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Patient Mobility and Health Care Quality when Regions and Patients Differ in Income*

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Abstract

This paper studies the effects of cross-border patient mobility on health care quality and welfare when income varies across and within regions. We use a Salop model with a high, middle and low income region, where, in each region, a policy maker chooses the level of health care quality that maximises welfare subject to costs being financed by general taxation. In equilibrium, regions with higher income offer better quality, implying that the high (low) income region imports (exports) patients and the middle-income region both imports and exports patients. Assuming DRG-pricing, we find that a reduction in mobility costs has generally heterogeneous effects on regional health care quality and welfare, with low and middle income regions being vulnerable to adverse effects of cross-border health care liberalisation. We also show that higher income inequality in a region might have negative spillover effects on quality provision in other regions because of cross-border patient mobility.

Keywords: Patient mobility; Health care quality; Income inequalities; Regional welfare.

JEL Classification: H51; H73; I11; I18

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1 Introduction

Cross-border patient mobility is currently a key issue for health policy. In the European Union (EU), patient mobility across member states has been high on the political agenda for many years, despite the fact that the free movement principles do not apply to health care provision. A key example is the new Directive adopted by the European Parliament and the Council in 2011, which gives patients the right to choose among health care providers across all member states within the EU.¹ On the 25th of October 2013, when the Directive came into force in the member states, the Health Commissioner Tonio Borg said:²

"Today is an important day for patients across the European Union. As of today, EU law in force enshrines citizens' right to go to another EU country for treatment and get reimbursed for it (...). For patients, this Directive means empowerment: greater choice of healthcare, more information, easier recognition of prescriptions across-borders."

Although patient mobility currently is fairly low across EU countries, enforcement of the new Directive may have a large impact on the demand for health care across borders. According to a recent Eurobarometer survey, 49% reported that they would be willing to travel to another EU country to receive medical treatment.³ This figure indicates a significant potential for cross-border patient flows within the EU.

Cross-border patient mobility is also a key policy issue in countries with regional health care provision. In Sweden, for example, the government implemented a 'free choice' reform in 2003, which allowed patients to demand health care outside their home region (county) and specified transfers payments across regions. A similar system is in place in Italy, where many patients migrate from the south to the north in order to obtain better medical care. However, in Canada, patient mobility across provinces is generally limited to emergency and sudden illness or allowed only in special circumstances. In the US, state-specific regulations restrict individuals from purchasing health insurance outside their home state, which limits patient mobility across state lines. However, during the debate over Obamacare, the Republicans promoted an alternative approach that involved

¹Directive 2011/24/EU of the European Parliament and of the Council of 9 March 2011 on the application of patients' rights in cross-border healthcare.

²The full statement of the Health Commissioner can be found here: http://europa.eu/rapid/press-release_MEMO-13-932_en.htm

³The survey, Special Eurobarometer 425 "Patients' rights in crossborder healthcare in the European Union", was conducted by TNS Opinion & Social for the European Commission in 2014; http://ec.europa.eu/public_opinion/index_en.htm.

allowing individuals to purchase health insurance across state lines.⁴

Understanding the effects of *liberalising* cross-border patient mobility is of great importance for health policy. However, the existing knowledge on patient mobility across countries or regions is scarce, and our paper contributes to filling this gap in the literature.⁵ As illustrated by the statement from the EU Health Commissioner, a key objective of liberalising cross-border patient mobility is to enhance patient choice and to improve access to high-quality medical care. This is perceived to stimulate competition and increase incentives for providers to offer better medical care to patients. In this paper, we show that these conjectures are not necessarily true, and that liberalisation of cross-border patient mobility can be counterproductive in achieving its goal of improved access to high-quality care.

We study the effects of *liberalisation* of cross-border health care on the quality of health care provision in the different countries (or regions) depending on whether they attract or export patients from other countries (or regions). We are also interested in whether stimulating cross-border patient mobility (by reducing the monetary or non-monetary access costs) improves welfare and is beneficial for the countries, and in case for whom (the exporting or importing countries), in order to provide some insight and guidance for health policy on this topic. Finally, we explore how intra- or inter-regional income inequality affects regional health care quality when patients are allowed to seek health care outside their own region/country.

To study the effects of cross-border patient mobility, we develop a Salop-type model with three regions that differ in the distribution of income, so that we have a high-income, a middle-income, and a low-income region. In each region, patients prefer to be treated by their local health care provider, and will only travel to a neighbouring region if the health care quality in this region is sufficiently large relative to the home region. More precisely, cross-border patient mobility occurs only when the utility gain from receiving better care in the neighbouring region exceeds the utility loss related to travel and possible copayments. In each region, a policy maker sets the health care quality in order to maximise the region's welfare subject to a budget constraint where the health care costs are financed by taxation and transfer payments related to patient mobility. To allow for income effects, we assume individuals have decreasing marginal utility of income, which implies that the marginal cost of raising tax revenues decreases with average income. Consequently, health

⁴See, for instance, <http://www.forbes.com/sites/theapothecary/2012/05/11/will-buying-health-insurance-across-state-lines-reduce-costs/>

⁵See, for instance, the review by Brekke et al. (2014a).

care quality is increasing in the regions' income level, implying patient mobility from lower income to higher income regions.

We focus on the equilibrium where the high-income region attracts patients from both the low- and middle-income region and the middle-income region attracts patients from the low-income region. This implies that the high-income (low-income) region only imports (exports) patients and the middle-income region both imports and exports patients. Assuming DRG-pricing, where the price per patient is set equal to the marginal treatment cost in each region, the importing (high- and middle-income) regions are fully compensated for the medical treatment of migrating patients. However, for the exporting (middle- and low-income) regions, migrating patients imply a financial loss if the marginal treatment cost is higher in the importing region. This will be the case under the reasonable assumption that treatment costs are higher in richer regions.

Based on this framework, we derive a rich set of results regarding the regional effects (on quality provision and welfare) of liberalising cross-border health care. First, increased patient mobility has no effect on quality provision or social welfare in the high-income region. The reason is simply that, for this region, mobility costs do not affect the benefit-side – since no patients in this region travel to another region to obtain care – or the cost-side – since migrating patients are fully compensated by the DRG-pricing, as explained above. However, for the two other regions, the effects of liberalising cross-border health care are somewhat mixed and depends partly on whether liberalisation happens through a reduction in monetary versus non-monetary mobility costs.

A reduction in *non-monetary* mobility costs (e.g. a simplification of administrative procedures) reduces quality in the middle-income region, and also reduces quality in the low-income region if indirect effects are sufficiently small. In both of these regions, the direct effects of lower (non-monetary) mobility costs on quality provision are unambiguously negative. Increased patient mobility reduces the marginal benefit of quality provision, because fewer patients will be treated in their home region. In addition, since patient export has monetary costs – both for the patients who migrate and for the remaining tax payers – higher mobility needs to be financed by a higher income tax rate for exporting regions, which increases the marginal cost of quality provision. For the low-income region, we also identify an indirect effect related to quality provision in this region being a strategic substitute to the quality provision in the middle-income region, which tends to counteract direct effects mentioned above. In sum, liberalisation of cross-border health care by reducing ‘red tape’ costs for patients has adverse effects on health care quality for at least one

region.

The effects of reducing *monetary* costs of patient mobility (i.e., patient copayments) are qualitatively similar to the effects of reducing non-monetary costs for the middle- and low-income regions, as described above. However, there is an additional budget effect that makes the overall effect generally indeterminate. A lower copayment implies that a larger share of the costs of patient export need to be financed by the exporting regions' tax payers, which in turn implies a tightening of the government's budget constraint. This gives the exporting (low- and middle-income) regions an incentive to increase quality in order to mitigate the increase in mobility caused by lower patient copayments.

The effects of cross-border health care liberalisation on *regional welfare* are also mixed, and we can identify potential winners and losers from such a policy. If liberalisation is done by reducing *non-monetary* mobility costs, the middle-income region benefits (in terms of higher social welfare) while the welfare effect in the low-income region is indeterminate. The middle-income region unambiguously benefits because of the cost reduction for those patients who seek treatment in the high-income region. A similar effect also applies to the low-income region. However, in this region there is a potentially counteracting welfare effect due to the quality reduction in the middle-income region, which harms the migrating patients but benefits the remaining tax payers in the low-income region. If, on the other hand, cross-border mobility is stimulated by a reduction in *monetary* mobility costs, the welfare effects in the middle- and low-income regions are generally ambiguous. In sum, adverse regional welfare-effects of cross-border health care liberalisation cannot be ruled out, but seem less likely if liberalisation is done by reducing non-monetary costs of mobility.

Finally, regarding the effects of income inequality on regional quality provision, we find that higher *inter-regional* income inequality tends to amplify inter-regional differences in health care quality, although the results are not clear-cut. Quality increases (decreases) in the high-income (middle-income) region, whereas the effect on quality provision in the low-income region is theoretically ambiguous. The effects of higher *intra-regional* income inequality, on the other hand, depend on the region in which income dispersion increases. Higher income inequality in the high-income region leads to higher quality in that region and lower quality in the other two regions, while higher income inequality in either the middle-income or the low-income region has no effect on quality provision in the high-income region and indeterminate effects on the other two regions. Thus, allowing for cross-border patient mobility can create negative spillover effects of higher income inequality in

the form of lower quality of health care in neighbouring regions.

In sum, the consequences of cross-border patient mobility are far from straightforward. As explained above, liberalising or encouraging patient mobility across regions may have adverse effects on health care quality and welfare, particularly in low- and middle-income regions. Moreover, increasing the income dispersion across regions, which can be interpreted as extending the EU towards Eastern Europe, may have positive effects on the high-income regions, but negative effects for the middle-income and possibly also the low-income regions. Thus, the new Directive from the EU is not necessarily to the benefit of all member states.

The literature on cross-border patient mobility is limited but growing. The recent papers by Andritsos and Tang (2013, 2014) use a queueing framework to analyse effect of cross-border patient mobility on waiting times and reimbursement policies.⁶ Andritsos and Tang (2013) find that patient mobility can increase patient welfare due to increased access to care. However, the effects on waiting times and reimbursement rates are mixed, and the additional costs of mobility are disproportionately shared between the participating countries. Andritsos and Tang (2014) find that patient mobility can be beneficial to public health-care systems (NHS), as health-care funders can reduce their costs without increasing the patients' waiting time. In border regions, where the cost of crossing the border is low, 'outsourcing' the high-cost country's elective care services to the low-cost country is a viable strategy from which both countries can benefit. Despite similarities, these studies do not consider the effect of patient mobility on health-care quality nor the role of differences in income distribution across and within regions, which is the key focus of our paper.

The closest paper to ours is Brekke et al. (2014b) who consider a Hotelling model with two regions that differ in health-care technology, where the region with more efficient technology offers higher health-care quality and attracts patients from the region with less efficient technology. A key finding is that the effects of patient mobility depend on the transfer payment. If the payment is below marginal cost, mobility leads to a 'race-to-the-bottom' in quality and lower welfare in both regions. Thus, patient mobility can have adverse effects on quality provision and welfare unless an appropriate transfer payment scheme is implemented. In the current paper, we take a different approach by focusing on differences in the income distribution across regions and the consequences

⁶There is also a paper by Petretto (2000) that looks at regionalisation of a National Health Service. It provides conditions for establishing whether devolution for health care expenditure is desirable. Variations in health expenditure will depend on its marginal benefit and the marginal cost of public funds, including higher or lower transfers originating from mobility. However, this paper has no explicit spatial dimension and it is not concerned with the quality of care. It is thus very different from ours.

for patient mobility and regional health-care quality and welfare.⁷ Differences in income across regions are an important source of mobility and have received much attention in the EU debate. The model is extended to three (rather than two) regions: therefore the same region can be both importing and exporting patients, which cannot arise with the two-region set up in Brekke et al. (2014b). Finally, we use more general cost functions, allow for copayments when patients demand care outside their region, and allow for heterogeneity in income within countries/regions (with richer patients more likely to move). Critically, we introduce income effects through decreasing marginal utility of income, which implies that qualities are in most reasonable scenarios strategic substitutes, and this is an important driver of some key results. We investigate the effect of policy-relevant parameters such as patients' copayments and inter- and intra-regional income dispersion. Thus, our paper is significantly different from Brekke et al. (2014b).

Our paper also relates to the broader health economics literature on provider competition and quality incentives. A key finding from this literature is that with regulated prices, competition increases health-care quality if providers are profit-maximisers, whereas the relationship between competition and quality is generally ambiguous if providers are (partly) altruistic.⁸ Despite some similarities, our study differs from this literature as we consider competition between regions (rather than providers), where health-care quality is set by policy makers that maximise regional welfare financed through taxation. Moreover, the income distribution across and within regions is central to our study, but not a part of the previously cited papers.⁹ Thus, the competitive mechanisms in our model are clearly different from the more general literature on provider competition and quality incentives.¹⁰

The rest of the paper is organised as follows. In Section 2 we present our model. In Section 3 we describe the strategic relationship between regions' optimal choices of quality provision. In Section 4 we analyse the effects of liberalising cross-border health care – through a reduction in either monetary or non-monetary mobility costs – on regional quality provision and welfare. In

⁷Analytically, differences in quality in the current paper are driven by differences in income. In Brekke et al. (2014b) countries differ in the marginal cost of quality, ie a country has a technology advantage.

⁸See for example Gravelle (1999), Gravelle and Sivey (2010), Brekke, Nuscheler and Straume (2006), and Brekke, Siciliani and Straume (2011). See Gaynor (2006) for an excellent review of the literature on competition and quality in health care markets.

⁹There is a paper by Aiura and Sanjo (2010) that uses a Hotelling model with two regions that differ in their population density to study incentives for health care quality. While this paper shares some similarities in the demand structure, the focus is very different as they study the impact of privatisation of local public hospitals.

¹⁰Our paper also relates to the economic literature on fiscal federalism and interregional competition, in particular the part of this literature concerned with cross-border shopping. However, this literature is mainly concerned with taxation rather than health-care quality as an incentive for cross-border mobility. See, for instance, Kanbur and Keen (1993), Trandel (1994), Wang (1999), and Nielsen (2001).

Section 5 we explore the effects of (inter-regional or intra-regional) income inequality on regional quality provision and analyse how these effects depend on cross-border patient mobility. Finally, Section 6 concludes the paper.

2 Model

Consider a market for health care where patients are uniformly distributed on a circle with circumference equal to 1 and the total patient mass normalised to 1. The market consists of three different regions, which can be interpreted either as neighbouring countries or neighbouring regions within the same country. The three regions, indexed by $i = L, M, H$, are of equal size, each covering $1/3$ of the circle. The index i denotes whether the region has Low, Middle or High average income. The market is served by three health care providers (hospitals), one in each region, where the provider in Region i is located at x_i . We assume that each provider is located at the center of its region, implying that the patients belonging to Region i are located on the line segment $[x_i - \frac{1}{6}, x_i + \frac{1}{6}]$. Each patient demands one unit of health care (one treatment) from the most preferred provider. We assume that health care provision is publicly funded through general income taxation and is free at the point of consumption (at least for patients who seek treatment in their own region).¹¹

The net utility of a patient located at z and receiving health care from the provider in Region i , located at x_i , is given by

$$U(z, x_i) = v + bq_i - t|z - x_i| + u(Y_k^i) \quad (1)$$

if the patient receives treatment in the region to which she resides. $v > 0$ is the patient's gross utility of being treated, $q_i \geq \underline{q}$ is the quality offered by the provider in Region i (with $b > 0$ measuring the marginal utility of quality)¹² and t is the marginal disutility of travelling.¹³ The utility of income is measured by a strictly concave utility function $u(\cdot)$. We assume that patients

¹¹We therefore do not allow for the presence of a private sector alternative. Adding this additional choice would make the presentation of the model much more complicated without gaining additional insights (see Barros and Siciliani, 2011 for a detailed review of the literature). Moreover, note that in our model patients may have to pay a copayment when choosing treatment in a different region, which has some analogies with modelling public versus private patient's choice.

¹²The lower bound \underline{q} represents the lowest possible quality the providers can offer without being charged with malpractice and is, for simplicity, normalised to 0.

¹³We assume that utility is linear in quality and distance. This is without loss of generality. There is strong empirical evidence showing that distance is a major predictor of patients' choice of hospital, see, e.g., Tay (2003) and Beckert et al (2012). We also assume that utility is separable in quality and consumption. Again, this is without loss of generality.

are heterogeneous in income y_k with $k = P, R$ and with $y_R > y_P$, i.e., we allow for high income (Rich) and low income (Poor) patients. Assuming a proportional income tax rate (or social security contribution), $\tau_i > 0$, set by the government of Region i , the net income of a type- k patient in Region i is given by

$$Y_k^i := y_k (1 - \tau_i). \quad (2)$$

The proportion of high-income patients, λ_i , is assumed to differ across regions, with $\lambda_H > \lambda_M > \lambda_L > 0$. For later reference, it is useful to define the average gross income in Region i as

$$\bar{y}_i := \lambda_i y_R + (1 - \lambda_i) y_P. \quad (3)$$

We also define the average utility gain of a marginal reduction in the income tax rate in Region i (when all patients in the region seek treatment in their own region) as

$$\bar{u}_{\tau_i} := \lambda_i u_Y (Y_R^i) y_R + (1 - \lambda_i) u_Y (Y_P^i) y_P. \quad (4)$$

The net utility of a patient located at z and receiving health care from the provider in a neighbouring Region j (different from where the patient resides), located at x_j , is given by

$$U(z, x_j) = v + bq_j - t|z - x_j| + u(\hat{Y}_k^i) - F, \quad (5)$$

where F is a non-monetary mobility cost (disutility) of seeking care in a different region (because of different administrative rules and language barriers, for example). We also assume that there is a monetary cost (copayment) π of receiving care in a different region, such that the net income of a type- k patient in Region i who seeks care in a different region is given by

$$\hat{Y}_k^i := y_k(1 - \tau_i) - \pi. \quad (6)$$

Assuming that each patient makes a utility-maximising choice of provider, and assuming that v is sufficiently large to ensure full market coverage in equilibrium, patients of type k who travel from Region i to Region j for treatment are located on a line segment of length $\max\{0, \phi_{ij}^k\}$, where

$$\phi_{ij}^k := \frac{1}{2t} \left(b(q_j - q_i) + u(\hat{Y}_k^i) - u(Y_k^i) - F \right). \quad (7)$$

Notice that

$$\frac{\partial \phi_{ij}^k}{\partial y_k} = \left(\frac{1 - \tau_i}{2t} \right) \left(u_Y \left(\widehat{Y}_k^i \right) - u_Y \left(Y_k^i \right) \right) > 0 \text{ if } \pi > 0. \quad (8)$$

Thus, as long as seeking treatment in a different region implies some monetary costs, richer patients are more prone to make this choice. The total number of patients travelling from Region i to Region j is then given by $\max \{0, \Phi_{ij}\}$, where

$$\Phi_{ij} := \lambda_i \phi_{ij}^R + (1 - \lambda_i) \phi_{ij}^P. \quad (9)$$

Notice here that $\partial \Phi_{ij} / \partial q_j = -(\partial \Phi_{ij} / \partial q_i) = b/2t$.

Since utility is assumed to be strictly concave in income, the marginal cost of raising tax revenues decreases with average income, implying that the optimally chosen health care quality will be higher in richer regions. This creates an incentive for patient migration from poorer to richer regions and we will assume that this is the direction of patient flows in equilibrium. In this case, total demand for health care in each region is given by

$$D_L = \frac{1}{3} - \Phi_{LH} - \Phi_{LM}, \quad (10)$$

$$D_M = \frac{1}{3} - \Phi_{MH} + \Phi_{LM}, \quad (11)$$

$$D_H = \frac{1}{3} + \Phi_{MH} + \Phi_{LH}. \quad (12)$$

The provider in Region i is assumed to have the following the cost function:

$$C(D_i, q_i) = c_i D_i + K(q_i), \quad (13)$$

where K is increasing and strictly convex in quality, and where $c_H \geq c_M \geq c_L$.

The policy maker in each region chooses quality to maximise the utility of its own residents subject to a budget constraint. As previously mentioned, we conjecture that quality is highest in the high-income region and lowest in the low-income region. In turn, this implies that the high-income region will attract (import) some patients, and the low-income region will export some patients. The middle-income region both imports patients from the low-income region and exports some patients to high-income region. We solve in turn the problem for each region.

2.1 High-income region

The maximisation problem for the policy maker in the high-income region is¹⁴

$$\max_{q_H} W_H := 2 \int_0^{\frac{1}{6}} (v + bq_H - tx) dx + \frac{\lambda_H}{3} u(Y_R^H) + \frac{1 - \lambda_H}{3} u(Y_P^H), \quad (14)$$

subject to the budget constraint

$$\tau_H \frac{\bar{y}_H}{3} = \frac{c_H}{3} + K(q_H) - (p_H - c_H)(\Phi_{LH} + \Phi_{MH}), \quad (15)$$

where p^H is the price received by region H per patient treated from other regions. From the budget constraint we can derive

$$\frac{\partial \tau_H}{\partial q_H} = \frac{3}{\bar{y}_H} \left(K'(q_H) - (p_H - c_H) \frac{b}{t} \right), \quad \frac{\partial \tau_H}{\partial q_M} = \frac{\partial \tau_H}{\partial q_L} = \frac{3(p_H - c_H)b}{2t\bar{y}_H}. \quad (16)$$

The first-order condition for optimal quality is given by

$$\frac{dW_H}{dq_H} = \frac{\partial W_H}{\partial q_H} + \frac{\partial W_H}{\partial \tau_H} \frac{\partial \tau_H}{\partial q_H} = 0, \quad (17)$$

which can be written as

$$\frac{b}{3} - \frac{\bar{u}_{\tau_H}}{\bar{y}_H} \left(K'(q_H) - (p_H - c_H) \frac{b}{t} \right) = 0. \quad (18)$$

The first term is the marginal utility of health care quality in Region H . Notice that all patients in Region H seek treatment in their own region and therefore all benefit from an increase in q_H . The second term is the marginal cost of health care quality, which is the higher income tax rate necessary to finance a marginal quality improvement, times the utility loss of higher taxes. Higher quality will attract more patients from neighbouring regions. Thus, the amount of tax revenues that need to be raised in order to finance higher health care quality depends partly on the profitability of treating such patients. If $p_H > (<) c_H$, less (more) tax revenues need to be raised when patient immigration increases.

We can also confirm that a higher share of rich patients (which implies higher average income)

¹⁴We assume that the problem is well-behaved, which requires either the cost function to be convex or the marginal utility of consumption to be decreasing (see Appendix).

reduces the marginal utility loss of income taxation since

$$\frac{\partial \left(\frac{\bar{u}_{\tau H}}{\bar{y}_H} \right)}{\partial \lambda_H} = \frac{[u_Y(Y_R^H) - u_Y(Y_P^H)] y_R y_P}{\bar{y}_H^2} < 0, \quad (19)$$

and therefore reduces the marginal cost of quality provision, implying a higher optimal level of health care quality.

2.2 Low-income region

The maximisation problem for the policy maker in the low-income region is:

$$\begin{aligned} \max_{q_L} W_L \quad & : = \lambda_L \left[\begin{aligned} & \int_0^{\frac{1}{6} - \phi_{LH}^R} (v + bq_L + u(Y_R^L) - tx) dx \\ & + \int_0^{\frac{1}{6} - \phi_{LM}^R} (v + bq_L + u(Y_R^L) - tx) dx \\ & + \int_0^{\phi_{LH}^R} (v + bq_H + u(\widehat{Y}_R^L) - t(\frac{1}{6} + x) - F) dx \\ & + \int_0^{\phi_{LM}^R} (v + bq_M + u(\widehat{Y}_R^L) - t(\frac{1}{6} + x) - F) dx \end{aligned} \right] \\ & + (1 - \lambda_L) \left[\begin{aligned} & \int_0^{\frac{1}{6} - \phi_{LH}^P} (v + bq_L + u(Y_P^L) - tx) dx \\ & + \int_0^{\frac{1}{6} - \phi_{LM}^P} (v + bq_L + u(Y_P^L) - tx) dx \\ & + \int_0^{\phi_{LH}^P} (v + bq_H + u(\widehat{Y}_P^L) - t(\frac{1}{6} + x) - F) dx \\ & + \int_0^{\phi_{LM}^P} (v + bq_M + u(\widehat{Y}_P^L) - t(\frac{1}{6} + x) - F) dx \end{aligned} \right], \quad (20) \end{aligned}$$

subject to the budget constraint¹⁵

$$\tau_L \frac{\bar{y}_L}{3} = \frac{c_L}{3} + K(q_L) + (p_H - \pi - c_L) \Phi_{LH} + (p_M - \pi - c_L) \Phi_{LM}, \quad (21)$$

from which we can derive

$$\frac{\partial \tau_L}{\partial q_L} = \frac{3 \left(K'(q_L) - (p_H + p_M - 2\pi - 2c_L) \frac{b}{2t} \right)}{\bar{y}_L (1 + \psi_L)}, \quad (22)$$

$$\frac{\partial \tau_L}{\partial q_H} = \frac{3b(p_H - \pi - c_L)}{2t\bar{y}_L(1 + \psi_L)}, \quad \frac{\partial \tau_L}{\partial q_M} = \frac{3b(p_M - \pi - c_L)}{2t\bar{y}_L(1 + \psi_L)}, \quad (23)$$

¹⁵Here we interpret π as a patient copayment, implying that the tax payers in Region L has to pay $p_i - \pi$ for each patient who travel to Region i for treatment ($i = H, M$).

where

$$\psi_L : = \frac{p_H + p_M - 2\pi - 2c_L}{2t\bar{y}_L} \rho_L, \quad (24)$$

$$\rho_L : = \lambda_L y_R \left(u_Y \left(\hat{Y}_R^L \right) - u_Y \left(Y_R^L \right) \right) + (1 - \lambda_L) y_P \left(u_Y \left(\hat{Y}_P^L \right) - u_Y \left(Y_P^L \right) \right). \quad (25)$$

Here the necessary increase in the income tax rate to finance higher health care quality depends partly on the corresponding changes in patient emigration. Higher quality of care in Region L leads to lower patient emigration. Whether this reinforces or dampens the tax increase necessary to finance higher quality, depends on whether patient emigration is unprofitable ($p_H + p_M - 2\pi > 2c_L$) or profitable ($p_H + p_M - 2\pi < 2c_L$). The net per-patient price paid by the low-income region is lower when patients' co-payment is higher. For a sufficiently high co-payment, emigration is profitable.

The first-order condition for optimal quality is given by

$$\frac{dW_L}{dq_L} = \frac{\partial W_L}{\partial q_L} + \frac{\partial W_L}{\partial \tau_L} \frac{\partial \tau_L}{\partial q_L} = 0, \quad (26)$$

which can be written as

$$\begin{aligned} \frac{dW_L}{dq_L} &= b \left(\frac{1}{3} - (\Phi_{LH} + \Phi_{LM}) \right) - \frac{(K'(q_L) - (p_H + p_M - 2\pi - 2c_L) \frac{b}{2t})}{\bar{y}_L (1 + \psi_L)} \times \\ &\quad \times \left[\begin{aligned} &\bar{u}_{\tau_L} + 3\lambda_L (\phi_{LH}^R + \phi_{LM}^R) y_R \left(u_Y \left(\hat{Y}_R^L \right) - u_Y \left(Y_R^L \right) \right) \\ &+ 3(1 - \lambda_L) (\phi_{LH}^P + \phi_{LM}^P) y_P \left(u_Y \left(\hat{Y}_P^L \right) - u_Y \left(Y_P^L \right) \right) \end{aligned} \right]. \end{aligned} \quad (27)$$

The first term is the marginal utility of higher quality for patients in Region L . These benefits accrue only to the patients who seek treatment in their own region. The second term is the marginal cost of health care quality, which is the utility loss of higher taxes. The second and third term in the square brackets are the extra (per patient) utility loss of higher taxes for rich and poor patients, respectively, who travel out of the region for treatment. If the co-payment is positive ($\pi > 0$), the net income is higher for patients who stay than for patients who go, implying an extra utility loss of higher taxes (because of decreasing marginal utility of income) for patients who are treated in other regions.

2.3 Middle-income region

The maximisation problem for the policy maker in the middle-income region is:

$$\begin{aligned}
\max_{q_M} W_M \quad &= \lambda_M \left[\int_0^{\frac{1}{6} - \phi_{MH}^R} (v + bq_M + u(Y_R^M) - tx) dx \right. \\
&\quad \left. + \int_0^{\phi_{MH}^R} (v + bq_H + u(\widehat{Y}_R^M) - t(\frac{1}{6} + x) - F) dx \right] \\
&\quad + (1 - \lambda_M) \left[\int_0^{\frac{1}{6} - \phi_{MH}^P} (v + bq_M + u(Y_P^M) - tx) dx \right. \\
&\quad \left. + \int_0^{\phi_{MH}^P} (v + bq_H + u(\widehat{Y}_P^M) - t(\frac{1}{6} + x) - F) dx \right] \\
&\quad + \int_0^{\frac{1}{6}} (v + bq_M + \lambda_M u(Y_R^M) + (1 - \lambda_M) u(Y_P^M) - tx) dx,
\end{aligned} \tag{28}$$

subject to

$$\tau_M \frac{\bar{y}_M}{3} = \frac{c_M}{3} + K(q_M) + (p_H - \pi - c_M) \Phi_{MH} - (p_M - c_M) \Phi_{LM}, \tag{29}$$

from which we can derive

$$\frac{\partial \tau_M}{\partial q_M} = \frac{3(K'(q_M) - (p_H - \pi + p_M - 2c_M) \frac{b}{2l})}{\bar{y}_M (1 + \psi_M)}, \tag{30}$$

$$\frac{\partial \tau_M}{\partial q_H} = \frac{3b(p_H - \pi - c_M)}{2t\bar{y}_M (1 + \psi_M)}, \quad \frac{\partial \tau_M}{\partial q_L} = \frac{3b(p_M - c_M)}{2t\bar{y}_M (1 + \psi_M)}, \tag{31}$$

where

$$\psi_M \quad : \quad = \frac{(p_H - \pi - c_M)}{2t\bar{y}_M} \rho_M, \tag{32}$$

$$\rho_M \quad : \quad = \lambda_M y_R (u_Y(\widehat{Y}_R^M) - u_Y(Y_R^M)) + (1 - \lambda_M) y_P (u_Y(\widehat{Y}_P^M) - u_Y(Y_P^M)). \tag{33}$$

Again, notice that the tax increase necessary to finance higher health care quality depends partly on the costs saved (or incurred) by reduced patient migration to Region H .

The first-order condition for optimal quality is given by

$$\frac{dW_M}{dq_M} = \frac{\partial W_M}{\partial q_M} + \frac{\partial W_M}{\partial \tau_M} \frac{\partial \tau_M}{\partial q_M} = 0, \tag{34}$$

which can be written as

$$\begin{aligned} \frac{dW_M}{dq_M} &= b \left(\frac{1}{3} - \Phi_{MH} \right) - \frac{(K'(q_M) - (p_H - \pi + p_M - 2c_M) \frac{b}{2t})}{\bar{y}_M (1 + \psi_M)} \times \\ &\times \left[\begin{aligned} &\bar{u}_{\tau_M} + 3\lambda_M \phi_{MH}^R y_R \left[u_Y(\hat{Y}_R^M) - u_Y(Y_R^M) \right] \\ &+ 3(1 - \lambda_M) \phi_{MH}^P y_P \left[u_Y(\hat{Y}_P^M) - u_Y(Y_P^M) \right] \end{aligned} \right]. \end{aligned} \quad (35)$$

The interpretation is completely equivalent to the interpretation for optimal quality in Region L , where the differences only account for differences in cross-regional patient flows.

Figure 1 illustrates the equilibrium.

[Figure 1 here]

3 Strategic interaction between regions

In order to understand the main mechanisms involved in the model, it is instructive to study the nature of the strategic interaction between the different regions. If the quality in Region j increases, what is the optimal response by Region i ? As we will show below, this depends partly on the direction of patient flow between these two regions.

Suppose that the patient flow in equilibrium is from Region j to Region i (which implies that $i = H, M, j = M, L, i \neq j$). The optimal response of the policy maker in Region i to a quality increase in Region j is then given by

$$\frac{d^2 W_i}{dq_i dq_j} = \frac{3b}{2t} (p_i - c_i) \omega_i \left[\lambda_i u_{YY} (Y_R^i) y_R^2 + (1 - \lambda_i) u_{YY} (Y_P^i) y_P^2 \right] + \sigma_{ij}, \quad (36)$$

where

$$\sigma_{ij} = \begin{cases} 0 & \text{if } i = H \\ \sigma_{ML} & \text{if } i = M \end{cases}, \quad (37)$$

and where ω_i is a positive term related to the marginal cost of quality provision in Region i .¹⁶

For the high-income region, the sign of the response to a quality increase in either the low- or middle-income region depends solely on whether the price received by the high-income region is

¹⁶

$$\omega_i = \begin{cases} \frac{(K'(q_M) - (p_H - \pi + p_M - 2c_M) \frac{b}{2t})}{[\bar{y}_M (1 + \psi_M)]^2} & \text{if } i = M \\ \frac{K'(q_H) - (p_H - c_H) \frac{b}{t}}{\bar{y}_H^2} & \text{if } i = H \end{cases}.$$

above or below the marginal cost of treatment. If $p_H > (<) c_H$, the quality response is negative (positive), implying strategic substitutability (complementarity). Intuitively, an increase in quality in one of the other regions reduces the number of migrating patients and the associated profits (if price is above marginal cost) for the high-income region. The higher marginal cost of providing quality implies that the high-income region responds by reducing quality. Qualities are strategically independent only if the price is equal to the marginal cost of treatment, or if the marginal utility from consumption is constant.

For the middle-income region, the response to a quality increase in the low-income region depends on the sum of two terms. First, it depends on whether patient migration from the low- to the middle-income region is profitable or not for the latter region (i.e., whether p_M is above or below c_M). The intuition is of course similar to the one given above for the high-income region. In addition, the total effect also depends on the term σ_{ML} , which is a function of the third-order derivative of the utility function, with limited economic intuition ($\sigma_{ML} = 0$ if $u_{Y^2} = 0$).

Consider now the policy response of Region j to a quality increase in Region i (i.e., the optimal policy response to a quality increase in a patient-importing region). The optimal response is given by

$$\frac{d^2 W_j}{dq_j dq_i} = -b \left(\frac{b}{2t} - \frac{\rho_j}{2t} \frac{\partial \tau_j}{\partial q_i} \right) - \omega_j \left[\begin{array}{c} \frac{3b}{2t} \rho_j - \gamma_j \frac{\partial \tau_j}{\partial q_i} \left(\begin{array}{c} \lambda_j y_R^2 \left(u_Y \left(\widehat{Y}_R^j \right) - u_Y \left(Y_R^j \right) \right)^2 \\ + (1 - \lambda_j) y_P^2 \left(u_Y \left(\widehat{Y}_P^j \right) - u_Y \left(Y_P^j \right) \right)^2 \end{array} \right) \\ - \frac{\partial \tau_j}{\partial q_i} \left(\lambda_j y_R^2 u_{Y^2} \left(Y_R^j \right) + (1 - \lambda_j) y_P^2 u_{Y^2} \left(Y_P^j \right) \right) \end{array} \right] + \sigma_{ji}, \quad (38)$$

where

$$\gamma_j = \begin{cases} \frac{3}{t} & \text{if } j = L \\ \frac{3}{2t} & \text{if } j = M \end{cases}, \quad (39)$$

ω_j is a positive term related to the marginal cost of quality provision in Region j ,¹⁷ and σ_{ji} is a term that depends on the third-order derivative of the utility function ($\sigma_{LH} = \sigma_{LM} = \sigma_{MH} = 0$ if $u_{Y^2} = 0$).

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$$\omega_j = \begin{cases} \frac{(K'(q_M) - (p_H - \pi + p_M - 2c_M) \frac{b}{2t})}{\bar{y}_M (1 + \psi_M)} & \text{if } j = M \\ \frac{(K'(q_L) - (p_H + p_M - 2\pi - 2c_L) \frac{b}{2t})}{\bar{y}_L (1 + \psi_L)} & \text{if } j = L \end{cases}$$

If we abstract from effects that work through the term σ_{ji} , the optimal response can be decomposed into three different effects: (i) a direct utility effect, (ii) an income effect, and (iii) indirect effects through the budget constraint. The first two effects are negative (suggesting strategic substitutability), whereas the third effect is a priori ambiguous and depend on the profitability of patient emigration. Below we will explain each of these three effects in detail.

(i) An increase in quality of a neighbouring (patient-importing) region reduces the number of patients who seek care in the home region. This reduces the marginal benefit of the exporting region to provide quality. This effect is captured by the first term in (38).

(ii) If patients who travel to a neighbouring region pay a co-pay ($\pi > 0$), their net income is lower and the marginal utility from income higher, which effectively increases the marginal cost of providing quality in the exporting region. This effect is captured by the first term on the second line of (38).

(iii) If patient mobility is either profitable or unprofitable for the exporting region, higher quality in a neighbouring region will affect the budget, and thereby the incentives for quality investments. This effect is captured by the terms including $\partial\tau_j/\partial q_i$ in (38). Suppose that mobility is unprofitable for the exporting region, such that $\partial\tau_j/\partial q_i > 0$. This has one first-order and two second-order effects on the incentives for quality provision. The first-order effect, given by the last term in the square brackets of (38), is that the tax increase will increase the marginal cost of quality provision (because of decreasing marginal utility of income). This effect is dampened by two second-order effects (given by the two other terms in (38) that include $\partial\tau_j/\partial q_i$). Because of copayments ($\pi > 0$), and since $u_{YY}(\cdot) < 0$, a higher tax rate will make it relatively more costly for patients to travel out of the region, which dampens mobility and therefore increases (reduces) the marginal benefit (cost) of quality provision.

Thus, given that the two second-order effects described above do not outweigh the first-order effect, the third effect reinforces (counteracts) the first two effects if patient migration is unprofitable (profitable) for the exporting region. In the rest of the paper we assume that the first two effects always outweigh the third effect, implying that quality in an exporting region is a strategic substitute to quality in an importing region.

4 Liberalisation of cross-border health care

In this section, we analyse how increased cross-border patient mobility is likely to affect quality provision and social welfare in each of the three regions. We do so by conducting comparative statics with respect to each of the two mobility cost parameters; the non-monetary cost F and the monetary cost π . A reduction in the patient copayment, π , has a straightforward policy interpretation, while a reduction in F can be interpreted as a policy to reduce the ‘red tape’ costs of seeking treatment in another region.

To keep comparative statics tractable, throughout the remainder of the analysis we assume that prices are set equal to the marginal treatment costs, i.e., $p_H = c_H$, $p_M = c_M$. This is in line with current DRG pricing in several countries where fixed costs are not included in the tariff. We also make the highly reasonable assumption that the patient copayment π is such that a patient from Region j seeking treatment in Region i never pays more than the difference between the price charged by the importing region and the price reimbursed by the exporting region; i.e., $\pi \leq c_i - c_j$. Finally, we assume that $u_{YYY} = 0$, without much loss of generality.

In the following, we also use a more compact notation and adopt the following definitions:

$$\Delta u_Y := u_Y \left(\widehat{Y}_k^i \right) - u_Y \left(Y_k^i \right) > 0 \quad (40)$$

is the difference in the marginal utility of income for patients who move and pay a copayment and those who do not;¹⁸

$$\bar{u}_{\tau_i \tau_i} := u_{YY}(\cdot) \left[\lambda_i y_R^2 + (1 - \lambda_i) y_P^2 \right] < 0 \quad (41)$$

is the expected degree of concavity (across patients with different income) of utility with respect to the tax rate;

$$u_{\pi_i} := \lambda_i u_Y \left(\widehat{Y}_R^i \right) + (1 - \lambda_i) u_Y \left(\widehat{Y}_P^i \right) > 0 \quad (42)$$

is the marginal utility of income due to a reduction in copayment; and

$$\widetilde{K}'_M(q_M) := K'(q_M) - (p_H - \pi - c_M) b/2t > 0 \quad (43)$$

¹⁸Under the assumption $u_{YYY} = 0$, notice that Δu_Y is the same for all patients, regardless of whether they are rich or poor, and regardless of which region they move from and to.

and

$$\tilde{K}'_L(q_L) := K'(q_L) - (p_H + p_M - 2\pi - 2c_L)b/2t > 0 \quad (44)$$

are the marginal costs of quality in Region M and Region L , respectively, net of financial transfers due to patients' mobility.

4.1 Administrative mobility costs

Suppose policymakers reduce the complexity of administrative procedures to obtain health care in a different region, in order to encourage mobility. In our model, this policy corresponds to a reduction in F . Applying Cramer's rule, we obtain

$$\frac{dq_H^*}{dF} = 0, \quad (45)$$

$$\frac{dq_M^*}{dF} = \left(-\frac{d^2W_M}{dq_M^2} \right)^{-1} \frac{d^2W_M}{dq_M dF}, \quad (46)$$

$$\frac{dq_L^*}{dF} = \left(-\frac{d^2W_L}{dq_L^2} \right)^{-1} \frac{d^2W_L}{dq_L dF} + \frac{dq_M^*}{dF} \frac{d^2W_L}{dq_L dq_M}, \quad (47)$$

where

$$\frac{d^2W_M}{dq_M dF} = \frac{b}{2t} \left(1 - \rho_M \frac{\partial \tau_M}{\partial F} \right) + \frac{\tilde{K}'_M(q_M)}{\bar{y}_M (1 + \psi_M)} \left[\frac{3\rho_M}{2t} - \bar{u}_{\tau_M \tau_M} \left(\frac{3(\Delta u_Y)^2}{u_{YY}(\cdot)t} - 1 \right) \frac{\partial \tau_M}{\partial F} \right] > 0, \quad (48)$$

$$\frac{d^2W_L}{dq_L dF} = \frac{b}{t} \left(1 - \rho_L \frac{\partial \tau_L}{\partial F} \right) + \frac{\tilde{K}'_L(q_L)}{\bar{y}_L (1 + \psi_L)} \left[\frac{3\rho_L}{t} - \bar{u}_{\tau_L \tau_L} \left(\frac{3(\Delta u_Y)^2}{u_{YY}(\cdot)t} - 1 \right) \frac{\partial \tau_L}{\partial F} \right] > 0, \quad (49)$$

and

$$\frac{\partial \tau_M}{\partial F} = -\frac{3(c_H - \pi - c_M)}{2t\bar{y}_M(1 + \psi_M)} \leq 0, \quad (50)$$

$$\frac{\partial \tau_L}{\partial F} = -\frac{3(c_H + c_M - 2\pi - 2c_L)}{2t\bar{y}_L(1 + \psi_L)} \leq 0. \quad (51)$$

A reduction in the cost of seeking care in a different region increases mobility flows across regions. The quality of the *high-income* region is not affected by changes in mobility given that, by assumption, the price is set equal to the marginal cost of treatment ($p_H = c_H$), and therefore increased mobility has no implications for the government's budget constraint and the associated tax rate.

Health-care quality in *middle-income* region goes down. We identify three different effects. The increase in mobility reduces the number of patients who receive health care in the middle-income region and the associated marginal benefit of quality provision. This effect tends to reduce quality. It also increases the number of patients who have to pay a copayment, which reduces the marginal utility of income and tightens the budget constraint. This effect also tends to reduce quality. Finally, as long as $\pi < c_H - c_M$, migration of patients to the high-income region is costly for the government of the middle-income region, implying that higher mobility increases the income tax rate ($\partial\tau_M/\partial F < 0$), which also contributes to lower quality provision in Region M .¹⁹

For the *low-income* region we can identify a direct effect of a reduction in F , and an indirect effect through the strategic responses to quality changes in other regions. The direct effect tends to reduce quality and has the same intuition as the one provided for the middle-income region. The main difference is that the low-income region has more patients migrating to other regions, which tends to amplify the effects. As discussed in Section 3, qualities in the low- and middle-income regions are strategic substitutes. Since the quality of the middle-income region decreases in response to higher mobility, the indirect effect goes in the opposite direction of the direct effect. For a sufficiently small indirect effect, quality decreases also in the low-income region.

We summarise the above-described effects as follows:

Proposition 1 *A reduction in the non-monetary cost of mobility has (i) no effect on quality in the high-income region, (ii) reduces quality in the middle-income region, and (iii) reduces quality also in the low-income region, if indirect effects are sufficiently small.*

4.2 Patient copayments

As an alternative to reducing non-monetary costs of mobility, suppose that policymakers stimulate cross-border patient mobility by reducing patient copayments (or other monetary costs of mobility).

¹⁹There are some second-order effects that dampen the increase in mobility: since higher mobility implies a tightening of the budget constraint, the higher tax rate implies that patients can now less easily afford the co-payment to receive care in a different region.

The effects of a change in π on qualities are given by²⁰

$$\frac{dq_H^*}{d\pi} = 0, \quad (52)$$

$$\frac{dq_M^*}{d\pi} = \left(-\frac{d^2W_M}{dq_M^2} \right)^{-1} \frac{d^2W_M}{dq_M d\pi}, \quad (53)$$

$$\frac{dq_L^*}{d\pi} = \left(-\frac{d^2W_L}{dq_L^2} \right)^{-1} \left(\frac{d^2W_L}{dq_L d\pi} + \frac{dq_M^*}{d\pi} \frac{d^2W_L}{dq_L dq_M} \right). \quad (54)$$

where

$$\begin{aligned} \frac{d^2W_M}{dq_M d\pi} = & \frac{b}{2t} \left(u_{\pi_M} - \rho_M \frac{\partial \tau_M}{\partial \pi} \right) + \frac{\tilde{K}'_M(q_M)}{\bar{y}_M(1+\psi_M)} \left[\frac{3\rho_M}{2t} - \bar{u}_{\tau_M \tau_M} \left(\frac{3(\Delta u_Y)^2}{2tu_{YY}(\cdot)} - 1 \right) \frac{\partial \tau_M}{\partial \pi} \right] \\ & - \frac{[\bar{u}_{\tau_M} + 3\Delta u_Y (\lambda_M \phi_{MH}^R y_R + (1-\lambda_M) \phi_{MH}^P y_P)]}{\bar{y}_M(1+\psi_M)} \left(\frac{b}{2t} - \frac{3u_{YY}(\cdot) \tilde{K}'_M(q_M)}{1+\psi_M} \right) \end{aligned} \quad (55)$$

$$\begin{aligned} \frac{d^2W_L}{dq_L d\pi} = & \frac{b}{t} \left(u_{\pi_L} - \rho_L \frac{\partial \tau_L}{\partial \pi} \right) + \frac{\tilde{K}'_L(q_L)}{\bar{y}_L(1+\psi_L)} \left[\frac{3\rho_L}{t} - \bar{u}_{\tau_L \tau_L} \left(\frac{3(\Delta u_Y)^2}{tu_{YY}(\cdot)} - 1 \right) \frac{\partial \tau_L}{\partial \pi} \right] \\ & - \frac{\left[\bar{u}_{\tau_L} + 3\Delta u_Y \left(\begin{array}{c} \lambda_L (\phi_{LH}^R + \phi_{LM}^R) y_R \\ + (1-\lambda_L) (\phi_{LH}^P + \phi_{LM}^P) y_P \end{array} \right) \right]}{\bar{y}_L(1+\psi_L)} \left(\frac{b}{2t} - \frac{3u_{YY}(\cdot) \tilde{K}'_L(q_L)}{1+\psi_L} \right) \end{aligned} \quad (56)$$

and

$$\frac{\partial \tau_M}{\partial \pi} = -\frac{2t\Phi_{MH} + 3(c_H - \pi - c_M) u_{\pi_M}}{2t\bar{y}_M(1+\psi_M)} < 0, \quad (57)$$

$$\frac{\partial \tau_L}{\partial \pi} = -\frac{2t(\Phi_{LH} + \Phi_{LM}) + 3(c_H + c_M - 2\pi - 2c_L) u_{\pi_L}}{2t\bar{y}_L(1+\psi_L)} < 0. \quad (58)$$

Analogously to a reduction in non-monetary costs F , an reduction in copayments, π , also lowers the cost of seeking care in a different region and therefore increases mobility flows across regions. However, differently from a change in non-monetary costs, a reduction in copayments also tightens the budget constraint of the middle- and low-income regions: a smaller copayment increases the tax rate necessary to finance mobility.

As before, the quality of the *high-income* region is not affected by changes in mobility given

²⁰The results in this section would be qualitatively similar if we instead assume a cost-sharing system where a patient from Region j seeking treatment in Region i pays $\pi^{ji} = \theta(p_i - p_j) = \theta(c_i - c_j)$, where $\theta \in (0, 1)$. In such a system, the special case $\theta = 1$ (which corresponds to $\pi = c_i - c_j$ in the current model set-up) would imply that cross-border patient mobility is budget neutral (i.e., $\partial \tau_i / \partial F = 0$).

that, by assumption, the price is set equal to the marginal cost of treatment ($p_H = c_H$), and therefore mobility has no implications for the government's budget constraint and the associated tax rate. Moreover, since no patients from the high-income region moves to a different region, there are no copayments paid.

The effect of a lower copayment in the *middle-income* region is qualitatively similar to a reduction in non-monetary costs F , and therefore tends to reduce quality. However, it contains one additional effect, given by the last term in (55). Since a lower copayment makes mobility more expensive for the government in the middle-income region, this region has stronger incentives to raise quality in order to limit migration to other regions: less expenses are now paid directly by the patient and mobility has a stronger negative effect on the government's finances. This effect could potentially reverse the effect on the quality provision in the middle-income region: quality may *increase* rather than decrease.

A similar direct effect of a copayment reduction, given by the last term in (56), can be identified for the *low-income* region. However, the overall effect on quality in the low-income region also depends on an indirect effect, namely the strategic response to quality changes in the middle-income region. Suppose that the sum of the direct effects are such that a copayment reduction tends reduce (increase) quality in the low- and middle-income region. Because of strategic substitutability, the reduction (increase) in quality in the low-income region is attenuated by the strategic response to the reduction (increase) of quality in the middle-income region, which – in isolation – tends to increase (reduce) quality in the low-income region.

The effects of lower monetary mobility costs on regional quality provision are summarised as follows:

Proposition 2 *A reduction in patient copayments has no effect on quality in the high-income region, and has an indeterminate effect on the quality of the low- and middle-income regions.*

4.3 Patient mobility and regional welfare

How does an increase in patient mobility – because of lower monetary or non-monetary mobility costs – affect social welfare in each of the three regions? Before proceeding to answer this question, it is instructive to consider some general characteristics of the welfare comparative statics. The welfare in each region is given by $W_i(q_H^*(x), q_M^*(x), q_L^*(x), x)$, where x is the parameter of interest. Notice first that, due to the envelope theorem, $\partial W_i^* / \partial q_i^* = 0$. Moreover, because of the assumption

$p_i = c_i$, indirect welfare effects in a particular region only come from quality changes in neighbouring regions to which the region in question is *exporting* patients. Assuming that the patient flow is from Region j to Region i , indirect welfare effects are given by

$$\frac{\partial W_j^*}{\partial q_i^*} = b\Phi_{ji} + \frac{\bar{u}_{\tau j}}{3} \frac{\partial \tau_j}{\partial q_i} \quad (59)$$

and are generally ambiguous. On the one hand, higher quality in Region i increases the utility of the patients who travel from Region j (first term in (59)). On the other hand, higher quality in Region i increases patient export to this region, which – if $\pi < c_i - c_j$ – implies a higher tax burden for the residents of Region j (second term in (59)).

4.3.1 Administrative mobility costs

Consider a reduction in F . For the *high-income* region the effect is zero: there are no patients moving from the high-income region to other regions, and mobility is budget neutral.

The effect of lower non-monetary mobility costs on welfare in the *low-income* region is

$$\frac{dW_L^*}{dF} = \frac{\partial W_L^*}{\partial F} + \frac{\partial W_L^*}{\partial q_M^*} \frac{\partial q_M^*}{\partial F}, \quad (60)$$

where

$$\frac{\partial W_L^*}{\partial F} = -(\Phi_{LH} + \Phi_{LM}). \quad (61)$$

A reduction in F has three different effects – one positive and two negative – on welfare in the low-income region: (i) it directly reduces the cost for all patients who move, which has a positive welfare effect, (ii) it increases the marginal tax rate (if mobility is unprofitable), which has a negative welfare effect, and (iii) it reduces quality in Region M , which – all else equal – reduces utility for those patients who move from Region L to Region M and therefore also has a negative welfare effect.

Finally, the effect of lower non-monetary mobility costs in the *middle-income* region is simply given by

$$\frac{dW_M^*}{dF} = \frac{\partial W_M^*}{\partial F} = -\Phi_{MH} < 0. \quad (62)$$

Thus, lower costs of mobility has an unambiguously positive effect on welfare in Region M , because of the cost reduction for those patients who travel to Region H for treatment.

Proposition 3 *A reduction in the non-monetary cost of mobility has (i) no effect on welfare in the high-income region, (ii) a positive welfare effect in the middle-income region, and (iii) an indeterminate effect on welfare in the low-income region.*

These welfare results suggest that there might be both winners and losers from a policy of facilitating cross-border patient mobility by reducing administrative costs, and that the potential losers are patients and tax payers in the low-income region.

4.3.2 Patient copayments

As for the case of non-monetary mobility costs, a reduction in the monetary cost π has no effect on welfare in the *high-income* region: there are no patients moving from the high-income region to other regions, and mobility is budget neutral.

However, in contrast to the effect of non-monetary mobility costs, the direct effects of a copayment reduction on welfare in the *low-income* and *middle-income* regions are ambiguous, and given by

$$\frac{\partial W_L^*}{\partial \pi} = -(\Phi_{LH} + \Phi_{LM})u_{\pi_L} - \frac{\bar{u}_{\tau_L}}{3} \frac{\partial \tau_L}{\partial \pi} \quad (63)$$

and

$$\frac{\partial W_M^*}{\partial \pi} = -\Phi_{MH}u_{\pi_M} - \frac{\bar{u}_{\tau_M}}{3} \frac{\partial \tau_M}{\partial \pi}. \quad (64)$$

On the one hand, and similarly to a reduction in non-monetary mobility costs, a larger copayment increases utility for those who move to a different region to obtain health care. On the other hand, it increases the tax rate necessary to finance patient exports.

In the middle-income region, the welfare effect is given only by the direct effect in (64), whereas the overall welfare effect in the low-income region is

$$\frac{dW_L^*}{d\pi} = \frac{\partial W_L^*}{\partial \pi} + \frac{\partial W_L^*}{\partial q_M^*} \frac{\partial q_M^*}{\partial \pi}, \quad (65)$$

where the indirect effect (because of strategic substitutability) depends on the sign of $\partial W_M^*/\partial \pi$.

Proposition 4 *A reduction in patient copayments has no effect on welfare in the high-income region, and has indeterminate effects on welfare in the middle- and low-income regions.*

Propositions 3 and 4 suggest that a policy of stimulating cross-border patient mobility might have adverse welfare effects at regional level. When seen in conjunction, these two propositions

also suggest that such adverse effects might be less likely if the policy implies a reduction in non-monetary, rather than monetary, mobility costs.

5 Income inequality

In this section we exploit the structural richness of our model to analyse how regional quality provision depends on the degree of income inequality – both across and within regions – when patients have the option to seek treatment outside their own region.

5.1 Inter-regional income inequality

In order to study the effects of inter-regional income inequality on regional quality provision, we assume that $\lambda_H = \lambda_M + \delta$ and $\lambda_L = \lambda_M - \delta$, where δ measures the degree of income dispersion across regions. An increase in δ has no effect on the income distribution in the middle-income region, increases the proportion of rich individuals in the high-income region and reduces it in the low-income region.

How does an increase in inter-regional income dispersion affect quality provision? The effects are given by

$$\frac{dq_H^*}{d\delta} = \left(-\frac{d^2W_H}{dq_H^2} \right)^{-1} \frac{d^2W_H}{dq_H d\delta}, \quad (66)$$

$$\frac{dq_M^*}{d\delta} = \left(-\frac{d^2W_M}{dq_M^2} \right)^{-1} \frac{dq_H^*}{d\delta} \frac{d^2W_M}{dq_M dq_H}, \quad (67)$$

$$\frac{dq_L^*}{d\delta} = \left(-\frac{d^2W_L}{dq_L^2} \right)^{-1} \left[\frac{d^2W_L}{dq_L d\delta} + \frac{dq_M^*}{d\delta} \frac{d^2W_L}{dq_L dq_M} + \frac{dq_H^*}{d\delta} \frac{d^2W_L}{dq_L dq_H} \right], \quad (68)$$

where

$$\frac{d^2W_H}{dq_H d\delta} = K'(q_H) (u_Y(Y_P^H) - u_Y(Y_R^H)) \frac{y_R y_P}{\bar{y}_H^2} - \bar{u}_{\tau_{HH}} \frac{\tau_H (y_R - y_P)}{\bar{y}_H^2} > 0, \quad (69)$$

$$\begin{aligned} \frac{d^2W_L}{dq_L d\delta} = & b (\phi_{LH}^P - \phi_{LH}^R + \phi_{MH}^P - \phi_{MH}^R) - \frac{b\rho_L}{t} \frac{\partial\tau_L}{\partial\delta} + \Psi \\ & + \frac{\tilde{K}'_L(q_L)}{1 + \psi_L} \left[\frac{y_P y_R}{\bar{y}_L^2} (u_Y(Y_R^H) - u_Y(Y_P^H)) - \frac{\partial\tau_L}{\partial\delta} \bar{u}_{\tau_L \tau_L} \right], \end{aligned} \quad (70)$$

and

$$\frac{\partial \tau_L}{\partial \delta} = \frac{\tau_L (y_R - y_P) - ((c_H - \pi - c_L) (\phi_{LH}^R - \phi_{LH}^P) + (c_M - \pi - c_L) (\phi_{LM}^R - \phi_{LM}^P))}{\bar{y}_L}, \quad (71)$$

and where Ψ is a complex term that tends to zero when the copayment tends to zero (the full expression is available in the Appendix).

As expected, increased inter-regional income inequality leads to higher quality provision in the *high-income* region. The intuition is relatively simple and consists of two effects. A higher income implies that, for a given tax rate, the average expected marginal utility of income is lower, and the tax rate necessary to finance health care is also lower. Both effects reduce the marginal cost of quality provision. There are no indirect effects since the quality choice of the high-income region is independent of qualities in other regions.

Since the *middle-income* region maintains the same average income, there are no direct effects on quality. However, since qualities are strategic substitutes, the increase in quality by the high-income region triggers a reduction in quality for the middle-income region.

The effects in the *low-income* region are considerably more involved. We can distinguish several direct and indirect effects. First, an increase in dispersion reduces the average income in the low-income region, which tends to reduce quality due to the higher tax rate and the higher marginal utility of income. Second, since poor patients are less willing than rich patients to seek treatment outside their region, an increase in the share of poor patients reduces overall mobility, which increases incentives to provide quality for two reasons: (i) more patients benefit from the quality investment and (ii) lower mobility reduces the tax rate and therefore the marginal cost of quality provision. Finally, since qualities are strategic substitutes across regions, there are two indirect effects going in opposite direction: the increase (reduction) in quality in the high- (middle-) income region triggers lower (higher) incentives for quality provision in the low-income region.

Proposition 5 *An increase in inter-regional income inequality leads to (i) higher quality in the high-income region, (ii) lower quality in the middle-income region, and (iii) has an ambiguous effect on quality in the low-income region.*

An increase in income dispersion always increases the quality difference between the high- and middle-income regions. If the income effect dominates, and quality also reduces in the low-income region, the quality difference between the high- and low-income regions will also increase. However,

the quality difference between the middle- and the low-income regions could reduce if the quality in the low-income region remains unchanged or changes to a smaller extent.

5.2 Intra-regional income inequality

Let us finally consider how increased income inequality in a particular region affects quality provision in the same and (potentially) other regions. We model income dispersion within Region i as a mean-preserving spread β such that $\tilde{y}_R^i := y_R + \frac{\beta}{\lambda_i}$ and $\tilde{y}_P^i := y_P - \frac{\beta}{1-\lambda_i}$. This definition implies collecting $\frac{\beta}{1-\lambda_i}$ euros from each of the poor and distributing this amount by giving $\frac{\beta}{\lambda_i}$ to each of the rich. Income inequality is increased without affecting average income.

The effect of higher income dispersion in the *high-income* region on the same region's optimal quality provision is given by

$$\frac{dq_H^*}{d\beta} = -\frac{d^2W_H}{dq_H d\beta} / \frac{d^2W_H}{dq_H^2}. \quad (72)$$

with

$$\frac{dW_H}{dq_H d\beta} = -[u_Y(Y_R^H) - u_Y(Y_P^H) + u_{YY}(\cdot)(Y_R^H - Y_P^H)] \frac{K'(q_H)}{\bar{y}_H} > 0. \quad (73)$$

Thus, higher income dispersion will increase the optimal quality level. The intuition is quite straightforward. As long as average income remains constant, higher income dispersion implies that the rich bear a larger share of the total tax burden. A tax reduction will therefore benefit the rich to a higher degree, which implies that the average utility gain of a marginal tax reduction is lower. This, in turn, implies that the optimal tax rate, and therefore the optimal quality provision, is higher. Given strategic substitutability between regions, a higher income dispersion in the high-income region will then ultimately lead to lower quality in the other two regions.

The effect of higher income dispersion in the *middle-income* region on that region's quality provision is given by

$$\frac{dq_M^*}{d\beta} = -\frac{d^2W_M}{dq_M d\beta} / \frac{d^2W_M}{dq_M^2}, \quad (74)$$

where²¹

$$\frac{d^2W_M}{dq_M d\beta} = \frac{\partial^2 W_M}{\partial \tau_M \partial \beta} \frac{\partial \tau_M}{\partial q_M} = \left[\begin{array}{c} u_Y(Y_P^M) - u_Y(Y_R^M) - u_{YY}(\cdot)(Y_R^M - Y_P^M) \\ -3\Delta u_Y\left(\frac{1}{2t}(\Delta u_Y(Y_R^M - Y_P^M)) + \phi_{MH}^R - \phi_{MH}^P\right) \end{array} \right] \frac{\partial \tau_M}{\partial q_M}. \quad (75)$$

The sign of this expression is a priori ambiguous and depends on the sign of the expression in the square brackets. The first line in this expression is positive and reflects the fact that, with higher income dispersion, a marginal tax reduction will to a larger extent benefit the rich, which implies that the average utility gain of a lower tax rate is smaller. This is the same effect as the one described above, for the high-income region, and contributes, all else equal, to a higher optimal quality provision.

The second line of the expression is negative and therefore pulls in the opposite direction. Although higher income dispersion does not affect total patient export (for given quality levels), it affects the *composition* of the patients who choose to travel out of the region, with an increase in the share of rich patients. Thus, higher income dispersion implies that a larger share of rich patients have to pay a copayment π for health care abroad, which, all else equal, increases the marginal utility of income for the rich (on average) and therefore counteracts the effect of higher income dispersion.

Finally, the own-region effects of higher income dispersion in the *low-income* region are equivalent to the ones of the middle-income region described above and therefore not explicitly presented. The only qualitative difference is that, while a quality change (positive or negative) in the middle-income region induced by higher income dispersion indirectly affects quality in the low-income region (due to strategic substitutability), a similar change in quality provision in the low-income region has no spillover effects to other regions (under the assumptions $p_i = c_i$ and $u_{YY} = 0$).

We summarise the above-described effects as follows:

Proposition 6 (i) *Higher income inequality in Region H leads to higher quality in the high-income region and lower quality in the middle- and low-income regions.* (ii) *Higher income inequality in either Region M or Region L has no effect on quality provision in the high-income region and indeterminate effects on quality in the low- and middle-income regions.*

²¹Notice that Δu_Y and Φ_{MH} do not depend on β (i.e., higher income inequality increases the number of rich patients and reduces the number of poor patients who travel out of the region to be treated, but the net effect is zero), implying that $\frac{\partial^2 W_M}{\partial q_M \partial \beta} = \frac{\partial \tau_M}{\partial \beta} = \frac{\partial^2 \tau_M}{\partial q_M \partial \beta} = 0$.

6 Conclusions

Cross-border patient mobility is an important issue across countries – as exemplified by the new regulation in the EU – and across regions within countries with regional health-care provision, such as Canada, Italy and Sweden. In this paper we study the consequences of cross-border patient mobility on the quality of health care and the corresponding regional welfare effects. We develop a Salop model with three regions; a high-income, a middle-income, and a low-income region. In each region, health-care quality is set by a policy maker maximising regional welfare subject to health-care costs being financed by taxation. Since the marginal cost of taxation is decreasing in income (due to decreasing marginal utility of income), health-care quality is increasing in the regions' income level. Thus, patient mobility occurs from lower-income regions with poorer health-care quality to higher-income regions with better health-care quality.

We focus on the (interior) equilibrium where (i) the high-income region attracts patients from both the low- and middle-income regions and (ii) the middle-income region attracts patients from the low-income region. Profitability of cross-border patient mobility depends on the transfer payment scheme and we assume DRG-pricing, where the importing region receives a price equal to marginal treatment cost for migrating patients.

While our analysis produces a rich set of results regarding regional effects of cross-border patient mobility on quality provision and welfare, we would like to highlight here three different results: First, an increase in patient mobility driven by a reduction in non-monetary mobility costs has no effect on quality in the high-income region, but reduces quality in the middle-income and, if indirect effects are small, also reduces quality in the low-income region. Thus, and perhaps counter-intuitively, patient mobility can have adverse effects on the quality of care in lower-income regions exporting patients to higher-income regions, and can therefore increase dispersion in health care quality between high- and low-income regions. This result may explain the delay in the application of the EU Directive in several member countries.²²

Second, lower patient copayment for cross-border health care has no effect on quality in the high-income region, and has an indeterminate effect on the quality in the low- and middle-income regions. This result shows that whether increased cross-border patient mobility amplifies or dampens dispersion in health care quality across different countries might crucially depend on the exact mechanism that stimulates mobility.

²²Evaluative study on the crossborder Healthcare Directive (2011/24/EU) Final report 21 March 2015.

Third, an increase in inter-regional income dispersion increases quality in the high-income region, reduces quality in the middle-income region, whereas the effect on quality provision in the low-income region is indeterminate. This result might assist in predicting the likely effects of austerity and the economic crisis, which has affected EU Member States in a differential way, and has been highlighted in the recent change of wind in the decisions by the European Court of Justice that has ruled against patients asking reimbursement for treatment abroad (Elchinov, Luca and Petru)²³, where patients were coming from countries with relatively lower income (i.e. Romania and Bulgaria). The concern was that, as a result of mobility, quality may decrease for those patients who do not seek care abroad.

In summary, the consequences and implications of cross-border patient mobility are far from straightforward. By way of concluding, we would like to highlight some limitations of our study. Our results are derived assuming DRG-pricing. While this is a widely used pricing scheme for hospital care in place in most Western countries, different regions may bilaterally agree on a different way of pricing cross-border care. However, there is still an underlying problem that a patient that is profitable to treat for the importing region might be unprofitable for the exporting region to send. Clearly, designing an optimal payment scheme for cross-border patients is a key challenge. We leave this issue for future research.

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²³ECJ judgment in Elchinov, C-173/09, EU:C:2010:581 (from the Bulgaria to Germany); ECJ order in Luca, C-430/12, EU:C:2013:467 (from the Romania to Austria); ECJ judgment in Petru, C-268/13, EU:C:2014:2271 (from Romania to Germany).

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Appendix A: Second-order derivatives

High-income region

The partial derivatives of the FOC of q_H with respect to q_H , q_M and q_L are

$$\frac{d^2W_H}{dq_H^2} = -\frac{\bar{u}_{\tau_H}}{\bar{y}_H} K''(q_H) + \frac{3(K'(q_H) - (p_H - c_H)\frac{b}{t})^2}{\bar{y}_H^2} \begin{pmatrix} \lambda_H u_{YY}(Y_R^H) y_R^2 \\ + (1 - \lambda_H) u_{YY}(Y_P^H) y_P^2 \end{pmatrix} < 0, \quad (\text{A1})$$

$$\frac{d^2W_H}{dq_H \partial q_i} = \frac{3b(p_H - c_H)(K'(q_H) - \frac{b}{t}(p_H - c_H))}{2t\bar{y}_H^2} \begin{pmatrix} \lambda_H u_{YY}(Y_R^H) y_R^2 \\ + (1 - \lambda_H) u_{YY}(Y_P^H) y_P^2 \end{pmatrix} < 0, \quad (\text{A2})$$

$i = L, M.$

Middle-income region

The partial derivatives of the FOC of q_M with respect to q_H , q_M and q_L are

$$\begin{aligned} \frac{d^2W_M}{dq_M \partial q_H} &= -b \left(\frac{b}{2t} - \frac{\rho_M}{t} \frac{\partial \tau_M}{\partial q_H} \right) - \frac{(K'(q_M) - (p_H - \pi + p_M - 2c_M)\frac{b}{2t})}{\bar{y}_M(1 + \psi_M)} \times \\ &\times \left\{ \left[\frac{3b}{2t}\rho_M - \frac{3}{2t} \frac{\partial \tau_M}{\partial q_H} \begin{pmatrix} \lambda_M y_R^2 (u_Y(\hat{Y}_R^M) - u_Y(Y_R^M))^2 \\ + (1 - \lambda_M) y_P^2 (u_Y(\hat{Y}_P^M) - u_Y(Y_P^M))^2 \end{pmatrix} \right] \right. \\ &\quad \left. - \frac{\partial \tau_M}{\partial q_H} \left[\lambda_M y_R^2 u_{YY}(Y_R^L) + (1 - \lambda_M) y_P^2 u_{YY}(Y_P^L) \right] \right\} \\ &- \frac{3b(p_H - \pi - c_M)^2 (K'(q_M) - (p_H - \pi + p_M - 2c_M)\frac{b}{2t})}{(2t)^2 \bar{y}_M^3 (1 + \psi_M)^3} \times \\ &\times \left\{ \begin{aligned} &\bar{u}_{\tau_M} + 3\lambda_M \phi_{MH}^R y_R [u_Y(\hat{Y}_R^M) - u_Y(Y_R^M)] \\ &+ 3(1 - \lambda_M) \phi_{MH}^P y_P [u_Y(\hat{Y}_P^M) - u_Y(Y_P^M)] \end{aligned} \right\} \\ &\times \left\{ \begin{aligned} &\lambda_M y_R^2 [u_{YY}(\hat{Y}_R^M) - u_{YY}(Y_R^M)] \\ &+ (1 - \lambda_M) y_P^2 [u_{YY}(\hat{Y}_P^M) - u_{YY}(Y_P^M)] \end{aligned} \right\} \end{aligned} \quad (\text{A3})$$

$$\begin{aligned}
\frac{d^2 W_M}{dq_M^2} &= \frac{b^2}{2t} + \frac{b}{2t} \left[\begin{array}{c} 3\lambda_M y_R \left[u_Y \left(\widehat{Y}_R^M \right) - u_Y \left(Y_R^M \right) \right] \\ + 3(1 - \lambda_M) y_P \left[u_Y \left(\widehat{Y}_P^M \right) - u_Y \left(Y_P^M \right) \right] \end{array} \right] \frac{\left(\begin{array}{c} K'(q_M) \\ - (p_H - \pi + p_M - 2c_M) \frac{b}{2t} \end{array} \right)}{\bar{y}_M (1 + \psi_M)} \\
&+ \left[\begin{array}{c} \lambda_M u_{YY} \left(Y_R^M \right) y_R^2 + (1 - \lambda_M) u_{YY} \left(Y_P^M \right) y_P^2 \\ + 3\lambda_M \phi_{MH}^R y_R^2 \left[u_{YY} \left(\widehat{Y}_R^M \right) - u_{YY} \left(Y_R^M \right) \right] \\ + 3(1 - \lambda_M) \phi_{MH}^P y_P^2 \left[u_{YY} \left(\widehat{Y}_P^M \right) - u_{YY} \left(Y_P^M \right) \right] \end{array} \right] \frac{\left(\begin{array}{c} K'(q_M) \\ - (p_H - \pi + p_M - 2c_M) \frac{b}{2t} \end{array} \right)^2}{(\bar{y}_M (1 + \psi_M))^2} \\
&- \left[\begin{array}{c} \bar{u}_{\tau_M} + 3\lambda_M \phi_{MH}^R y_R \left[u_Y \left(\widehat{Y}_R^M \right) - u_Y \left(Y_R^M \right) \right] \\ + 3(1 - \lambda_M) \phi_{MH}^P y_P \left[u_Y \left(\widehat{Y}_P^M \right) - u_Y \left(Y_P^M \right) \right] \end{array} \right] \times \tag{A4} \\
&\times \left\{ \frac{K''(q_M)}{\bar{y}_M (1 + \psi_M)} + \frac{3(K'(q_M) - (p_H - \pi + p_M - 2c) \frac{b}{2t})^2}{\bar{y}_M^2 (1 + \psi_M)^3} \frac{p_H - c}{2t \bar{y}_M} \left[\begin{array}{c} \lambda_M y_R^2 \left[u_{YY} \left(\widehat{Y}_R^M \right) - u_{YY} \left(Y_R^M \right) \right] \\ + (1 - \lambda_M) y_P \left[u_{YY} \left(\widehat{Y}_P^M \right) - u_{YY} \left(Y_P^M \right) \right] \end{array} \right] \right\}
\end{aligned}$$

$$\begin{aligned}
\frac{d^2 W_M}{dq_M dq_L} &= \frac{3b(p_M - c_M)}{2t \bar{y}_M (1 + \psi_M)} \frac{(K'(q_M) - (p_H - \pi + p_M - 2c_M) \frac{b}{2t})}{\bar{y}_M (1 + \psi_M)} \times \\
&\times \left[\begin{array}{c} \lambda_M u_{YY} \left(Y_R^M \right) y_R^2 + (1 - \lambda_M) u_{YY} \left(Y_P^M \right) y_P^2 \\ + 3\lambda_M \phi_{MH}^R y_R^2 \left[u_{YY} \left(\widehat{Y}_R^M \right) - u_{YY} \left(Y_R^M \right) \right] \\ + 3(1 - \lambda_M) \phi_{MH}^P y_P^2 \left[u_{YY} \left(\widehat{Y}_P^M \right) - u_{YY} \left(Y_P^M \right) \right] \end{array} \right] \\
&+ \frac{3b(p_M - c_M)(p_H - \pi - c_M)(K'(q_M) - (p_H + p_M - 2c_M) \frac{b}{2t})}{(2t)^2 \bar{y}_M^3 (1 + \psi_M)^3} \tag{A5} \\
&\times \left\{ \begin{array}{c} \bar{u}_{\tau_M} + 3\lambda_M \phi_{MH}^R y_R \left[u_Y \left(\widehat{Y}_R^M \right) - u_Y \left(Y_R^M \right) \right] \\ + 3(1 - \lambda_M) \phi_{MH}^P y_P \left[u_Y \left(\widehat{Y}_P^M \right) - u_Y \left(Y_P^M \right) \right] \end{array} \right\} \\
&\times \left\{ \begin{array}{c} \lambda_M y_R^2 \left[u_{YY} \left(\widehat{Y}_R^M \right) - u_{YY} \left(Y_R^M \right) \right] \\ + (1 - \lambda_M) y_P^2 \left[u_{YY} \left(\widehat{Y}_P^M \right) - u_{YY} \left(Y_P^M \right) \right] \end{array} \right\}
\end{aligned}$$

Low-income region

The partial derivatives of the FOC of q_L with respect to q_H , q_M and q_L are:

$$\begin{aligned}
\frac{d^2 W_L}{dq_L dq_H} = & -b \left(\frac{b}{2t} - \frac{\rho_L}{t} \frac{\partial \tau_L}{\partial q_H} \right) - \frac{(K'(q_L) - (p_H + p_M - 2\pi - 2c_L) \frac{b}{2t})}{\bar{y}_L (1 + \psi_L)} \times \\
& \times \left\{ \begin{aligned} & \frac{3b}{2t} \rho_L - \frac{3}{t} \frac{\partial \tau_L}{\partial q_H} \left(\begin{aligned} & \lambda_L y_R^2 (u_Y (\hat{Y}_R^L) - u_Y (Y_R^L))^2 \\ & + (1 - \lambda_L) y_P^2 (u_Y (\hat{Y}_P^L) - u_Y (Y_P^L))^2 \end{aligned} \right) \\ & - \frac{\partial \tau_L}{\partial q_H} \left[\lambda_L y_R^2 u_{YY} (Y_R^L) + (1 - \lambda_L) y_P^2 u_{YY} (Y_P^L) \right] \end{aligned} \right\} \\
& - \left[\begin{aligned} & \bar{u}_{\tau_L} + 3\lambda_L (\phi_{LH}^R + \phi_{LM}^R) y_R (u_Y (\hat{Y}_R^L) - u_Y (Y_R^L)) \\ & + 3(1 - \lambda_L) (\phi_{LH}^P + \phi_{LM}^P) y_P (u_Y (\hat{Y}_P^L) - u_Y (Y_P^L)) \end{aligned} \right] \quad (A6) \\
& \times \frac{3b(p_H - \pi - c_L)^2 (K'(q_L) - (p_H + p_M - 2\pi - 2c_L) \frac{b}{2t})}{(2t)^2 (\bar{y}_L (1 + \psi_L))^3} \\
& \times \left\{ \begin{aligned} & \lambda_L y_R^2 [u_{YY} (\hat{Y}_R^L) - u_{YY} (Y_R^L)] \\ & + (1 - \lambda_L) y_P^2 [u_{YY} (\hat{Y}_P^L) - u_{YY} (Y_P^L)] \end{aligned} \right\}
\end{aligned}$$

$$\begin{aligned}
\frac{d^2 W_L}{dq_L dq_M} = & -b \left(\frac{b}{2t} - \frac{\rho_L}{t} \frac{\partial \tau_L}{\partial q_M} \right) - \frac{(K'(q_L) - (p_H + p_M - 2\pi - 2c_L) \frac{b}{2t})}{\bar{y}_L (1 + \psi_L)} \times \\
& \times \left\{ \begin{aligned} & \frac{3b}{2t} \rho_L - \frac{3}{t} \frac{\partial \tau_L}{\partial q_M} \left(\begin{aligned} & \lambda_L y_R^2 (u_Y (\hat{Y}_R^L) - u_Y (Y_R^L))^2 \\ & + (1 - \lambda_L) y_P^2 (u_Y (\hat{Y}_P^L) - u_Y (Y_P^L))^2 \end{aligned} \right) \\ & - \frac{\partial \tau_L}{\partial q_M} \left[\lambda_L y_R^2 u_{YY} (Y_R^L) + (1 - \lambda_L) y_P^2 u_{YY} (Y_P^L) \right] \end{aligned} \right\} \\
& - \left[\begin{aligned} & \bar{u}_{\tau_L} + 3\lambda_L (\phi_{LH}^R + \phi_{LM}^R) y_R (u_Y (\hat{Y}_R^L) - u_Y (Y_R^L)) \\ & + 3(1 - \lambda_L) (\phi_{LH}^P + \phi_{LM}^P) y_P (u_Y (\hat{Y}_P^L) - u_Y (Y_P^L)) \end{aligned} \right] \quad (A7) \\
& \times \frac{3b(p_M - \pi - c_L)^2 (K'(q_L) - (p_H + p_M - 2\pi - 2c_L) \frac{b}{2t})}{(2t)^2 (\bar{y}_L (1 + \psi_L))^3} \\
& \times \left\{ \begin{aligned} & \lambda_L y_R^2 [u_{YY} (\hat{Y}_R^L) - u_{YY} (Y_R^L)] \\ & + (1 - \lambda_L) y_P^2 [u_{YY} (\hat{Y}_P^L) - u_{YY} (Y_P^L)] \end{aligned} \right\},
\end{aligned}$$

$$\begin{aligned}
\frac{d^2 W_L}{dq_L^2} &= \frac{b}{t} \left(b + \left(\begin{array}{c} \lambda_L (\phi_{LH}^R + \phi_{LM}^R) y_R (u_Y (\widehat{Y}_R^L) - u_Y (Y_R^L)) \\ + (1 - \lambda_L) (\phi_{LH}^P + \phi_{LM}^P) y_P (u_Y (\widehat{Y}_P^L) - u_Y (Y_P^L)) \end{array} \right) \frac{\partial \tau_L}{\partial q_L} \right) \\
&+ \left\{ \frac{b}{t} \rho_L + \frac{\partial \tau_L}{\partial q_L} \left[\begin{array}{c} \frac{1}{3} (\lambda_L u_{YY} (Y_R^L) y_R^2 + (1 - \lambda_L) u_{YY} (Y_P^L) y_P^2) \\ + \left(\begin{array}{c} \lambda_L y_R^2 (u_Y (\widehat{Y}_R^L) - u_Y (Y_R^L))^2 \\ + (1 - \lambda_L) y_P^2 (u_Y (\widehat{Y}_P^L) - u_Y (Y_P^L))^2 \end{array} \right) \end{array} \right] \right\} \frac{\partial \tau_L}{\partial q_L} \quad (\text{A8}) \\
&- \left[\begin{array}{c} 3\bar{u}_{\tau_L} + 3\lambda_L (\phi_{LH}^R + \phi_{LM}^R) y_R (u_Y (\widehat{Y}_R^L) - u_Y (Y_R^L)) \\ + 3(1 - \lambda_L) (\phi_{LH}^P + \phi_{LM}^P) y_P (u_Y (\widehat{Y}_P^L) - u_Y (Y_P^L)) \end{array} \right] \frac{K''(q_L)}{\bar{y}_L (1 + \psi_L)}.
\end{aligned}$$

Appendix B: Comparative statics

Assume that $p_H = c_H$, $p_M = c_M$, and $u_{YYY} = 0$, which implies $\frac{d^2 W_H}{dq_H dq_M} = \frac{d^2 W_H}{dq_H dq_L} = \frac{d^2 W_M}{dq_M dq_L} = 0$.

Totally differentiating the FOCs with respect to qualities and a parameter x , we obtain

$$\left| \begin{array}{ccc|c|c} \frac{d^2 W_H}{dq_H^2} & 0 & 0 & dq_H & \frac{d^2 W_H}{dq_H dx} \\ \frac{d^2 W_M}{dq_M dq_H} & \frac{d^2 W_M}{dq_M^2} & 0 & dq_M & \frac{d^2 W_M}{dq_M dx} \\ \frac{d^2 W_L}{dq_L dq_H} & \frac{d^2 W_L}{dq_L dq_M} & \frac{d^2 W_L}{dq_L^2} & dq_L & \frac{d^2 W_L}{dq_L dx} \end{array} \right| dx = 0 \quad (\text{B1})$$

where

$$\begin{aligned}
\frac{d^2 W_M}{dq_M \partial q_H} &= -b \left(\frac{b}{2t} - \frac{\rho_M}{t} \frac{\partial \tau_M}{\partial q_H} \right) - \frac{(K'(q_M) - (p_H - \pi - c_M) \frac{b}{2t})}{\bar{y}_M (1 + \psi_M)} \times \\
&\times \left\{ \left[\begin{array}{c} \frac{3b}{2t} \rho_M - \frac{3}{2t} \frac{\partial \tau_M}{\partial q_H} \left(\begin{array}{c} \lambda_M y_R^2 (u_Y (\widehat{Y}_R^M) - u_Y (Y_R^M))^2 \\ + (1 - \lambda_M) y_P^2 (u_Y (\widehat{Y}_P^M) - u_Y (Y_P^M))^2 \end{array} \right) \right] \right\}, \quad (\text{B2}) \\
&\quad - \frac{\partial \tau_M}{\partial q_H} u_{YY}(\cdot) \left[\lambda_M y_R^2 + (1 - \lambda_M) y_P^2 \right]
\end{aligned}$$

$$\begin{aligned}
\frac{d^2 W_L}{dq_L dq_H} &= -b \left(\frac{b}{2t} - \frac{\rho_L}{t} \frac{\partial \tau_L}{\partial q_H} \right) - \frac{(K'(q_L) - (p_H + p_M - 2\pi - 2c_L) \frac{b}{2t})}{\bar{y}_L (1 + \psi_L)} \times \\
&\times \left\{ \begin{array}{c} \frac{3b}{2t} \rho_L - \frac{3}{t} \frac{\partial \tau_L}{\partial q_H} \left(\begin{array}{c} \lambda_L y_R^2 (u_Y (\widehat{Y}_R^L) - u_Y (Y_R^L))^2 \\ + (1 - \lambda_L) y_P^2 (u_Y (\widehat{Y}_P^L) - u_Y (Y_P^L))^2 \end{array} \right) \\ - \frac{\partial \tau_L}{\partial q_H} u_{YY}(\cdot) \left[\lambda_L y_R^2 + (1 - \lambda_L) y_P^2 \right] \end{array} \right\} \quad (\text{B3})
\end{aligned}$$

$$\frac{d^2W_L}{dq_L dq_M} = -b \left(\frac{b}{2t} - \frac{\rho_L}{t} \frac{\partial \tau_L}{\partial q_M} \right) - \frac{(K'(q_L) - (p_H + p_M - 2\pi - 2c_L) \frac{b}{2t})}{\bar{y}_L (1 + \psi_L)} \times$$

$$\times \left\{ \begin{array}{l} \frac{3b}{2t} \rho_L - \frac{3}{t} \frac{\partial \tau_L}{\partial q_M} \left(\begin{array}{l} \lambda_L y_R^2 \left(u_Y \left(\widehat{Y}_R^L \right) - u_Y \left(Y_R^L \right) \right)^2 \\ + (1 - \lambda_L) y_P^2 \left(u_Y \left(\widehat{Y}_P^L \right) - u_Y \left(Y_P^L \right) \right)^2 \end{array} \right) \\ - \frac{\partial \tau_L}{\partial q_M} u_{YY}(\cdot) \left[\lambda_L y_R^2 + (1 - \lambda_L) y_P^2 \right] \end{array} \right\} \quad (\text{B4})$$

The determinant of the above matrix is

$$\Delta = \frac{d^2W_H}{dq_H^2} \frac{d^2W_M}{dq_M^2} \frac{d^2W_L}{dq_L^2} < 0 \quad (\text{B5})$$

High-income region

The effect of x on q_H is given by

$$\frac{dq_H^*}{dx} = - \frac{\frac{d^2W_M}{dq_M^2} \frac{d^2W_L}{dq_L^2} \frac{d^2W_H}{dq_H dx}}{\Delta} = \left(- \frac{d^2W_H}{dq_H^2} \right)^{-1} \frac{d^2W_H}{dq_H dx} \quad (\text{B6})$$

Since quality in the high-income region is independent of other qualities, there is only one direct effect and no indirect effects.

Middle-income region

The effect of x on q_M is given by

$$\begin{aligned} \frac{dq_M^*}{dx} &= - \frac{1}{\Delta} \left[\frac{d^2W_M}{dq_M dx} \frac{d^2W_H}{dq_H^2} \frac{d^2W_L}{dq_L^2} - \frac{d^2W_H}{dq_H dx} \frac{d^2W_L}{dq_L^2} \frac{d^2W_M}{dq_M dq_H} \right] \\ &= \left(- \frac{d^2W_M}{dq_M^2} \right)^{-1} \left[\frac{d^2W_M}{dq_M dx} + \frac{dq_H^*}{dx} \frac{d^2W_M}{dq_M dq_H} \right] \end{aligned} \quad (\text{B7})$$

The first term is the direct effect of x on q_M , while the second term the indirect effect through a quality change in the high-income region.

Low-income region

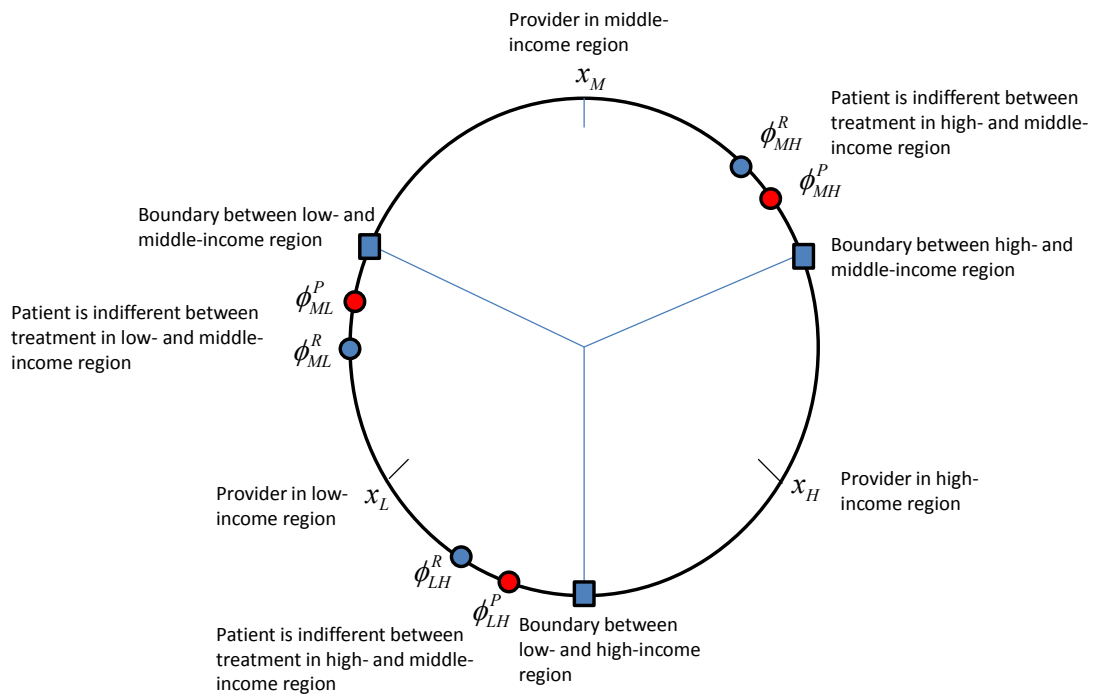
The effect of x on q_L is given by:

$$\begin{aligned} \frac{dq_L^*}{dx} &= -\frac{1}{\Delta} \left[\frac{d^2W_L}{dq_L dx} \left(\frac{d^2W_H}{dq_H^2} \frac{d^2W_M}{dq_M^2} \right) - \frac{d^2W_M}{dq_M dx} \frac{d^2W_H}{dq_H^2} \frac{d^2W_L}{dq_L dq_M} \right. \\ &\quad \left. - \frac{d^2W_H}{dq_H dx} \left(\frac{d^2W_M}{dq_M^2} \frac{d^2W_L}{dq_L dq_H} - \frac{d^2W_M}{dq_M dq_H} \frac{d^2W_L}{dq_L dq_M} \right) \right] \\ &= \left(-\frac{d^2W_L}{dq_L^2} \right)^{-1} \left[\frac{d^2W_L}{dq_L dx} + \frac{dq_M^*}{dx} \frac{d^2W_L}{dq_L dq_M} + \frac{dq_H^*}{dx} \frac{d^2W_L}{dq_L dq_H} \right] \end{aligned} \quad (\text{B8})$$

The full expression for $\frac{d^2W_L}{dq_L d\delta}$ in section 5.1 is given by

$$\begin{aligned} \frac{d^2W_L}{dq_L d\delta} &= b(\phi_{LH}^P - \phi_{LH}^R + \phi_{MH}^P - \phi_{MH}^R) - \frac{b}{t} \rho_L \frac{\partial \tau_L}{\partial \delta} \\ &\quad + \frac{(K'(q_L) - (p_H + p_M - 2c_L) \frac{b}{2t})}{(1 + \psi_L)} \frac{y_P y_R}{\bar{y}_L^2} \left(\begin{array}{c} u_Y(Y_R^H) - u_Y(Y_P^H) \\ + (\phi_{LH}^R + \phi_{LM}^R) (u_Y(\hat{Y}_R^L) - u_Y(Y_R^L)) \\ - (\phi_{LH}^P + \phi_{LM}^P) (u_Y(\hat{Y}_P^L) - u_Y(Y_P^L)) \end{array} \right) \\ &\quad + \frac{(K'(q_L) - (p_H + p_M - 2c_L) \frac{b}{2t})}{(1 + \psi_L) \bar{y}_L} \frac{\partial \tau_L}{\partial \delta} \left[\begin{array}{c} \left(\frac{3}{t} \lambda_L y_R^2 (u_Y(\hat{Y}_R^L) - u_Y(Y_R^L))^2 \right. \\ \left. + \frac{3}{t} (1 - \lambda_L) y_P^2 (u_Y(\hat{Y}_P^L) - u_Y(Y_P^L))^2 \right) \\ \left. - u_{YY}(\cdot) [\lambda_L y_R^2 + (1 - \lambda_L) y_P^2] \right] \\ &\quad + \frac{(K'(q_L) - (p_H + p_M - 2\pi - 2c_L) \frac{b}{2t})}{(1 + \psi_L)^2 \bar{y}_L^2} \times \\ &\quad \times \left[\begin{array}{c} \bar{u}_{\tau_L} + 3\lambda_L (\phi_{LH}^R + \phi_{LM}^R) y_R (u_Y(\hat{Y}_R^L) - u_Y(Y_R^L)) \\ + 3(1 - \lambda_L) (\phi_{LH}^P + \phi_{LM}^P) y_P (u_Y(\hat{Y}_P^L) - u_Y(Y_P^L)) \end{array} \right] \\ &\quad \times \left[\begin{array}{c} \left(\begin{array}{c} y_P (u_Y(\hat{Y}_P^L) - u_Y(Y_P^L)) \\ - y_R (u_Y(\hat{Y}_R^L) - u_Y(Y_R^L)) \end{array} \right) \frac{(p_H + p_M - 2\pi - 2c_L) \bar{y}_L}{2t} \end{array} \right]. \end{aligned} \quad (\text{B9})$$

Figure 1. Patients' mobility (rich and poor patients)



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