^{nm}_A < q^C_{A,fm} & \\ q^{nm}_B > q^C_{B,fm} > q^D_{B,fm} & d_B > 0 \\ q^{nm}_B > q^D_{B,fm} > q^C_{B,fm} & d_B < 0 \\ q^{nm}_B > q^D_{B,fm} = q^C_{B,fm} & d_B = 0 \end{cases} \quad \Delta q^{nm} < \Delta q^D_{FM} < \Delta q^C_{FM}$$

$$c_A - c_B - \tfrac{w_B}{2} > -\tfrac{m}{4z}\tfrac{d_B(\theta_B-\theta_A)}{\theta_A\theta_B} : \begin{cases} q^D_{A,fm} = q^{nm}_A > q^C_{A,fm} & \\ q^{nm}_B < q^C_{B,fm} < q^D_{B,fm} & d_B > 0 \\ q^{nm}_B < q^D_{B,fm} < q^C_{B,fm} & d_B < 0 \\ q^{nm}_B < q^D_{B,fm} = q^C_{B,fm} & d_B = 0 \end{cases} \quad \Delta q^{nm} > \Delta q^D_{FM} > \Delta q^C_{FM}$$

$$c_A - c_B - \tfrac{w_B}{2} = -\tfrac{m}{4z}\tfrac{d_B(\theta_B-\theta_A)}{\theta_A\theta_B} : \quad q^D_{A,fm} = q^{nm}_A = q^C_{A,fm}, q^D_{B,fm} = q^{nm}_B = q^C_{B,fm}$$

Proof. From (23), the choice $p = c_A$ is feasible in a decentralized setting under (21) and the additional restriction

$$-\frac{m}{2z}\frac{2\theta_A + d_B}{2\theta_A} < c_A - c_B - \frac{w_B}{2} < \frac{m}{2z}\frac{\theta_B - \theta_A}{\theta_A}.$$

Compared to (17), the upper bound in the above equation is always higher than what required in centralization. Moreover, the condition $q^{nm}_A - q^{nm}_B < \frac{m}{4\beta}$, equivalent to $m\theta_A\theta_B > \beta^2(\theta_A - \theta_A)$, implies that $\frac{\theta_B-\theta_A}{\theta_A+\theta_B} - \frac{m(2\theta_A\theta_B+d_B(\theta_A+\theta_B)}{2\beta^2(\theta_A+\theta_B)}$ is higher than $\frac{\theta_B-\theta_A}{\theta_A} - \frac{m}{2\beta^2}(2\theta_B + d_B)$. Thus, the conditions in the statement assure that the choice $p = c_A$ is feasible for both the centralized and the decentralized setting.

For this choice of p, quality in Region A is not affected by mobility, while $q^D_{B,fm}$ is higher or lower than q^{nm}_B depending on the sign of $c_A - c_B - \frac{w_B}{2} + \frac{md_B(\theta_B-\theta_A)}{4z\theta_A\theta_B}$, which is also the threshold for increased/decreased quality with free mobility in the centralized setting. Note that since

$$-\frac{md_B(\theta_B - \theta_A)}{4z\theta_A\theta_B} + \frac{m(2\theta_A + d_B)}{4z\theta_A} = \frac{m(2\theta_B + d_B)}{4z\theta_B}$$
$$-\frac{md_B(\theta_B - \theta_A)}{4z\theta_A\theta_B} - \frac{m(\theta_B - \theta_A)}{4z\theta_A} + \frac{m^2(2\theta_B + d_B)}{4z\beta^2} = \frac{m(2\theta_B + d_B)(m\theta_A\theta_B - \beta^2(\theta_B - \theta_A)}{4z\beta^2\theta_A\theta_B}$$
$$\frac{m(\theta_B - \theta_A)}{2z\theta_A} + \frac{md_B(\theta_B - \theta_A)}{4z\theta_A\theta_B} = \frac{m(\theta_B - \theta_A)(2\theta_B + d_B)}{4z\theta_A\theta_B}$$

the term $-\frac{md_B(\theta_B-\theta_A)}{4z\theta_A\theta_B}$ is always in the range of feasible values for $c_A - c_B - \frac{w_B}{2}$. Since

$$q^D_{B,fm} - q^C_{B,fm} = d_B \frac{\beta z\theta_B}{m} \frac{c_A - c_B - \frac{w_B}{2} + \frac{md_B(\theta_B-\theta_A)}{4z\theta_A\theta_B}}{(2\theta_B + d_B)(2\theta_A\theta_B + d_B(\theta_A + \theta_B))}$$

we can conclude that if $c_A - c_B - \frac{w_B}{2} < -\frac{md_B(\theta_B-\theta_A)}{4z\theta_A\theta_B}$, quality in Region B both in a centralized and a decentralized setting is lower with mobility, and lower with centralization when $d_B < 0$ or higher when $d_B > 0$. On the contrary, values of $c_A - c_B - \frac{w_B}{2}$ above this threshold entail a quality in B which increases with free mobility in both settings, higher in centralization for $d_B < 0$ and lower for $d_B > 0$. □

As already discussed, if $c_A - c_B - \frac{w_B}{2} < -\frac{m}{4z}\frac{d_B(\theta_B-\theta_A)}{\theta_A\theta_B}$, the marginal benefits from introducing mobility in Region B outweigh the related costs and in both institutional settings the gap becomes larger: in centralization by simultaneously increasing quality in Region A and decreasing it in Region B, in decentralization for $p = c_A$ only by decreasing it in B. However, if the decision on quality is taken locally, whenever $d_B < 0$ the decrease in quality is lower. In fact, in this case the benefit from quality on the consumer surplus is higher than the disutility of providing the service to more patients, thus the regulator in Region B is more prone to offer a slightly higher quality level compared to the central planner. From a policy point of view, this means that the institutional setting matters even when the qualitative effects of allowing patients mobility may go in the same direction.

The next result shows that the outcome from central decision making cannot be reproduced in a decentralized setting.

Corollary 2. *Let the hypotheses in Corollary 1 be satisfied and let* $c_A - c_B - \frac{w_B}{2} < -\frac{m}{4z}\frac{d_B(\theta_B-\theta_A)}{\theta_A\theta_B}$. *Then, denoting by* $W^D_{A,fm}(p)$ *and* $W^D_{B,fm}(p)$ *the welfare in Region A and B obtained by substituting the quantities in (22), there exists a price* $p^* = argmax(W^D_{A,fm}(p) + W^D_{B,fm}(p))$ *such that* $p^* > c_A$, *for which quality is underprovided in Region A and overprovided in Region B with respect to the centralized setting. Under the same condition, the price* $\tilde{p}$ *that allows the quality in Region A to be equal to* $q^C_{A,fm}$ *is larger than* p^* *and also in this case there is overprovision in Region B.*

Proof. The second order derivative with respect to p of $W^D_{A,fm} + W^D_{B,fm}$ is $-\frac{\beta^2 z^2(2\theta_A+d_B)(\theta_A+\theta_B)}{2m^2\theta_A^2(2\theta_B+d_B)}$, thus is negative under the hypotheses. The FOC is solved by

$$p^* = c_A - \frac{2\theta_A\theta_B}{(\theta_A+\theta_B)(2\theta_A+d_B)}\left(c_A - c_B - \frac{w_B}{2} + \frac{m}{4z}\frac{d_B(\theta_B-\theta_A)}{\theta_A\theta_B}\right)$$

which is greater than c_A under the condition in the statement. Since

$$\tilde{p} = c_A - \frac{2\theta_A\theta_B}{2\theta_A\theta_B + d_B(\theta_A+\theta_B)}\left(c_A - c_B - \frac{w_B}{2} + \frac{m}{4z}\frac{d_B(\theta_B-\theta_A)}{\theta_A\theta_B}\right)$$

we have

$$\tilde{p} = p^* + \frac{2\theta_A^2}{2\theta_A\theta_B + d_B(\theta_A+\theta_B)}(p^* - c_A)$$

thus $\tilde{p} > p^*$. Since both qualities in the decentralized setting are increasing in p, making explicit their dependence on the price in the notation, the following holds

$$q^C_{A,fm} = q^D_{A,fm}(\tilde{p}) > q^D_{A,fm}(p^*), \qquad q^C_{B,fm} < q^D_{B,fm}(p^*) < q^D_{B,fm}(\tilde{p})$$

as described in the statement. □

5. Regulated Mobility

In this section, we turn to a different setting, where restrictions to patients' mobility are imposed and the number of those that can move cross boundary is used as a policy variable. There are several reasons that induce decision-makers to take this decision: it may be a problem related to underprovision, excess demand, or it may simply be that the neighboring Region is more efficient at producing health care. As in Section 4, we first consider a first-best setting, where a central policy maker chooses quality and decides which patients may choose to access care outside their region by optimizing total welfare and compare the results with the related decentralized setting.

5.1. Centralized Decision Making

Let us analyze the case where a utilitarian supra-regional regulator sets qualities and decides which patients may seek care in the neighboring region so to maximize the sum of the two welfare functions. In this case, denoting by x the distance from the nearest local provider of the last patient that is treated locally, the profit of provider j in region A is:

$$\Pi_j = (p_A - c_A)\left(\frac{1}{4} + \frac{\beta}{2m}(q_j - q_{-j})\right) + (p - c_A)z\left(\frac{1}{8} - x\right) - \frac{1}{2}\theta_A q_j^2,$$

for $j = 1,2,\ -j = 2,1$, thus private providers only react to the reimbursement p_A and there effectively is no competition on the border, so that the reaction function corresponds to the case $z = 0$. The welfare functions of the two regions are:

$$\begin{aligned} W_{A,rm} &= r_A(1-t_A) + 4\int_0^{\frac{1}{8}}(v + \beta q_A - ms)\,\mathrm{d}s \\ &\qquad \frac{p_A - c_A}{2} + 2z(p - c_A)\left(\frac{1}{8} - x\right) - \theta_A q_A^2 \qquad (24) \\ W_{B,rm} &= r_B(1-t_B) - \frac{w_B}{2}\left(\frac{1}{2} - 2z\left(\frac{1}{8} - x\right)\right)^2 + 4\int_0^{\frac{1}{8}}(v + \beta q_B - ms)\,\mathrm{d}s \\ &\qquad + 2z\int_x^{\frac{1}{8}}\left(\beta(q_A - q_B) - m\left(\frac{1}{4} - 2s\right)\right)\mathrm{d}s \qquad (25) \end{aligned}$$

and the optimization problem for the central planner is

$$\max_{p_A, q_B, x}\ (W_{A,rm} + W_{Brm}) \quad \text{s.t.} \begin{cases} p_A \geq c_A, \\ \Pi_j \geq 0,\ j = 1,2, \\ q_B \geq 0, \\ 0 \leq x \leq \frac{1}{8}, \\ q_A = \frac{\beta}{2m\theta_A}(p_A - c_A), \\ t_A r_A = p_A \frac{1}{2}, \\ t_B r_B = c_B\left(\frac{1}{2} - 2z\left(\frac{1}{8} - x\right)\right) + \theta_B\, q_B^2 + 2zp\left(\frac{1}{8} - x\right). \end{cases} \qquad (26)$$

The following result on the existence of an internal solution is obtained:

Proposition 4. *Let $z > 0$, $\theta_A \geq \frac{\beta^2}{4m}$ and $2\theta_A\theta_B(w_B z + m) - z\beta^2(\theta_A + \theta_B) > 0$. If*

$$c_A - c_B - \frac{w_B}{2} < \frac{\beta^2}{4}\frac{\theta_B - \theta_A}{\theta_A\theta_B} \tag{27}$$
$$c_A - c_B - \frac{w_B}{2} > \frac{\beta^2}{4}\frac{\theta_B - \theta_A}{\theta_A\theta_B} - \frac{2\theta_A\theta_B(w_B z + m) - z\beta^2(\theta_A + \theta_B)}{4\theta_A\theta_B}\min\left\{\frac{1}{2}, \frac{4m\theta_A - \beta^2}{z\beta^2}\right\}$$

problem (26) admits the following internal solution:

$$\begin{aligned}
p^C_{A,rm} &= c_A + \frac{m}{2} - \frac{2mz\theta_A\theta_B}{2\theta_A\theta_B(w_B z + m) - z\beta^2(\theta_A + \theta_B)}\left(c_A - c_B - \frac{w_B}{2} - \frac{\beta^2}{4}\frac{\theta_B - \theta_A}{\theta_A\theta_B}\right),\\
q^C_{A,rm} &= \frac{\beta}{4\theta_A} - \frac{z\beta\theta_B}{2\theta_A\theta_B(w_B z + m) - z\beta^2(\theta_A + \theta_B)}\left(c_A - c_B - \frac{w_B}{2} - \frac{\beta^2}{4}\frac{\theta_B - \theta_A}{\theta_A\theta_B}\right),\\
q^C_{B,rm} &= \frac{\beta}{4\theta_B} + \frac{z\beta\theta_A}{2\theta_A\theta_B(w_B z + m) - z\beta^2(\theta_A + \theta_B)}\left(c_A - c_B - \frac{w_B}{2} - \frac{\beta^2}{4}\frac{\theta_B - \theta_A}{\theta_A\theta_B}\right),\\
x^C_{rm} &= \frac{1}{8} + \frac{\theta_A\theta_B}{2\theta_A\theta_B(w_B z + m) - z\beta^2(\theta_A + \theta_B)}\left(c_A - c_B - \frac{w_B}{2} - \frac{\beta^2}{4}\frac{\theta_B - \theta_A}{\theta_A\theta_B}\right).
\end{aligned} \tag{28}$$

Proof. The Hessian matrix of W_{rm} is

$$\begin{bmatrix} -4z(w_B z + m) & -\frac{z\beta^2}{m\theta_A} & 2z\beta \\ -\frac{z\beta^2}{m\theta_A} & -\frac{\beta^2}{2m^2\theta_A} & 0 \\ 2z\beta & 0 & -2\theta_B \end{bmatrix}$$

is negative definite if $2\theta_A(w_B z + m) - z\beta^2 > 0$ and $2\theta_A\theta_B(w_B z + m) - z\beta^2(\theta_A + \theta_B) > 0$, with the second condition being stricter than the first one. The system of FOCs admits the unique solution in (28); the conditions on $c_A - c_B - \frac{w_B}{2}$ required to have $0 < x^C_{rm} < \frac{1}{8}$ are also sufficient for both qualities to be positive. In fact, since $\theta_A q^C_{A,rm} + \theta_B q^C_{B,rm} = \frac{\beta}{2}$ and $x^C_{rm} = \frac{1}{8} - \frac{1}{z\beta}\left(\frac{\beta}{4} - \theta_B q^C_{B,rm}\right)$, if x^C_{rm} is in the feasible range, the following holds: $q^C_{A,rm} > \frac{\beta}{4\theta_A}$ and $q^C_{B,rm} > \frac{(2-z)\beta}{8\theta_B} > 0$. Also, since $\Pi_A = (p^C_{A,rm} - c_A)\left(\frac{1}{2} - \frac{\beta^2}{4m^2\theta_A}(p^C_{A,rm} - c_A)\right)$ the constraint for the profit can also be stated in terms of a restriction on $c_A - c_B - \frac{w_B}{2}$ and combining all requirements the constraint in (27) is found. □

From the existence conditions, it follows that for $z > 0$, quality in Region A is higher than without mobility and the converse is true for quality in B, thus the quality gap is always larger with mobility, with a size that decreases with $c_A - c_B - \frac{w_B}{2}$. The flow of patients for regulated mobility is $2z\left(\frac{1}{8} - x^C_{rm}\right)$, while from (2), the same quality gap in free mobility would result in a total flow of patients equal to $\frac{z\beta}{m}(q^C_{A,rm} - q^C_{B,rm})$. The difference between the flow with patients' choice and the regulated one is

$$\frac{z}{m}\frac{(2m\theta_A\theta_B - z\beta^2(\theta_A + \theta_B))(c_A - c_B - \frac{w_B}{2}) + z\frac{w_B}{2}\beta^2(\theta_B - \theta_A)}{2\theta_A\theta_B(w_B z + m) - z\beta^2(\theta_A + \theta_B)}.$$

Supposing that for $w_B = 0$ the objective function is concave, i.e., $2m\theta_A\theta_B - z\beta^2(\theta_A + \theta_B) > 0$, a larger number of patients would move, given the quality gap, for

$$c_A - c_B - \frac{w_B}{2} > -\frac{z\beta^2 w_B(\theta_B - \theta_A)}{2(2m\theta_A\theta_B - z\beta^2(\theta_A + \theta_B))}. \tag{29}$$

The quantity on the right-hand side is always lower than the upper bound for existence; if $2m\theta_A\theta_B - z\beta^2(\theta_A + \theta_B) < 2\beta^2(\theta_B - \theta_A)$ it is also lower than the lower bound for existence, so that in this case the flow would always be higher with free mobility.

Proposition 5. *Let $z > 0$, $\theta_A \geq \frac{\beta^2}{4m}$, $2\theta_A + d_B > 0$, $2m\theta_A\theta_B - z\beta^2(\theta_A + \theta_B) > 0$, and conditions in (17), and (27) be satisfied.*

Then, if $w_B \neq 0$ whenever (29) holds, in centralization regulated mobility gives higher quality in Region A and lower in Region B compared to free mobility, with a flow which is lower, both compared to free mobility in centralization and with free patients' choice with the same qualities.

For $w_B = 0$, the qualities in a centralized setting are the same in the two cases, but the flow is restricted in the case of regulated mobility when $c_A > c_B$.

Proof. Since $2m\theta_A\theta_B > z\beta^2(\theta_A + \theta_B)$, we have $2\theta_A\theta_B + d_B(\theta_A + \theta_B) > \frac{z^2\beta^2 w_B(\theta_A+\theta_B)}{m^2}$, thus conditions in Proposition 2 and 4 are satisfied. For a centralized setting, the quality difference in Region A between free mobility and regulated mobility is:

$$q^C_{A,rm} - q^C_{A,fm} = \frac{z^2\beta\theta_B}{m^2} w_B \frac{(c_A - c_B - \frac{w_B}{2})(2m\theta_A\theta_B - z\beta^2(\theta_A + \theta_B)) + z\frac{w_B}{2}\beta^2(\theta_B - \theta_A)}{(2\theta_A\theta_B(w_B z + m) - z\beta^2(\theta_A + \theta_B))(2\theta_A\theta_B + d_B(\theta_A + \theta_B))}.$$

Thus, if $w_B = 0$, the same result in terms of quality is obtained, due to the equality $\theta_A q_A + \theta_B q_B = \frac{\beta}{2}$, which is valid in both cases. However, from the above discussion, the flow of patients in the two cases is the same only if $c_A = c_B$ as well.

Since, by standard calculations, it also is

$$2z\left(\frac{1}{8} - x^C_{rm}\right) - \frac{z\beta}{m} = -\frac{2m\theta_A\theta_B > z\beta^2(\theta_A + \theta_B)}{z\beta\theta_B w_B}(q^C_{A,rm} - q^C_{A,fm})$$

and the comparison of patients' flows is also proven. □

5.2. Decentralized Decision Making

Let us now turn to a different institutional setting where mobility is regulated, but decisions are taken at regional level in a game between the two Regions A and B. As in Section 5.1, let x denote the distance from the nearest local provider of the last patient that is treated locally. As already observed, private providers only react to the reimbursement p_A and set $q_A = \frac{\beta}{2m\theta_A}(p_A - c_A)$. For any given x and p, the goal of the regulator in Region A is:

$$\max_{p_A} W_{A,rm} \quad \text{s.t.} \begin{cases} p_A \geq c_A, \\ \Pi_j \geq 0,\ j = 1,2, \\ q_A = \frac{\beta}{2m\theta_A}(p_A - c_A), \\ t_A r_A = p_A \frac{1}{2} \end{cases}$$

and that of the regulator in Region B is:

$$\max_{q_B} W_{B,rm} \quad \text{s.t.} \begin{cases} q_B \geq 0, \\ t_B r_B = c_B\left(\frac{1}{2} - 2z\left(\frac{1}{8} - x\right)\right), + \theta_B q_B^2 + 2zp\left(\frac{1}{8} - x\right) \end{cases}$$

with the welfare functions $W_{A,rm}$ and $W_{B,rm}$ defined in (24) and (25), respectively. In both cases, the objective functions are concave and the internal decisions in Regions A and B are:

$$p^D_{A,rm} = c_A + \frac{m}{2}, \tag{30}$$

$$q^D_{A,rm} = \frac{\beta}{4\theta_A}, \tag{31}$$

$$q^D_{B,rm} = \frac{\beta}{4\theta_A} - \frac{z\beta}{\theta_B}\left(\frac{1}{8} - x\right). \tag{32}$$

Thus, in Region A, mobility has no effect on both quality and reimbursement, while quality in Region B is lower and depends on the size of outgoing patients.

Let us now analyze the case where also the decision on the price p and the size of the flow (through x) are taken by local authorities through a bargaining process. The disagreement payoffs in this case are represented by the welfare levels of no mobility, which will be denoted by W_A^{nm} and W_B^{nm}, respectively, and are obtained by substituting the quantities in (9)–(11) in the associated objective functions. Denoting by $W_{A,rm}^D(x,p)$ and $W_{B,rm}^D(x,p)$ the functions obtained by substituting the quantities in (30)–(32) in (24) and (25), the price p and the distance x result from the solution of the following Nash bargaining problem:

$$\begin{array}{l} \max_{x,p}\left(\alpha \ln(W_{A,rm}^D(x,p) - W_A^{nm}) + (1-\alpha)\ln(W_{B,rm}^D(x,p) - W_B^{nm})\right) \\ \quad \text{s.t. } 0 \le x \le \frac{1}{8}, \quad p \ge c_A, \end{array} \tag{33}$$

where α is the bargaining power of Region A. Then, the following result holds:

Proposition 6. *Let* $2\theta_B(w_B z + m) - z\beta^2 > 0$ *and*

$$\frac{\beta^2(\theta_B - \theta_A)}{4\theta_A\theta_B} - \frac{2\theta_B(w_B z + m) - z\beta^2}{8\theta_B} < c_A - c_B - \frac{w_B}{2} < \frac{\beta^2(\theta_B - \theta_A)}{4\theta_A\theta_B}.$$

Then, problem (33) *admits the following unique internal solution:*

$$x_{rm}^D = \frac{1}{8} + \theta_B \frac{c_A - c_B - \frac{w_B}{2} - \frac{\beta^2(\theta_B - \theta_A)}{4\theta_A\theta_B}}{2\theta_B(w_B z + m) - z\beta^2}, \tag{34}$$

$$p_{rm}^D = c_A - \frac{\alpha}{2}\left(c_A - c_B - \frac{w_B}{2} - \frac{\beta^2(\theta_B - \theta_A)}{4\theta_A\theta_B}\right). \tag{35}$$

Substituting the value x_{rm}^D in $q_{B,rm}^D$, the following quality for Region B is found

$$\frac{\beta}{4\theta_B} + z\beta \frac{c_A - c_B - \frac{w_B}{2} - \frac{\beta^2(\theta_B - \theta_A)}{4\theta_A\theta_B}}{2\theta_B(w_B z + m) - z\beta^2}$$

which is higher than $q_{B,rm}^C$. This also means that the flow of patients in this case is lower with respect to a centralized decision for regulated mobility, since in both cases $2z\left(\frac{1}{8} - x\right) = \frac{1}{2} - \frac{2\theta_B}{\beta} q_B$. Thus, if decisions are taken at local level, the quality in Region B is set to a higher level than in centralization, the gap is lower and the regions agree on a flow of patients which is smaller than what would be optimal for total welfare maximization. Note that in this case, the value x_{rm}^D is the same that optimizes the sum $W_{A,rm} + W_{B,rm}$.

6. Discussion

The model we have presented shows that the question of whether patients' mobility is beneficial to improve quality of care does not have a plain answer. The first interesting result that emerges from the analysis is that institutional setting matters when mobility is allowed, but, even more importantly is that a trade-off may emerge between equity (in terms of quality differences among provided treatments) and welfare (finding an allocation that maximizes social benefits).

It is in fact important to remember that quality decisions at local level reflect communities' preferences and ability to pay, but also efficiency in health care delivery. Efficiency requires using scarce resources in order to maximize social benefits and this objective may not be compatible with a more uniform level of care across regions. In our paper, this element becomes quite clear if we compare solutions where mobility is not allowed with frameworks where the latter is permitted. When the regional differences in terms of costs to deliver health care (either because of a different input costs c_A vs. c_B or because of other organizational costs (w_B)) are significant, so that one of the regions is better at delivering health care, patients' mobility is encouraged through an increase in the quality gap. Thus, the first notable result: there is not an outright answer as concerns the desirable effects of patients' mobility. The latter certainly increases total welfare (as seen in both centralized settings), but this goal may be reached by increasing the gap, thus the policy of opening borders should not, by itself, be used to reduce quality differences.

The second interesting result is that in a setting where the organization of health care is different across regions (market oriented in Region A, vertically integrated in Region B), institutional settings play an important role. The latter may reflect political choices at national level (as in the case of UK where provision is centralized vs. Spain or Italy where it is decentralized) or it may reflect a different framework altogether (mobility at EU level where only the decentralized model can be applied, since each country may decide their level of health care provision).

Decentralization with free patients' mobility increases quality in the high skill region whenever the cross-border price is higher than the marginal cost, while in Region B the effect depends on a comparison of costs and benefits, as in the centralized case. Whenever it is increased in a centralized setting, the same is true in decentralization and the effect is larger, due to the price p. When decreasing q_B is optimal in centralization, the same may not be true when quality is set at local level, if the price is high enough. When the price equals the marginal cost, the gap moves in the same direction with respect to no mobility in both centralization and decentralization, but the effect is curbed in decentralization. What is also interesting is that even though quality may be tuned using p, it is not possible to use it to reach the centralized solution.

Policies aimed at regulating the mobility flow have a different effect at central and decentralized level. When choices are made by a central planner, quality is always increased in the high skill region and decreased in the low skill one. Depending on the difference in costs in the two regions, quality in Region A may be higher or lower than in a centralized setting with free mobility. If the efficiency gap is sufficiently high, the resulting quality gap is higher with regulated mobility, but fewer patients are allowed to move. In the case $w_B = 0$, qualities in the two regions are the same, but the flow of patients is restricted anyway if the cost c_A is higher than c_B. In a decentralized setting, the quality in Region A is the same as in the no mobility case. In other words, the regulation cancels out the incentive for private providers to increase quality due to the cross-border price.

Although patients' choice improves welfare compared to the case where mobility is not allowed, welfare optimization calls for the regulation of flows and only under specific conditions on the efficiency gap among regions mobility may be used as a tool to reduce disparities. When the regulated flow is smaller than the one with free mobility, a system of prior authorization as in the EU is necessary (Greer et al., 2024). On the contrary, waiting lists and other nudging devices may have to be put in place in order to make patients decide to travel to be treated.

7. Conclusions

During recent decades, cross-border mobility in healthcare has gained increasing attention in industrialized countries. This reflects structural, cultural, economic, and political changes. An increasing emphasis on patients' rights and patients' choice in many European countries has caused a surge in the number of people that seek treatment abroad, as well as a growth in inter-regional mobility at national level. These trends have contributed to an increased interest on the part of policy-makers in cross-border patient mobility. In general, patients' choice is sought as a means to improve efficiency and to enhance quality.

While Brekke et al. (2014a) show that in general this is the case both from a theoretical and an empirical point of view, the most recent literature seems to cast serious doubts on this conclusion (Finotelli, 2021). Our model allows us to interpret these countervailing results. In fact, we show that institutional settings are quite relevant in determining the success of patients mobility as a tool to improve welfare.

The first interesting result is that decentralization with free patients' mobility increases quality in the high skill region, provided that the price is higher than the marginal cost, while in Region B the effect depends on a comparison of costs and benefits. In particular, if heterogeneity in efficiency is high, Region B may reduce quality, i.e., patients' mobility may have the opposite effect. This result is in line with what was observed in Italy as concerns patients' mobility and quality of care. Quality of care has decreased in the exporting regions, which are also becoming poorer (GIMBE, 2025; Rbm-Censis, 2019). In this case, it would be better to restrict the flow of patients.

The second notable result derives from the comparison with a centralized setting. As in the decentralized case, quality in Region A is non decreasing, provided that the price is sufficiently high and in Region B it depends on the parameters. However, such an effect is higher in centralization.

The results we have presented have interesting policy implications both at national and supranational level. Since the onset of Covid, the role of the EU in the health care sector has been at the hearth of a lively debate (Greer et al., 2024; Guthmuller et al., 2021; Röhrling et al., 2018). In this respect, our model shows that, in line with what foreseen by the EU law, health care provision is better left at national level and that patients' mobility should be regulated.

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Notes

1. See Levaggi and Levaggi (2024) for a review of the literature on the application of Hotelling and Salop competition models in health care markets.
2. Note that this is compatible with the constraint (17) whenever the quality gap with no mobility $q_A^{nm} - q_B^{nm}$ is lower than $m/(4\beta)$.

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