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The effect of cross-border healthcare on quality, public health insurance, and income redistribution

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The effect of cross-border healthcare on quality, public health insurance, and income redistribution*

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Abstract

In this study, we examine the effect of cross-border healthcare with public health insurance. We consider its effect on healthcare quality, public health insurance, and income redistribution. We use a two-country Hotelling model in which consumers are divided into two groups: high- and low-income consumers. The governments, which aim to maximize consumers' surplus, impose an income tax on consumers to provide reimbursement for healthcare services and subsidy to hospitals and improve income redistribution among consumers, and the hospitals decide their healthcare quality to maximize their profits. Under these assumptions, we obtain the following results. Promoting cross-border healthcare increases reimbursement for healthcare services and improve healthcare quality in the patient-importing countries. On the other hand, the patient-exporting countries do not always increase reimbursement or improve healthcare quality as part of promoting cross-border healthcare. Further, when non-monetary frictions for cross-border healthcare are low, income redistribution in the patient-exporting countries weakens as a result of tax deduction to support cross-border patients.

1 Introduction

This study analyzes the effect of cross-border healthcare on the quality of healthcare as well as public health insurance and income redistribution schemes. Although the globalization of healthcare has been increasing, it is limited to a handful of wealthy households in countries pursuing universal health coverage. This is because when patients receive medical treatment abroad, they do not use (or face difficulty in using) public insurance. Thus, medical treatment abroad is fairly expensive

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as compared with treatment in the home country. In this regard, European Union (EU) countries have been reforming their healthcare systems. In the EU, patients' rights in cross-border healthcare are authorized by a directive adopted by the European Parliament and the Council in 2011.[1] This directive states that the costs of cross-border healthcare shall be reimbursed or paid directly by the Member State up to an amount that would have been paid by the state, which implies that patients can receive treatment abroad by paying the same fees as applicable in the home country (although they must incur travel costs for the visit abroad). Therefore, this directive would have a large impact on the demand for cross-border healthcare in the EU. Although expansion of cross-border healthcare is expected to improve healthcare quality,[2] it would influence the public health insurance scheme if the costs of cross-border healthcare are reimbursed by the home country. Additionally, since Glied (2008) shows that public health insurance reduces income inequality in a nation, an income redistribution scheme would also be influenced through a change in the public health insurance scheme. Therefore, the current study offers insight on how tax and social security schemes are affected, before the real diffusion, by the implementation of cross-border healthcare with reimbursement by public health insurance.

We use a two-country Hotelling model to study the effect of cross-border healthcare on healthcare quality, public health insurance, and income redistribution. Each country's consumers are divided into two groups: high- and low-income consumers. The governments, which aim to maximize consumers' surplus, impose an income tax on consumers to provide reimbursement for healthcare services and subsidy to hospitals and improve income redistribution among consumers, and the hospitals decide their healthcare quality to maximize their profits.

Under these assumptions, we obtain the following results. Countries that encourage hospitals

[1] Refer to directive 2011/24/EU of the European Parliament and of the Council dated March 9, 2011, on the application of patients' rights in cross-border healthcare.

[2] Previous literature shows that competition-inducing policies increase healthcare quality only under certain conditions. For example, Gravelle and Sivey (2010) show that consumers better informed about hospitals lead to quality improvement only if the initial information was relatively imprecise, and/or the hospitals have similar quality-producing technologies and, thus, provide similar quality in equilibrium. Brekke *et al.* (2011) show that easy access to healthcare always improves quality if the profit margin is positive, the marginal cost of treatment is constant, and the cost for quality is independent of treatment volume; otherwise, easy access to healthcare has an indeterminate effect on quality.

to take in patients from a foreign country (hereafter patient-importing countries) increase reimbursement and improve healthcare quality. However, promoting cross-border healthcare does not cause income redistribution in the country because the higher reimbursement, which incentivizes hospitals to attract more foreign patients by improving their healthcare quality, is funded by the income from foreign patients. On the other hand, countries that entrust their patients to hospitals in a foreign country (hereafter the patient-exporting countries) do not always increase reimbursement or improve healthcare quality as part of implementing cross-border healthcare. Although the patient-exporting countries obtain the same effect as the patient-importing countries, a reduction in the proportion of patients receiving healthcare services at a domestic hospital influences government strategies in the patient-exporting countries. Further, when non-monetary frictions for cross-border healthcare are low, income redistribution in the patient-exporting countries weakens as a result of tax deduction to support cross-border patients.

The present study is closely related to Andritsos and Tang (2013, 2014) and Brekke *et al.* (2014b, 2016), which analyze the effect of cross-border patient mobility with reimbursement under public health insurance.[3] Andritsos and Tang (2013) show that cross-border patient mobility decreases waiting time if the reimbursement is fixed. Andritsos and Tang (2014) show that cross-border patient mobility reduces reimbursement costs without increasing the patients' waiting time. Brekke *et al.* (2014b) show, assuming two regions that differ in healthcare technology, that the effect of cross-border patient mobility depends on reimbursement from the patient-exporting region to the patient-importing region. For example, if the reimbursement is equal to the marginal cost, quality and welfare remain unchanged in the patient-importing region and quality decreases and welfare increases in the patient-exporting region. Brekke *et al.* (2016) show, assuming three regions in which the average income levels are different, that quality and welfare remain unchanged in the high-income regions and that the effects on quality and welfare in the middle- and low-income countries are ambiguous if reimbursement is equal to the marginal cost. Andritsos and Tang's (2013, 2014)

[3]Brekke *et al.* (2014a) review the literature on cross-border patient mobility.

models assume that governments decide reimbursement and operational capacity in healthcare, whereas Brekke *et al.* (2014b, 2016) model local government decisions on the quality of healthcare service under a given reimbursement condition. In reality, however, the governments of many European countries have provided public hospitals semi-autonomy, empowering them to make key strategic, financial, and clinical decisions themselves (Saltman *et al.*, 2011). Therefore, the present model assumes that governments decide the level of reimbursement to hospitals, and hospitals decide the quality of healthcare services under the reimbursement offered by the governments. Under this assumption, the governments cannot directly enforce provisions of healthcare services, and reimbursement is endogenously decided by local governments. Further, the present study considers the effect on income redistribution, unlike the above-mentioned studies.

The remainder of this paper is organized as follows. Section 2 presents the model. Section 3 presents the equilibrium quality of hospitals. Section 4 demonstrates the equilibrium strategies of governments. Section 5 describes how the equilibrium property changes with continual expansion of cross-border healthcare. Finally, Section 6 concludes the study.

2 Model

Consider a healthcare market in which consumers (patients) are divided into two groups: high-income (y^H) and low-income (y^L) consumers ($y^H > y^L$). Both groups are uniformly distributed on a line $L = [-1, 1]$. The market is served by two healthcare providers (hospitals), located at the endpoints of L. The market consists of two different countries, Country 1 and Country 2. The consumers and the hospital located on the line segment $L_1 = [-1, 0]$ belong to Country 1, while the remaining consumers and the hospital located on the line segment $L_2 = [0, 1]$, belong to Country 2. The population in each country is 1. The proportion of high-income consumers, denoted by $\lambda_i \in (0, 1)$ for country i, differs between the countries. Further, we assume that each consumer demands one unit of healthcare (one treatment).

Governments. The government in each country collects income tax at the rate τ_i $(i = 1, 2)$ from

consumers and utilize the tax revenue to provide reimbursement for healthcare services and subsidy to the hospital and its consumers.

The reimbursement per treatment of healthcare in Country i is denoted by p_i. When the consumers in Country i receive healthcare services from the domestic hospital, the government pays p_i to the hospital. When they receive healthcare services from the foreign hospital in Country j, the government pays $\min\{p_i, p_j\}$ to the hospital.[4] The subsidy to hospitals in each country is fixed and denoted by T_i. The subsidy to consumers is equally distributed among them, and the subsidy per consumer in Country i is denoted by s_i. Therefore, the budget constraint of the government in Country i is given by

$$[\lambda_i y_i^H + (1-\lambda_i) y_i^L]\tau_i = \begin{cases} s_i + p_i + T_i & p_i \leq p_j \\ s_i + (1-\Phi)p_i + \Phi p_j + T_i & p_i > p_j \end{cases}. \tag{1}$$

where $i \neq j$ and Φ denotes the number of consumers who receive healthcare services from foreign Country j.

Taxes on consumers and subsidies provided to them result in income redistribution among consumers, and the redistributed income of high- and low-income consumers in Country i is obtained as

$$\overline{y_i^H} = (1-\tau_i) y_i^H + s_i, \tag{2}$$

and

$$\overline{y_i^L} = (1-\tau_i) y_i^L + s_i, \tag{3}$$

respectively. Note that $\overline{y_i^H} = \overline{y_i^L} = s_i$ when $\tau = 1$; that is, perfect redistribution is achieved when the tax rate is 100%.

Consumers. Each consumer demands one unit of healthcare (one treatment) from the most preferred hospital. The utility of a patient located at $x_i \in L_i$ and treated by the hospital in Country

[4] EU directive 2011/24/EU expects that patients will be reimbursed the same amount as they would receive in their own country for the same type of healthcare, and if the treatment abroad is cheaper than in the home country, the reimbursement will reflect the real price of the treatment. See http://europa.eu/rapid/press-release_ MEMO-13-918_en.htm.

j, located at z_j, is given as follows.[5]

$$U(x_i, z_j) = \begin{cases} v + bq_j - t|x_i - z_j| + u(\overline{y_i^k}) & \text{if } i = j \\ v + bq_j - t|x_i - z_j| + u(\overline{y_{ij}^k}) - F & \text{if } i \neq j \end{cases} \tag{4}$$

where

$$\overline{y_{ij}^k} = \overline{y_i^k} - \max[p_j - p_i, 0]. \tag{5}$$

$v > 0$ is the patient's reservation benefits by being treated, and $q_j \geq \underline{q}$ is the quality offered by the hospital in Country j with $b > 0$ measuring the marginal benefits of quality. The lower bound $\underline{q}$ represents the lowest possible quality the hospitals can offer without being charged with malpractice and is, for simplicity, normalized to 0. $t|x_i - z_j|$ is the disutility from traveling to a hospital, which is in proportion to the distance, $u(\cdot)$ is a utility function of consumption of goods and services other than healthcare that satisfies the Inada conditions ($u'(\cdot) > 0$, $u''(\cdot) < 0$, $u'(0) = \infty$, and $u'(\infty) = 0$). We assume that the price of goods and services other than healthcare services is one, and consumers expend all of their income for goods and services. Therefore, $u(\cdot)$ is a function of their redistributed income less copayment for healthcare. F is the non-monetary mobility cost (disutility) of seeking care in a different region (because of the difference in language and culture, as well as attachment, for example). We also assume that patients can receive healthcare from the domestic hospital without a copayment, whereas patients who receive healthcare from the foreign hospital have to make good the difference in reimbursement between the foreign and home countries, $\max[p_j - p_i, 0]$, as a copayment for healthcare.[6] Note that we can interpret t and F as non-monetary friction parameters of cross-border healthcare. In these settings, a proportion of consumers in the country with lower hospital quality receive cross-border healthcare services. In other words, if $q_i > q_j$, a proportion of consumers in Country j receive healthcare services from

[5]Regarding the utility function in the present model, we basically follow the model presented by Brekke *et al.* (2016). This utility function is separable into healthcare quality, distance, and consumption, and is justified because distance is a major factor of patients' choice of hospitals (see Tay (2003) and Beckert *et al.* (2012)), and because healthcare service does not substitute for consumption of other goods and services.

[6]If reimbursement in the foreign country is lower than in the home country, consumers obtain reimbursement from the home country up to the amount decided in the foreign country.

Country i, and the amount is

$$\Phi \equiv \max\{\lambda_j\phi^H + (1-\lambda_j)\phi^L, \lambda_j\phi^H, 0\}$$
$$= \begin{cases} \frac{1}{2t}\left[b(q_i - q_j) + \lambda_j(u(\overline{y_{ji}^H}) - u(\overline{y_j^H})) + (1-\lambda_j)(u(\overline{y_{ji}^L}) - u(\overline{y_j^L}))) - F\right] & \text{if } \phi^H \geq \phi^L > 0 \\ \frac{\lambda_j}{2t}\left[b(q_i - q_j) + (u(\overline{y_{ji}^H}) - u(\overline{y_j^H})) - F\right] & \text{if } \phi^H > 0 \geq \phi^L \\ 0 & \text{if } 0 \geq \phi^H \geq \phi^L \end{cases} \tag{6}$$

where

$$\phi^k \equiv \frac{1}{2t}\left[b(q_j - q_i) + (u(\overline{y_{ij}^k}) - u(\overline{y_i^k})) - F\right]. \tag{7}$$

Note that $\phi^H \geq \phi^L$ because $u(\overline{y_{ij}^k}) - u(\overline{y_i^k}) < 0$, $u'(\overline{y_{ij}^k}) - u'(\overline{y_i^k}) > 0$, and $\overline{y_{ij}^H} \geq \overline{y_{ij}^L}$. In other words, high-income consumers tend to prefer high-quality hospitals in the foreign country as compared to low-income consumers, because the marginal utility for consumption other than healthcare services is smaller for high-income consumers than for low-income consumers, whereas the marginal benefits from healthcare services are the same between high- and low-income consumers.

Hospitals. If Country i faces a demand for D_i treatments, the profit earned from providing these treatments with quality q_i is given by

$$\pi_i = (p_i - c)D_i - G(q_i) + T_i, \tag{8}$$

where $c > 0$ is the marginal cost of treatment and $G(q_i)$ denotes the costs for providing healthcare quality, q_i.[7] We assume that $G'(q_i) > 0$, $G''(q_i) > 0$, and $G'''(q_i) \geq 0$.

3 Hospitals' choice of quality: Second-stage outcome

In this section, we consider a two-stage game in which hospitals choose the quality of their healthcare services. In the first stage, the government in each country chooses a tax rate (τ_i), the subsidy to

[7] For simplicity, we assume that the marginal cost of quality provision is independent of treatment volume, implying that quality is a public good for hospital patients. This is a widely used assumption in the theoretical literature on quality competition between hospitals (see, e.g., Barros and Martinez-Giralt, 2002; and Gravelle and Sivey, 2010).

consumers (s_i), the reimbursement per unit of healthcare (p_i), and the subsidy to the hospital (T_i) to maximize total consumer utility in the country,

$$\max_{\tau_i, s_i, p_i, T_i} \int_{x_i \in L_i} \max\{U(x_i, z_i), U(x_i, z_j)\} \tag{9}$$

under the budget constraint (1) and a non-negative profit constraint, $\pi_i \geq 0$. In the second stage, hospitals choose the quality of their healthcare services to maximize their profits, $\max_{q_i} \pi_i$.

Since $D_i = 1 + \Phi$ and $D_j = 1 - \Phi$ when $q_i \geq q_j$, we obtain

$$\frac{\partial \pi(q_k)}{\partial q_k} = -G'(q_k) + \begin{cases} \frac{b}{2t}(p_k - c) & \text{if } \phi^H \geq \phi^L > 0 \\ \frac{\lambda_j b}{2t}(p_k - c) & \text{if } \phi^H > 0 \geq \phi^L \\ 0 & \text{if } 0 \leq \phi^H \leq \phi^L \end{cases}, \text{ where } k = i, j. \tag{10}$$

The equilibrium quality, q_i^*, q_j^* is one of the following cases: (1) $q_i^* = q_j^* = 0$, (2) $q_i^* = q^*(p_i) > q_j^* = 0$, and (3) $q_i^* = q^*(p_i) > q_j^* = q^*(p_j)$ where

$$G'(q^*(p_i)) = \begin{cases} \frac{b}{2t}(p_i - c) & \text{if } \phi^H(q_i^*, q_j^*) \geq \phi^L(q_i^*, q_j^*) > 0 \\ \frac{\lambda_i b}{2t}(p_i - c) & \text{if } \phi^H(q_i^*, q_j^*) > 0 \geq \phi^L(q_i^*, q_j^*) \end{cases}. \tag{11}$$

When some consumers receive cross-border healthcare services, the demand for healthcare services is elastic to the quality of healthcare, and hospitals improve the quality of their healthcare services as long as their marginal revenue is larger than the marginal cost of quality improvement. Since higher reimbursement increases the marginal revenue of hospitals, governments can influence hospitals' healthcare quality by changing the reimbursement level. On the other hand, when no consumer receives cross-border healthcare, the demand is inelastic to healthcare quality, and hospitals cannot increase their revenue through quality improvement. Therefore, hospitals provide the minimum quality-of-service regardless of reimbursement level, and governments cannot influence quality changes in hospitals' healthcare services.

Additionally, we obtain the following lemma on the relationship between reimbursement per treatment and equilibrium quality.

Lemma 1. *If Country i takes in foreign patients from Country j, the reimbursement per treatment is larger in Country i than in Country j. That is, if $q_i > q_j$, $p_i > p_j$.*

Proof. Assume $q_i > q_j$. Since $G(q)$ is an increasing function, in order to satisfy (11), $b(p_1-c)/(2t) > b(p_2-c)/(2t)$ (that is, $p_i > p_j$) has to be satisfied. ■

Lemma 1 implies that the equilibrium reimbursement per treatment is larger in the patient-importing country than in the patient-exporting country. Therefore, in an equilibrium, the budget constraint (1) is rewritten as

$$[\lambda_i y_i^H + (1-\lambda_i) y_i^L]\tau_i = s_i + p_i + T_i. \tag{12}$$

4 Governments' choice of reimbursement levels and redistribution of income: First-stage outcome

In this section, as a benchmark case, we first derive the equilibrium in which no consumer receives cross-border healthcare services because of a large t or F and/or no public insurance scheme for cross-border healthcare. In the second, we derive the equilibrium in which a proportion of consumers receive healthcare services.

4.1 Closed-border case.

When no consumer receives cross-border healthcare services in the equilibrium, every consumer receives healthcare from the domestic hospital. Therefore,

$$\begin{aligned}\int_{x_i \in L_i} \max\{U(x_i, z_i), U(x_i, z_j)\} dx_i &= \int_{x_i \in L_i} U(x_i, z_i) dx_i \\ &= v + bq^*(p_i) - \frac{1}{2}t + \lambda_i u(\overline{y_i^H}) + (1-\lambda_i) u(\overline{y_i^L}).\end{aligned} \tag{13}$$

As Section 3 shows, when no consumer receives cross-border healthcare services, the government cannot induce hospitals to change their quality of healthcare through reimbursement, p_i, and the subsidy to hospital, T_i. Therefore, the government decides p_i and T_i so that the profits of hospitals

are equal to 0, satisfying the non-negative profit constraint of hospitals. Since the costs of hospitals are $c + G(q_i^*)$, in equilibrium, $p_i^* + T_i^* = c + G(q_i^*)$, so the budget constraint (12) is

$$[\lambda_i y_i^H + (1 - \lambda_i) y_i^L]\tau_i = s_i + c + G(q_i^*). \tag{14}$$

From the budget constraint, we obtain $d\tau_i/ds_i = [\lambda_i y_i^H + (1 - \lambda_i) y_i^L]$, which gives

$$\begin{aligned} \frac{d}{d\tau_i} \int_{x_i \in L_i} U(x_i, z_i) dx_i &= \lambda_i u'(\overline{y_i^H}) \left(\frac{d\overline{y_i^H}}{d\tau_i} + \frac{d\overline{y_i^H}}{ds_i} \frac{ds_i}{d\tau_i} \right) + (1 - \lambda_i) u'(\overline{y_i^L}) \left(\frac{d\overline{y_i^L}}{d\tau_i} + \frac{d\overline{y_i^L}}{ds_i} \frac{ds_i}{d\tau_i} \right) \\ &= \lambda_i (1 - \lambda_i)(y^H - y^L)(u'(\overline{y_i^L}) - u'(\overline{y_i^H})) \end{aligned} \tag{15}$$

and we obtain the following proposition:

Proposition 1. *We consider a closed-border equilibrium, in which the tax rate is equal to 1. The subsidy to consumers is equal to the tax revenue less hospital costs. The sum of reimbursements and hospital subsidy is equal to the hospital costs. Further, the equilibrium quality of healthcare services is at the minimum level.*

Proof. Since $u'(\overline{y_i^L}) > u'(\overline{y_i^H})$ except for $\tau = 1$, $(d/d\tau_i) \int_{x_i \in L_i} U(x_i, z_i) dx_i > 0$ for $\tau \in [0, 1)$, and the proposition is proved. ■

Since the government cannot control the quality of healthcare services that hospitals provide, it sets the reimbursement level and subsidy to hospitals so as to satisfy the non-negative profits constraint of hospitals. This setting is similar to the diagnosis-related group (DRG)-based payment that most countries have adopted. Consequently, the quality level of healthcare service is minimal. Additionally, since the utility for consumption other than healthcare is concave, this marginal utility is larger for low-income consumers than for high-income consumers. Thus, the government can improve total consumer utility by income redistribution from high- to low-income consumers. Accordingly, the government collects all income from consumers and redistributes the amount equally among them after deducting hospital costs.

4.2 Cross-border case

Patient-importing countries. Every consumer in Country i, which imports patients, receives healthcare from the domestic hospital. Therefore,

$$\begin{aligned}\int_{x_i \in L_i} \max\{U(x_i, z_i), U(x_i, z_j)\} dx_i &= \int_{x_i \in L_i} U(x_i, z_i) dx_i \\ &= v + bq^*(p_i) - \frac{1}{2}t + \lambda_i u(\overline{y_i^H}) + (1-\lambda_i) u(\overline{y_i^L}). \end{aligned} \tag{16}$$

The government in Country i chooses the reimbursement level (p_i), tax rate (τ_i), and subsidy (s_i, T_i) to maximize (16) under the budget constraint (12) and a non-negative profits constraint, $\pi_i \geq 0$. If p_i and T_i are fixed, from (12), we obtain

$$\left.\frac{ds}{d\tau}\right|_{p_i \text{ and } T_i \text{ is fixed.}} = \lambda_i y^H + (1-\lambda_i) y^L, \tag{17}$$

which gives

$$\begin{aligned}\left.\frac{d}{d\tau_i}\int_{x_i \in L_i} U(x_i, z_i) dx_i\right|_{p_i \text{ and } T_i \text{ is fixed.}} &= \lambda_i u'(\overline{y_i^H}) \left(\frac{d\overline{y_i^H}}{d\tau_i} + \frac{d\overline{y_i^H}}{ds_i}\frac{ds_i}{d\tau_i}\right) \\ &\quad + (1-\lambda_i) u'(\overline{y_i^L}) \left(\frac{d\overline{y_i^L}}{d\tau_i} + \frac{d\overline{y_i^L}}{ds_i}\frac{ds_i}{d\tau_i}\right) \\ &= \lambda_i (1-\lambda_i)(y^H - y^L)(u'(\overline{y_i^L}) - u'(\overline{y_i^H})) \end{aligned} \tag{18}$$

and, in turn, the following lemma:

Lemma 2. *In the patient-importing country, total consumer utility is maximum at $\tau = 1$ for any values of p_i.*

Proof. Since $u'(\overline{y_i^L}) > u'(\overline{y_i^H})$ except for $\tau = 1$, $(d/d\tau_i)\int_{x_i \in L_i} U(x_i, z_i) dx_i > 0$ for $\tau \in [0, 1)$, and the lemma is proved. ■

The marginal utility for consumption other than healthcare is larger for low-income than high-income consumers regardless of hospital quality level. Therefore, as described in the closed-border case, the government collects all income from consumers and redistributes the amount equally among them after deducting hospitals costs.

Substituting $\tau_i = 1$ into (12), (2), and (3), we obtain $p_i = \lambda_i y_i^H + (1-\lambda_i) y_i^L - s_i - T_i$ and $\overline{y_i^H} = \overline{y_i^L} = s_i$, which lead to

$$\begin{aligned}\frac{\partial}{\partial s_i}\int_{x_i \in L_i} U(x_i, z_i)dx_i\Big|_{\tau_i=\tau_i^*=1} &= b\frac{dq^*(p_i)}{dp_i}\frac{\partial p_i}{\partial s_i} + \lambda_i u'(s_i) + (1-\lambda_i)u'(s_i) \\ &= -b\frac{dq^*(p_i)}{dp_i} + u'(s_i), \end{aligned} \tag{19}$$

and

$$\begin{aligned}\frac{\partial}{\partial T_i}\int_{x_i \in L_i} U(x_i, z_i)dx_i\Big|_{\tau_i=\tau_i^*=1} &= b\frac{dq^*(p_i)}{dp_i}\frac{\partial p_i}{\partial T_i} \\ &= -b\frac{dq^*(p_i)}{dp_i} < 0, \end{aligned} \tag{20}$$

and, in turn, to the following proposition:

Proposition 2. *In an equilibrium, the government of the patient-importing country chooses the tax rate as 1, and the reimbursement level and subsidy for consumers, so as to equalize the marginal benefits from reimbursement and subsidy. Further, the government chooses the minimum subsidy to the hospital that satisfies the non-negative profit constraint of the hospital.*

Proof. See Appendix A.

In the cross-border case, the government has the power to induce hospitals to improve the quality of their healthcare services by increasing the reimbursement level, which in turn increases consumers' benefits. However, an increase in reimbursement decreases the subsidy to consumers, which reduces consumers' benefits. Therefore, the government balances reimbursement and subsidy so as to equalize the marginal benefits between them. Consequently, the reimbursement is more than c. Additionally, the profit of the hospital might be more than 0 when b is sufficiently large. Therefore, Proposition 2 implies that, with a significant expansion in cross-border healthcare, the hospital would change from the conventional DRG-based payment systems.

Patient-exporting country. We consider Country j in which a proportion of consumers receive

cross-border healthcare services. The total consumer utility is given as

$$\begin{aligned}\int_{x_j\in L_j}\max\{U(x_j,z_j),U(x_j,z_i)\}dx_j &= v+bq^*(p_i)[\lambda_j\phi^H+(1-\lambda_j)\phi^L]+bq^*(p_j)[\lambda_j(1-\phi^H)\\ &+(1-\lambda_j)(1-\phi^L)]+\lambda_j[\phi^H u(\overline{y_{ji}^H})+(1-\phi^H)u(\overline{y_j^H})]+(1-\lambda_j)[\phi^L u(\overline{y_{ji}^L})+(1-\phi^L)u(\overline{y_j^L})]\\ &-\lambda_j t\left[\int_0^{\phi^H}(1+x)dx+\int_{\phi^H}^1(1-x)dx\right]-(1-\lambda_j)t\left[\int_0^{\phi^L}(1+x)dx+\int_{\phi^L}^1(1-x)dx\right]\\ &-F[\lambda_j\phi^H+(1-\lambda_j)\phi^L]. \end{aligned} \tag{21}$$

The government in Country j chooses reimbursement level (p_j), tax rate (τ_j), and subsidy (s_j, T_j) so as to maximize (21) under the budget constraint (12) and the non-negative profit constraint, $\pi_i \geq 0$. If p_j and T_j are fixed,

$$\begin{aligned}\frac{d}{d\tau_j}\int_{x_j\in L_j}\max\{U(x_j,z_j),U(x_j,z_i)\}dx_j\Big|_{p_j \text{ and } T_j \text{ are fixed.}} &= \lambda_j[b(q^*(p_i^C)-q^*(p_j^C))\\ &+(u(\overline{y_{ji}^H})-u(\overline{y_j^H}))-2t\phi^H-F]\frac{d\phi^H}{d\tau}+(1-\lambda_j)[b(q^*(p_i^C)-q^*(p_j^C))+(u(\overline{y_{ji}^L})-u(\overline{y_j^L}))\\ &-2t\phi^L-F]\frac{d\phi^L}{d\tau}+\lambda_j\left[\phi^H u'(\overline{y_{ji}^H})\left(\frac{d\overline{y_{ji}^H}}{d\tau_j}+\frac{d\overline{y_{ji}^H}}{ds_j}\frac{ds_j}{d\tau_j}\right)+(1-\phi^H)u'(\overline{y_j^H})\left(\frac{d\overline{y_j^H}}{d\tau_j}+\frac{d\overline{y_j^H}}{ds_j}\frac{ds_j}{d\tau_j}\right)\right]\\ &+(1-\lambda_j)\left[\phi^L u'(\overline{y_{ji}^L})\left(\frac{d\overline{y_{ji}^L}}{d\tau_j}+\frac{d\overline{y_{ji}^L}}{ds_j}\frac{ds_j}{d\tau_j}\right)+(1-\phi^L)u'(\overline{y_j^L})\left(\frac{d\overline{y_j^L}}{d\tau_j}+\frac{d\overline{y_j^L}}{ds_j}\frac{ds_j}{d\tau_j}\right)\right] \end{aligned} \tag{22}$$

Substituting (2), (3), (7), and (17) into (22), we obtain

$$\begin{aligned}\frac{d}{d\tau_j}\int_{x_j\in L_j}\max\{U(x_j,z_j),U(x_j,z_i)\}dx_j\Big|_{p_i \text{ and } T_j \text{ are fixed.}} &= \lambda_j(1-\lambda_j)(y^H-y^L)\\ &\times[\phi^L u'(\overline{y_{ji}^L})+(1-\phi^L)u'(\overline{y_j^L})-\phi^H u'(\overline{y_{ji}^H})-(1-\phi^H)u'(\overline{y_j^H})], \end{aligned} \tag{23}$$

which leads to the following lemma.

Lemma 3. *In an equilibrium, the average marginal utility of low- and high-income consumers is equal.*

Proof. See Appendix B.

The right side of (23) is equal to 0 when $\tau = 1$, because $y_{ji}^H = y_{ji}^L$, $y_j^H = y_j^L$, and $\phi^H = \phi^L$ when $\tau = 1$. Therefore, when $\tau = 1$, the first-order condition to maximize total consumer utility is satisfied. However, total consumer utility is not always maximum at $\tau = 1$.

Proposition 3. *When t is sufficiently large, the equilibrium tax rate is equal to 1. On the contrary, when t is sufficiently small, the equilibrium tax rate is below 1, because the second-order condition to maximize total consumer utility is not satisfied.*

Proof. See Appendix C.

Proposition 3 implies that an expansion in cross-border healthcare resulting from a reduction in the disutility from traveling to a hospital (t) influences income redistribution in the patient-exporting country. In other words, total consumer utility in the patient-exporting country does not necessarily increase by redistributing income to low-income consumers from high-income consumers. The reason for this result is that high-income consumers tend to visit a hospital abroad more than low-income consumers do. Since consumers who receive treatment abroad have to make a copayment, the marginal utility of high-income consumers who receive treatment abroad is not always higher than that of low-income consumers who receive treatment in their home country. In particular, if the difference in redistributed income is sufficiently small between high- and low-income consumers, the marginal utility of high-income consumers who receive treatment abroad is lower than that of low-income consumers who receive treatment in their home country. Therefore, if τ is close (but not equal) to 1 and the ratio of high-income consumers receiving healthcare services from the foreign hospital (ϕ^H) is sufficiently larger than that of low-income consumers receiving healthcare services from the foreign hospital (ϕ^L), redistributing income to low-income consumers from high-income consumers decreases total consumer utility. We consider an extreme case, in which $\phi^H = 1$ and $\phi^L = 0$. In this case, the marginal utility of high-income consumers is $u'(\overline{y_{ji}^H})$ and that of low-income consumers is $u'(\overline{y_j^L})$. If τ is close (but not equal) to 1, $u'(\overline{y_{ji}^H}) > u'(\overline{y_j^L})$. Thus, redistributing income to low-income consumers from high-income consumers decreases total consumer utility in this case.

As (7) shows, the difference between ϕ^H and ϕ^L is larger when t is smaller. Therefore, if t is sufficiently small, total consumer utility is maximized at a tax rate below 1.

If τ_j is fixed,

$$\begin{aligned}
\frac{d}{ds_j}\int_{x_j\in L_j}\max\{U(x_j,z_j),U(x_j,z_i)\}dx_j\Bigg|_{\tau_j \text{ is fixed.}} &= \lambda_j[b(q^*(p_i^C)-q^*(p_j^C))\\
&+(u(\overline{y_{ji}^H})-u(\overline{y_j^H}))-2t\phi^H]\frac{d\phi^H}{d\tau}+(1-\lambda_j)[b(q^C(p_i^C)-q^*(p_j^C))+(u(\overline{y_{ji}^L})-u(\overline{y_j^L}))\\
&-2t\phi^L]\frac{d\phi^L}{d\tau}+b\frac{dq^*(p_j)}{dp_j}\frac{dp_j}{ds_j}[\lambda_j(1-\phi^H)+(1-\lambda_j)(1-\phi^L)]\\
&+\lambda_j\left[\phi^H u'(\overline{y_{ji}^H})\left(\frac{d\overline{y_{ji}^H}}{ds_j}+\frac{d\overline{y_{ji}^H}}{dp_j}\frac{dp_j}{ds_j}\right)+(1-\phi^H)u'(\overline{y_j^H})\frac{d\overline{y_j^H}}{ds_j}\right]\\
&+(1-\lambda_j)\left[\phi^L u'(\overline{y_{ji}^L})\left(\frac{d\overline{y_{ji}^L}}{ds_j}+\frac{d\overline{y_{ji}^L}}{dp_j}\frac{dp_j}{ds_j}\right)+(1-\phi^L)u'(\overline{y_j^L})\frac{d\overline{y_j^L}}{ds_j}\right] \qquad (24)
\end{aligned}$$

From (12), $\partial p_j/\partial s_j=-1$. Additionally, from (2), (3), and (5), we obtain $\partial\overline{y_j^H}/\partial s_j=\partial\overline{y_{ji}^H}/\partial s_j=\partial\overline{y_j^L}/\partial s_j=\partial\overline{y_{ji}^L}/\partial s_j=1$ and $\partial\overline{y_{ji}^H}/\partial p_j=\partial\overline{y_{ji}^L}/\partial p_j=-1$. Thus,

$$\begin{aligned}
\frac{\partial}{\partial s_j}\int_{x_j\in L_j}\max\{U(x_j,z_j),U(x_j,z_i)\}dx_j\Bigg|_{\tau_j \text{ is fixed.}} &= [\lambda_j(1-\phi^H)+(1-\lambda_j)(1-\phi^L)]\\
&\times\left[\frac{\lambda_j(1-\phi^H)u'(\overline{y_j^H})+(1-\lambda_j)(1-\phi^L)u'(\overline{y_j^L})}{\lambda_j(1-\phi^H)+(1-\lambda_j)(1-\phi^L)}-b\frac{dq^*(p_j)}{dp_j}\right], \qquad (25)
\end{aligned}$$

which is positive when

$$b\frac{dq^*(p_j)}{dp_j}<\frac{\lambda_j(1-\phi^H)u'(\overline{y_j^H})+(1-\lambda_j)(1-\phi^L)u'(\overline{y_j^L})}{\lambda_j(1-\phi^H)+(1-\lambda_j)(1-\phi^L)}. \qquad (26)$$

The left-hand side of this equation indicates marginal benefits for reimbursement, and the right-hand side represents the average marginal utility from consumption other than healthcare services for consumers who receive healthcare services from the domestic hospital. An increase in reimbursement decreases subsidy to consumers, resulting in a decrease in consumption other than healthcare services. Therefore, the government increases (decreases) reimbursement if the marginal benefit of healthcare services from an increase in reimbursement is greater (smaller) than the marginal loss of consumption other than healthcare services for consumers who receive healthcare services from the domestic hospital.

As well as the government in the patient-importing country, the government in the patient-exporting country also balances reimbursement and subsidy so as to equalize the marginal benefits

between the two. However, note that the government in the patient-exporting country takes care of only consumers who receive healthcare services from the domestic hospital, because the quality of the domestic hospital does not influence the benefits to patients who receive healthcare services at the foreign hospital.

Accordingly, we obtain the following proposition.

Proposition 4. *When b is sufficiently small or consumers' income (y^H and y^L) is sufficiently low, the equilibrium subsidy to consumers is equal the tax revenue less hospital costs and the equilibrium reimbursement is so small that the hospital would choose minimal quality. Otherwise, the equilibrium subsidy to consumers and reimbursement to the hospital is so determined that the marginal benefits from an increase in reimbursement is equal to the marginal losses from a decrease in subsidy for consumers who receive healthcare services from the domestic hospital. The equilibrium subsidy to the hospital is determined as the minimum value so as to satisfy the non-negative profits constraint of the hospital.*

Proof. See Appendix D.

4.3 Sub-game perfect equilibrium.

Having clarified the equilibrium strategies of the two governments in both the closed- and cross-border cases, we describe the equilibrium property in the two countries in which income distribution among consumers is different.

Proposition 5. *We assume that $\lambda_1 > \lambda_2$. When b is sufficiently small, t is sufficiently large, F is sufficiently large, or consumers' income (y^H and y^L) is sufficiently low, no consumer receives cross-border healthcare services and the quality level of the hospitals is minimal. Otherwise, Country 1 (Country 2) imports (exports) patients, and the reimbursement is larger and quality higher in Country 1 than in Country 2.*

Proof. See Appendix E.

The larger t and F are, the greater is the frictional force against foreign healthcare services.

Additionally, since healthcare services are luxury goods,[8] low income can become an impediment to foreign healthcare services. Further, if b is sufficiently small, a minimum quality of healthcare services would be the best from the point of the view of social welfare. Accordingly, even if cross-border healthcare is permitted, no consumer receives cross-border healthcare services in the equilibrium for some range of parameters.

When some consumers receive cross-border healthcare services, the quality of healthcare is different between countries. The larger the total income, the larger the tax revenue. Further, the larger the total income, the lower the marginal utility from consumption other than healthcare. Therefore, a country with a large total income spends more money on reimbursement to hospitals and provides higher quality healthcare than a country with a relatively low total income.

4.4 Impacts of Border Openings

From Propositions 1 and 5, we present the healthcare impacts of opening the border as the following proposition.

Proposition 6. *If provision of cross-border healthcare induces some consumers to access cross-border healthcare services, the equilibrium quality of hospitals in at least the patient-importing country and the total consumer utility in both countries increase in cross-border healthcare compared to closed-border healthcare.*

Proof. Proposition 5 shows that the equilibrium hospital quality is higher in the patient-exporting country compared to the patient-importing country, which means that cross-border healthcare increases the equilibrium quality of hospitals in at least the patient-importing country. If the equilibrium quality is greater than 0, the benefit from a quality upgrade over 0 outweighs its cost; thus, the total consumer utility increases with cross-border healthcare provision. Even if the equilibrium quality remains at 0 in cross-border healthcare, utility is greater for patients who cross the border compared to those under closed-border healthcare. Therefore, cross-border healthcare

[8] This is because the utility function of consumption of goods and services other than healthcare services is concave for consumption.

increases total consumer utility in both countries if cross-border healthcare provision induces some consumers to access cross-border healthcare services. ■

When some consumers receive cross-border healthcare services, the patient-importing country provides an incentive to hospitals to take in foreign consumers. Therefore, the quality of healthcare in the patient-importing country improves through border openings for healthcare. On the other hand, the patient-exporting country does not need to provide an incentive to hospitals to take in foreign consumers; thus, the patient-exporting country cannot always improve the quality of healthcare by opening the border for healthcare.

According to Proposition 3, an equilibrium tax rate below 1 implies that opening of the border weakens income redistribution. However, Proposition 6 shows that cross-border healthcare increases total consumer utility even if cross-border healthcare weakens income redistribution. This implies that cross-border healthcare enables consumers to receive high-quality healthcare services in a foreign country and that their benefits outweigh the losses from the weakened income redistribution.

5 Discussion

This section examines, through comparative statics of the parameters t and F, how the equilibrium property changes as cross-border healthcare continually expands.

When t and F are sufficiently large in an equilibrium, no patient receives cross-border healthcare services in either country. In this equilibrium, governments do not provide an incentive for hospitals to improve their quality. Thus, the equilibrium property does not change if any of the parameters, including t and F, change. When t and F decrease below their respective threshold values, the equilibrium property discontinuously changes. In the changed equilibrium, a proportion of consumers in Country 2 cross the border, and reimbursement is larger and quality of healthcare services better in Country 1 than in Country 2, as the previous propositions show.

When a proportion of consumers in Country 2 receive cross-border healthcare services in an equilibrium, the government of at least Country 1 provides an incentive for hospitals to improve the

quality of their healthcare services, and the lower t, as a direct effect, provides a greater incentive for the governments to increase reimbursement to hospitals, as shown in (11). The government of Country 2 also has the same incentive if the hospital in Country 2 provides higher-than-the-minimum healthcare quality. In addition to the direct effect of a decrease in t, three indirect effects occur, when a proportion of consumers in Country 2 receive cross-border healthcare services. First, a decrease in t induces patients to move from Country 2 to Country 1, increasing (decreasing) the revenue of the hospital in Country 1 (Country 2). This movement reduces (increases) the subsidy to hospitals and increases (decreases) reimbursement and hospital quality if the governments provide subsidy to their hospitals ($T_i > 0$). Second, a decrease in t causes an increase in ϕ^H and ϕ^L, larger in the former than in the latter, when the equilibrium tax rate in Country 2 is below 1, as shown in (7). The right-hand side of (26) is greater because the increases in ϕ^H and ϕ^L differ. In other words, a decrease in t increases the average marginal utility for consumption of other than healthcare services by the consumers of Country 2. A higher average marginal utility provides the government in Country 2 an incentive to increase subsidy to consumers and decrease reimbursement. Finally, the right-hand side of (23) changes because the increases in ϕ^H and ϕ^L differ. In particular, when $u'(\overline{y_{ji}^H}) - u'(\overline{y_j^H}) \geq u'(\overline{y_{ji}^L}) - u'(\overline{y_j^L})$, the right-hand side of (23) decreases. Thus, a lower t reduces the equilibrium tax rate in Country 2. Decreasing the equilibrium tax rate reduces the tax revenue and, in turn, the equilibrium reimbursement and quality in Country 2.

A lower F has no direct effect because it does not incentivize hospitals to improve the quality of their services, as shown in (11). On the other hand, it has three indirect effects, because a lower F induces patients to move from Country 2 to Country 1. However, note that the number of patients moving from Country 2 to Country 1 with a decrease in F is the same between high- and low-income consumers. Therefore, the equilibrium reimbursement and quality changes following a decrease in F are different from those caused by a decrease in t

Accordingly, the effect of a decrease in t and F on equilibrium reimbursement and quality, when a proportion of consumers in Country 2 receive cross-border healthcare services, is summarized in

the following proposition.

Proposition 7. *Assume that a proportion of consumers in Country 2 receive cross-border healthcare services in equilibrium. A decrease in t and F increases the equilibrium reimbursement and quality in the patient-importing country. However, the effect of a decrease in t and F on the equilibrium reimbursement and quality in the patient-exporting country is ambiguous.*

6 Conclusion

In this study, we examined the effect of cross-border healthcare with public health insurance. The main findings are as follows. First, the implementation of cross-border healthcare induces at least the patient-importing country to increase reimbursement to hospitals and improve their quality. Second, the patient-exporting country exerts indirect negative effects on quality improvement. Therefore, quality improvement in the patient-exporting country through continual expansion in cross-border healthcare is ambiguous. Finally, huge expansion in cross-border healthcare in the patient-exporting country resulting from a reduction in non-monetary friction influences income redistribution.

The present model implicitly assumes that income redistribution does not influence the total amount of wealth. Under this assumption, governments will redistribute consumers' income equally; however, it does not reflect the real situation. Since income redistribution would influence the total amount of wealth, governments will not conduct a perfectly equal income redistribution. Even if we consider the effect of income redistribution on the total amount of wealth, the equilibrium depends on the marginal benefits from healthcare and the marginal utility from consumption other than healthcare. Therefore, the essential results would not change, but a more precise analysis should be considered in future research.

Further, the present model assumes profit-maximizing hospitals and governments that aim to maximize consumers' utility. We can also assume altruistic hospitals or welfare-maximizing governments. However, the effect uncovered by this model is not lost even under this assumption.

This is because altruistic hospitals consider profits and welfare-maximizing governments consider consumers' utility as part of their objective. However, it would involve additional effects, which should be clarified in future research.

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Appendix

A. Proof of Proposition 2. From Lemma 2, total consumer utility is also maximum at $\tau = 1$ under equilibrium reimbursement. Therefore, the equilibrium tax rate in country i, τ_i^*, is equal to 1. Since the hospital in the patient-importing country has higher quality than that in the patient-exporting country, the quality of the hospital in the patient-importing country is more than minimum quality level. Therefore, (11) is satisfied in the equilibrium in which a proportion of consumers in Country j receive healthcare services from Country i, which means that p_i^* must be more than c. Additionally, when $s_i = 0$, the right-hand side of (19) is positive infinity because $u(0) = \infty$. Thus, s_i^* must be more than 0. Therefore, p_i^* and s_i^* are not corner solutions, and thus, the right-hand side of (19) is equal to 0 in the equilibrium. As (20) shows, an increase in T_i decreases total consumer utility. Therefore, T_i^* is the minimum value to satisfy a non-negative profits constraint. ■

B. Proof of Lemma 3. As shown in (23), the necessary condition for an interior solution is

$$\phi^L u'(\overline{y_{ji}^L}) + (1-\phi^L)u'(\overline{y_j^L}) = \phi^H u'(\overline{y_{ji}^H}) - (1-\phi^H)u'(\overline{y_j^H}), \tag{27}$$

which implies that the average marginal utility of low-income consumers equals that of high-income consumers. This condition is satisfied when $\tau = 1$ which is a corner solution. Further, since $u'(0)$ is infinite, the equilibrium tax rate is more than the lower bound of τ that satisfies a non-negative profits constraint of the hospital and the budget constraint. Accordingly, this lemma is proved. ■

C. Proof of Proposition 3. We define $\overline{y_j} \equiv \overline{y_j^H}|_{\tau=1} = \overline{y_j^L}|_{\tau=1} = \lambda_j y^H + (1-\lambda_j)y^H - p_j - T_j$ and $\overline{y_{ji}} \equiv \overline{y_{ji}^H}|_{\tau=1} = \overline{y_{ji}^L}|_{\tau=1} = \overline{y_j} - (p_i^C - p_j)$. The second-order condition to maximize total consumer utility under $\tau = 1$ is

$$\begin{aligned}\frac{d^2}{d\tau_j^2}\int_{x_j\in L_j}\max\{U(x_j,z_j),U(x_j,z_i)\}dx_j\Bigg|_{p_i \text{ and } T_j \text{ are fixed and } p_j<p_i^C.} &= \lambda_j(1-\lambda_j)(y^H-y^L)^2 \\ \times\Bigg[\lambda_j\left\{\frac{(u'(\overline{y_{ji}^L})-u'(\overline{y_j^L}))^2}{2t}+\phi^L u''(\overline{y_{ji}^L})+(1-\phi^L)u''(\overline{y_j^L})\right\} \\ +(1-\lambda_j)\left\{\frac{(u'(\overline{y_{ji}^H})-u'(\overline{y_j^H}))^2}{2t}+\phi^H u''(\overline{y_{ji}^H})+(1-\phi^H)u''(\overline{y_j^H})\right\}\Bigg]. \quad (28)\end{aligned}$$

This condition is satisfied when

$$(u'(\overline{y_{ji}})-u'(\overline{y_j}))^2 + 2t[\Phi u''(\overline{y_{ji}})+(1-\Phi)u''(\overline{y_j})] < 0. \quad (29)$$

The first term of the left-hand side in (29) is positive and the second term of the left-hand side in (29) is negative. If t is sufficiently small, the second term is close to 0, and thus, the second-order condition is not satisfied. When the second-order condition is not satisfied, total consumer utility is not maximum at $\tau = 1$. In other words, it is maximum at $\tau < 1$. If t is sufficiently large, the second-order condition is satisfied. Additionally, when t is sufficiently large, ϕ^H and ϕ^L is close to 0, in which the right-hand side of (23) is positive. Therefore, total consumer utility is maximum at $\tau = 1$. ■

D. Proof of Proposition 4. When b is sufficiently small or consumers' income (y^H and y^L) is sufficiently low, (26) is satisfied at any s_j that satisfies the budget constraint (12). Since the costs of hospitals are paid from the government's budget, the equilibrium subsidy to consumers is equal to the amount deducting the costs of hospitals from tax revenue when b is sufficiently

small or consumers' income (y^H and y^L) is sufficiently low. If (26) is not always satisfied in the budget constraint (12), the left-hand side of (26) must be equal to the left-hand side of (26) in the equilibrium. Further,

$$\begin{aligned}\frac{\partial}{\partial T_j}\int_{x_j\in L_j}\max\{U(x_j,z_j),U(x_j,z_i)\}dx_j\Bigg|_{p_i \text{ and } s_j \text{ are fixed.}}&\\ = b\frac{dq^*(p_j)}{dp_j}\frac{\partial p_j}{\partial T_j}[\lambda_j(1-\phi^H)+(1-\lambda_j)(1-\phi^L)]&\\ = -b\frac{dq^*(p_j)}{dp_j}[\lambda_j(1-\phi^H)+(1-\lambda_j)(1-\phi^L)]<0,&\end{aligned} \tag{30}$$

which implies that an increase in T_j decreases total consumer utility. Therefore, the equilibrium subsidy to a hospital is determined as a minimum value so as to satisfy a non-negative profits constraint of a hospital. ■

E. Proof of Proposition 5. When t is sufficiently large or F is sufficiently large, no consumer receives cross-border healthcare services, because the friction of cross-border healthcare is very large. Therefore, the governments do not give an incentive to a hospital in order to raise its quality, and the quality level of the hospitals is minimum.

When b is sufficiently small or consumers' income (y^H and y^L) is sufficiently low, the right-hand side of (19) is positive at any s_i that satisfies the budget constraint (12). Therefore, the equilibrium reimbursement to a hospital is so small that the equilibrium quality of the hospital in the patient-importing country would be minimum. Accordingly, the equilibrium quality of the hospital is minimum in both countries, and no consumer receives cross-border healthcare services.

If some consumers receive cross-border healthcare services and the equilibrium tax rate is 1 in both countries, the first-order conditions to maximize total consumer utility with regard to p and s are identical in both countries, and they are $b(dq^*(p)/dp) = u'(s)$ and $s+p+T = \lambda y^H + (1-\lambda_j)y^L$. Since $\lambda_1 > \lambda_2$, $s_1 > s_2$ if $p_1 = p_2$. Therefore, p_1 must be larger than p_2 to satisfy the first-order conditions. Further, when the equilibrium tax rate is less than 1 in Country 2, the tax revenue becomes smaller than when the tax rate is 1, which implies that the equilibrium reimbursement to a hospital becomes smaller than when the tax rate is 1. Accordingly, when some consumers

receive cross-border healthcare services, the equilibrium reimbursement is larger in Country 1 than in Country 2.

From (11), the quality of the hospital becomes larger as the reimbursement increases. Therefore, the equilibrium quality is also larger in Country 1 than in Country 2. ■

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