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PEER GROUP, DISTANCE AND TUITION FEES: WHEN WIDENING UNIVERSITY PARTICIPATION IS STILL BETTER

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Peer Group, Distance and tuition fees: when widening university participation is still better

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Abstract

We study the effects of introducing a new university in a two-city model where individuals with heterogeneous innate ability choose whether to attend university. When attending university, they benefit from a peer group effect given by the average ability they share with the university. However, attendance implies the payment of a tuition fee and, for commuting individuals, mobility costs. We consider a two-city setting, and we compare a scenario with only one university with another one with one university for each city. We show that in the two-university system, there exists a symmetric Nash Equilibrium for every mobility cost and (at least) two asymmetric Nash Equilibria only for sufficiently low mobility costs. In the latter scenario, we are able to characterise the existence of two equilibria for extremely high and extremely low tuition fees. In the former, both universities exhibit the same average ability that is in turn lower than the one arising in a monopolistic system. In the asymmetric scenario, the "top" ("bottom") university instead has a higher (lower) peer group than the monopolistic one, regardless of the tuition fees. We further show that the introduction of a new university is always welfare improving.

Keywords: Peer Group, Mobility Cost, Tuition Fees *JEL codes*: I2, L3

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1 Introduction

The welfare effect of a change in the number of universities has been widely investigated both theoretically and empirically. There exists strong empirical evidence of the necessity of widening higher education participation by means of an increasing number of universities.[1] Mobility costs and the peer group effect at university (as measured by the average ability of the students) have been found to be the main determinants of the individuals' sorting behavior as well as the welfare effect a change in the number of universities may induce.[2] The extant literature has widely shown how when mobility costs are sufficiently high an asymmetric university system may arise where a top (high average ability) and a bottom (low average ability) university coexist, with the top one attracting the ablest students. Recently Cesi and Paolini (2014) showed that the introduction of a new university induces a welfare improvement that is stronger when the university system is symmetric (that is, universities have the same average student ability). Borrowing their definition of student average ability as a proxy for the peer group effect, our model extends their results to the introduction of a tuition fee that is identical across universities. We show that a two-university system that is both symmetric and asymmetric ensures a higher welfare than a monopolistic university under both high and low tuition fees. In particular, the stronger welfare improvement is obtained when the introduction of the second university leads to a symmetric system (identical peer group effects).

We borrow the two-city/two-university model in Cesi and Paolini (2014), where a two-university system (one in each city) is compared to a monopolist scenario in which the university is located only in one city. Unlike their paper, we allow universities to charge a tuition fee, equal across universities and across students.

Like the no-fees system proposed in Cesi and Paolini (2014), we show that both symmetric and asymmetric university systems might arise even under extreme levels of tuition fees. This result suggests that an extremely high tuition fee may have the same effect as "free" enrolment in terms of a more equal university system. As in Cesi and Paolini (2014), we find that introducing a new university is always welfare improving. This result holds in the symmetric equilibrium for sufficiently low levels of tuition fees, for given transportation costs. In the asymmetric scenario, it is confirmed under both a negligible fee and a tuition fee such that the average ability (peer group effect) in the top university is the maximal one.

This result suggests that when the tuition fee is sufficiently high, the university system is characterized by the highest level of asymmetry and at the same time the higher welfare is obtained in a symmetric two-university system. We therefore replicate an *élite* system (usually obtained in the literature via competition among universities) even under a tuition scheme in which fees are identical across universities. More interestingly the welfare improvement does not depend on the tuition fees because the occurrence of a symmetric university system (inducing the strongest welfare improvement) is obtained for any level of tuition fees.

Our paper aims to contribute to the literature on students' sorting behavior at university (Del Rey 2001, De Fraja and Iossa 2002, Del Rey and Wauthy 2006, Gautier and Wauthy 2007, Poyago-Theotoky and Tampieri 2014). In particular we study the role of peer group

[1] See Cesi and Paolini (2014) for a recent survey.

[2] See, among others, Frenette (2004) for the role of mobility costs and Sacerdote (2001) for the peer group effects.

effect by integrating the model in Cesi and Paolini (2014). Unlike Gautier and Wauthy (2007), whose main focus is the study of the " tension between teaching and research" our focus is on the impact of the fees scheme and peer group on students' choice.

The remainder of this paper is divided as follows. After having presented the main ingredients of the model in Section 2, we provide equilibrium analysis for a one-university (section 3) and a two-university system (section 4). We follow up by providing some welfare analysis in section 5, and finally, we draw the conclusions (section 6).

2 The model

We follow Cesi and Paolini (2014) and consider a spatial model of two cities indexed $j = A, B$, in which each city may host one university that "produces" graduates. In each city, individuals are uniformly and independently distributed according to their innate ability $\theta \in [0, 1]$, with the total population in each city normalised to 1. Universities charge a tuition fee f, assumed to be the same in both universities.[3] The utility of each individual i attending university j is:[4]

$$U_i^j = \theta_i(1 + \bar{\theta}_j) - f \tag{1}$$

where $\bar{\theta}_j$ measures the average ability at the university j that henceforth will also be called the peer group effect. The distance between universities (cities) is normalized to 1. A student located in j has no mobility cost of attending university j, but he faces a liner cost t if attending $-j \neq j$.

When instead individual i does not attend university, he is defined as unskilled, u, and his utility is:

$$U_{i,u} = \theta_i \tag{2}$$

3 Monopolistic University

In the monopolistic scenario, we only have one university located in the city A. In this scenario, each student can only choose between going to the monopolistic university and being unskilled. The monopolistic university (denoted by A) is attended by the individuals living in both cities who pay the fee f and possibly face the mobility cost t enjoining an improvement of the ability rather than remain unskilled. The only cost for students living in A is represented by the fee, whereas students living in B face both the fee and mobility costs to commute to the other city.

[3]This assumption is in line with most university systems in continental Europe. Jongbloed (2004) and Jongbloed (2005) report how tuition fees charged by public universities are fixed or negligibly different in countries like Austria, Belgium, Denmark, Germany, Italy and Spain.

[4]The model does not change if we introduce a family income that is heterogenous among individuals. Because the tuition f is fixed and equal in both the universities income does not enter the individuals' sorting behavior. It is possible then to show that the model is robust to the introduction of an individual-specific income.

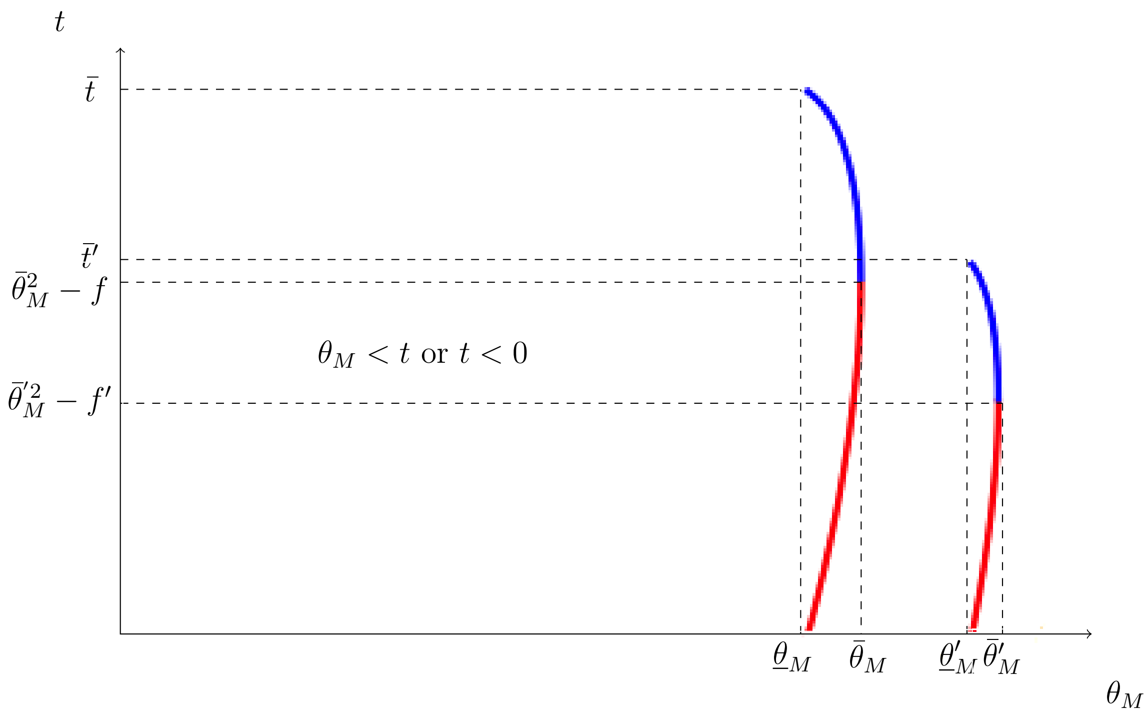

Figure 1: Monopolistic University: Mobility Cost and Average Ability for given f with $f' > f$.

Once mobility costs have been faced and fees are paid, individuals can move freely between cities, so that the peer group is endogenous. Let us define the average ability at the monopolistic university, θ_M, in the following Lemma:

Lemma 1. *Let* $\bar{t} = \frac{\sqrt{2f^2+\sqrt{4f+1}(1-2f)+1}}{4\sqrt{2}} + \frac{\sqrt{4f+1}+1-2f}{8}$, θ_M *is a concave function in the mobility cost for every mobility cost* $t \in [0, \bar{t}]$, *increasing for low mobility costs and decreasing for high mobility costs.* $\bar{t}$ *depends negatively on* f *and takes value* $1/2$ *when* $f = 0$.

An individual living in A has to choose between remaining unskilled and attending the university. This choice depends on the peer group effect and the fee. The sorting behavior is similar to Cesi and Paolini (2014), and only for students with high ability to pay the fee is it worth it.

A similar mechanism holds for individuals living in B, who decide according to the fee, the peer group and mobility costs. When mobility costs and/or tuition fees are too high compared to the peer group effect, none from B finds it profitable to switch to A. On the other hand, for a reasonable level of these costs, this sorting behavior works, and the peer group becomes endogenous. For a given fee, a rise in the mobility cost (or in the tuition fee at a given mobility cost) increases the lowest ability such that individuals from B find it beneficial to attend University A. For a moderate rise in the mobility costs, only less able individuals find it too costly to move to A. When, instead, the rise in the mobility cost is sufficiently strong, the same effect also occurs for the high ability individuals, and the average ability at the monopolistic university starts to decrease. The trend of the monopolistic peer group effect in Cesi and Paolini (2014) is then preserved.

An increase in the tuition fees makes the sorting behavior less likely to occur, as the lowest ability such that a student attends university, θ_M, turns out to be higher and the maximal $\bar{t}$ lower. Graphically, the curve in Figure 1 shifts towards the right and it shrinks as long as we move from f to a higher f'. Clearly, this depends on the fact that higher fees make it more costly and, in turn, less appealing to attend the university for both individuals in A and in B. Only the most able individuals find it optimal to attend the university, thus increasing the average ability of students coming from both cities. For a more rigorous and analytical analysis of this trend see the Appendix.

4 Two-University System

As in Cesi and Paolini (2014), we assume a costless introduction of a new university in city B (University B henceforth). In this scenario individuals sort across universities according to the mobility costs and the peer groups, here denoted by θ_A^d and θ_B^d. For a given ability, the mobility cost and the tuition fee represent the "effective" costs of attending university. Only the individuals whose costs are offset by the average ability (peer-group) of other students will attend university and possibly commute to another city. In a two-university system, individuals in each city can be potentially sorted into three groups. Individuals that do not attend university are characterised by a relatively low ability, so that the extra benefit they receive by attending university does not cover the tuition fee. Individuals exhibiting a medium ability will attend the university of their own city and, if the universities are asymmetric, some high-ability individuals will decide to commute to the university where the average ability is higher.

An individual living in A with ability θ chooses university B only if $\theta_B^d > \theta_A^d$ and if:

$$U^A\left(\theta_A^d, y\right) \leq U^B\left(\theta_B^d\right) - t \tag{3}$$

that gives:

$$\theta \geq \frac{t}{\theta_B^d - \theta_A^d} \tag{4}$$

A person born in A chooses university A if his ability is:

$$\theta \geq \frac{f}{\theta_A^d} \tag{5}$$

An individual living in B with ability θ chooses university A only if $\theta_A^d > \theta_B^d$ and if:

$$U^A\left(\theta_A^d\right) - t \leq U^B\left(\theta_B^d\right) \tag{6}$$

that gives:

$$\theta \geq \frac{t}{\theta_A^d - \theta_B^d} \tag{7}$$

University B is chosen instead if:

$$\theta \geq \frac{f}{\theta_B^d} \tag{8}$$

This allows us to to define the expected peer groups in the two universities as follows:

$$\theta_A^d = \frac{\int_{\frac{f}{\theta_A^d}}^{\frac{t}{\theta_B^d - \theta_A^d}} \theta d\theta + \int_{\frac{t}{\theta_A^d - \theta_B^d}}^{1} \theta d\theta}{\int_{\frac{f}{\theta_A^d}}^{\frac{t}{\theta_B^d - \theta_A^d}} d\theta + \int_{\frac{t}{\theta_A^d - \theta_B^d}}^{1} d\theta} \tag{9}$$

and

$$\theta_B^d = \frac{\int_{\frac{f}{\theta_B^d}}^{\frac{t}{\theta_A^d - \theta_B^d}} \theta d\theta + \int_{\frac{t}{\theta_B^d - \theta_A^d}}^{1} \theta d\theta}{\int_{\frac{f}{\theta_B^d}}^{\frac{t}{\theta_A^d - \theta_B^d}} d\theta + \int_{\frac{t}{\theta_B^d - \theta_A^d}}^{1} d\theta} \tag{10}$$

To find the equilibrium values of θ_A^d and θ_B^d from (9) and (10), as in Cesi and Paolini (2014) we need some further specifications on the integrals. The first and the second term of the numerators identify, respectively, the ability of the students living in that city and those coming from the other. The denominators simply give their mass. The thresholds depend on which university has the higher peer group and on the fees.

Assume an asymmetric equilibrium with $\theta_A^d > \theta_B^d$ and consider a marginal increase of the tuition fee in both universities. We will observe two effects. A positive direct effect on the access to the university. The minimal ability required to be willing to attend gets higher in both universities, inducing θ_A^d and θ_B^d to increase. Formally, $\frac{f}{\theta_A^d}$ and $\frac{f}{\theta_B^d}$ in the integrals shift upwards.On the other hand, an indirect effect concerning the switching is present. In particular, we have two cases:

1. If the increase in the average ability is very strong in university A relative to university B, some of the best students in B move to university A. This force pushes downwards both average abilities, mitigating the direct effect discussed above. In particular, in university A less able people enter the pool of students and then university B loses some high-ability individuals.

2. On the contrary, if the increase in ability is stronger in university B, the less able individuals from university A move to university B. This force pushes upwards both average abilities, emphasising the direct effect in point 1. In university A, less able people are exiting the pool while university B enrols more high-ability individuals.

To avoid empty universities (i.e., nobody is willing to enroll given the fee f), we assume an upward threshold for the tuition fee defined as $f_{max} \equiv \frac{t\theta_B^d}{\theta_A^d - \theta_B^d}$, which gives the highest possible value such that the low ability university survives. In particular, for any tuition fee $f \leq f_{max}$, at least one individual attends the university with the lower average ability.

We now can proceed to formalize the effect on the peer group effects for low and high values of the tuition fee.

Proposition 2. *There exist two type of equilibria:*

1. *For any t, there exist a symmetric equilibrium with $\tilde{\theta}_A^d = \tilde{\theta}_B^d = \tilde{\theta} = \frac{\sqrt{4f+1}+1}{4}$.*

2. *Asymmetric equilibria may arise when $t < 3 - 2\sqrt{2}$.*

   (a) *When $f = 0$:*
   (i) $\underline{\theta}_j^{d*} = \frac{1+t}{2}$ $\underline{\theta}_i^{d*} = \frac{1+t}{4} - \sqrt{t^2 - 6t + 1}$
   (ii) $\underline{\theta}_j^{d*} = \frac{1+t}{2}$ $\underline{\theta}_i^{d**} = \frac{1+t}{4} + \sqrt{t^2 - 6t + 1}$, with $j, i \in \{A, B\}$ and $i \neq j$.

   (b) *When $f = f_{max}$:*
   (i) $\bar{\theta}_j^{d*} = 1$ and $\bar{\theta}_i^{d*} = \frac{1}{2}\left(1 - \sqrt{1-4t}\right)$
   (ii) $\bar{\theta}_j^{d*} = 1$ and $\bar{\theta}_i^{d**} = \frac{1}{2}\left(1 + \sqrt{1-4t}\right)$, with $j, i \in \{A, B\}$ and $i \neq j$.

A complete proof of the characterisation of all equilibria is relegated to the appendix. Proposition 2 shows that even when the tuition fee is sufficiently high, both symmetric and asymmetric university systems arise as in the case of no tuition fee. We obtain then the same qualitative result in Cesi and Paolini (2014) but with an extremely high tuition fee. This result suggests that an extremely high tuition fee may have the same effect of a free-of-charge enrolment in terms of the "equality" of the university system.

5 Welfare Analysis

The welfare analysis follows Cesi and Paolini (2014).[5] We follow their definition of welfare as the unweighted sum of the individual utilities, net of the mobility cost, and make a comparison over the several peer group effects.

To avoid situations in which a university is empty (i.e., nobody is willing to enroll given the fee f), we assume that the fee cannot be too high. A sufficient condition to rule out this case is that $f \leq \frac{t\theta_B^d}{\theta_A^d - \theta_B^d} \equiv f_{max}$, which represents the highest possible value the fee can take for the low ability university to survive. Just above this value, no student will enroll in university B, as all agents who have ability sufficient to cover the fee are going to commute to A.

Denoting j as the high-peer group and $i \neq j$ as the low-peer group university in an asymmetric equilibrium, the following Lemma applies:

Lemma 3. *i) If $f = f_{max}$, then: $\bar{\theta}_j^{d*} = \theta_M(f_{max}) > \bar{\theta}_i^{d**} > \bar{\theta}_i^{d*} > \tilde{\theta}(f_{max})$; ii) if $f = 0$, then $\underline{\theta}_j^{d*} > \theta_M(0) > \tilde{\theta}(0) > \underline{\theta}_i^{d**} > \underline{\theta}_i^{d*}$,*

Proof. For $f = 0$, the proof follows exactly Cesi and Paolini (2014). When $\bar{\theta}_A^{d*}$ and $\bar{\theta}_B^{d**}$ are the equilibrium abilities of the asymmetric equilibrium, we have $f_{max}^{**} = \frac{1}{2}\left(1 - 2t + \sqrt{1-4t}\right)$. Plugging f_{max}^{**} into the equilibrium average abilities, we get:

$$\bar{\theta}_A^{d*} = \theta_M = 1, \quad \bar{\theta}_B^{d**} = \frac{1}{2}\left(1 + \sqrt{1-4t}\right) \text{ and } \tilde{\theta} = \frac{1}{4}\left(\sqrt{3 - 4t + 2\sqrt{1-4t}} + 1\right).$$

[5] See Cesi and Paolini (2014) for the definition of the welfare.

When $\bar{\theta}_A^{d*}$ and $\bar{\theta}_B^{d*}$ are the equilibrium abilities of the asymmetric equilibrium, $f_{max}^* = \frac{1}{2}\left(1 - 2t - \sqrt{1-4t}\right)$. Plugging f_{max}^* into the equilibrium average abilities, we get:

$$\bar{\theta}_A^{d*} = \theta_M = 1, \quad \bar{\theta}_B^{d*} = \frac{1}{2}\left(1 - \sqrt{1-4t}\right) \text{ and } \tilde{\theta} = \frac{1}{4}\left(\sqrt{3 - 4t - 2\sqrt{1-4t}} + 1\right).$$

By straightforward comparisons of the values above, the lemma is proved. ■

We provide the welfare for the two extreme values of the fees $f \equiv \{0, f_{max}\}$, knowing that in general tuition fees tend to increase average abilities both in the monopolistic and in the duopolistic case. The results in Lemma 3 enable us to state the welfare analysis in the following proposition:

Proposition 4. *i) If $f = 0$, then $W_S > W_a > W_M$ for all $t \in (0, 3-2\sqrt{2}]$ and $W_S > W_M$ for all $t \in (3-2\sqrt{2}, 1/2]$; ii) if $f = f_{max}$, then $W_S > W_a = W_M$ for all $t \in (0, 3-2\sqrt{2}]$ and $W_S > W_M$ for all $t \in (3-2\sqrt{2}, 1/2]$.*

Proof. For $f = 0$, the proof is in Cesi and Paolini (2014).

Assume $f = f_{max}^{**}$ or $f = f_{max}^*$. In both cases, the asymmetric equilibrium in the two-university system and the monopolistic university coincide. In particular we will have $\bar{\theta}_j^{d*} = \theta_M = 1$, i.e., nobody attends the low-peer group university in the asymmetric case and an infinitesimally small mass of agents attends the high-peer group university (or the unique university). This extreme scenario is clearly dominated from a welfare point of view by the case of a symmetric system where (i) more individuals attend the university (the ones with ability at least $\frac{f_{max}}{\tilde{\theta}}$) and (ii) the ablest agents do not bear the mobility cost.

■

We find that when individuals' sorting behavior depends on mobility costs, peer group effects and the tuition fee, introducing a new university is always welfare improving. This has already been shown in Cesi and Paolini (2014) in a model without tuition fees. Although the results shown in Lemma 3 and Proposition 5 hold only for the two extreme values of the tuition fee, they are still very meaningful. We may in fact consider by continuity a fee either so small to be negligible ($f \to 0$) or the maximal one compatible with the low-peer group university surviving in the asymmetric equilibrium ($f \to f_{max}$). In both cases, the welfare improves when moving from a monopolistic to a two-university system, and it is maximal when the latter is symmetric. In particular, in this paper, we extend the result in Cesi and Paolini (2014) to two levels (high and low) of tuition fees. Another direct policy implication is that even a public university system in which the tuition fees are regulated to be identical across universities may replicate an *élite* university system with an extremely asymmetric university system with only sufficiently able individuals attending university. As shown in Cesi and Paolini (2014), an asymmetric university system can then be achieved even without opening the system to competition. However, the welfare improvement does not depend on the tuition fees because the arising of a symmetric university system (inducing the stronger welfare improvement) is obtained for any level of the tuition fees.

6 Conclusion

This paper contributes to the literature on the effect of peer group ability on the university choice when universities charge a uniform tuition fee. We introduce such a tuition system in Cesi and Paolini (2014) and confirm that the introduction of a new university, when tuition fees are sufficiently high, leads to both symmetric and asymmetric university systems, which is the same result obtained in Cesi and Paolini (2014) with no tuition fees. Moreover, as in Cesi and Paolini (2014), we find that the introduction of a new university is always welfare improving. This result holds under both a negligible fee (similar to the no tuition case in Cesi and Paolini (2014) and the maximal tuition fee that can be charged in a asymmetric equilibrium where the bottom university survives. Although, as in the previous literature, we replicate an *élite* asymmetric university system, the welfare improvement does not depend on the tuition fees because the arising of a symmetric university system (inducing the stronger welfare improvement) is obtained for any level of the tuition fee. Further research could find it profitable to check the robustness of these results to a tuition fees system depending on individual income, where agents are clearly heterogenous in that dimension.

7 Appendix

Proof of Lemma 1

Proof. Here we show that θ_M is a concave function in t for every $t \in [0, \bar{t}]$. See the Figure 1. Consider an agent with ability θ living in city A. If the average ability in university A is θ_M, this agent attends the university if his ability offsets the payment of the fee, i.e.:

$$\theta \geq \frac{f}{\theta_M} \tag{11}$$

We thus have that the ability of individuals from city A who attend university will be given by:

$$\theta_A^m = \frac{\int_{\frac{f}{\theta_M}}^1 \theta d\theta}{\int_{\frac{f}{\theta_M}}^1 d\theta} = \frac{f + \theta_M}{2\theta_M} \tag{12}$$

Following the same argument, a student living in city B has ability such that:

$$\theta \geq \frac{t + f}{\theta_M} \tag{13}$$

In expected terms we thus have that the ability of individuals born in city B who enroll at university will be given by:

$$\theta_B^m = \frac{\int_{\frac{f+t}{\theta_M}}^1 \theta d\theta}{\int_{\frac{f+t}{\theta_M}}^1 d\theta} = \frac{f + \theta_M}{2\theta_M} \tag{14}$$

By computing the weighted average of θ_A^m and θ_B^m as determined in (12) and (14), θ_M solves the following:

$$\theta_M = \frac{2f^2 + 2ft - 2\theta_M^2 + t^2}{4f\theta_M - 4\theta_M^2 + 2\theta_M t} \tag{15}$$

The solutions with respect to t are $t_1 = \theta_M^2 - f - \sqrt{\Delta}$ and $t_2 = \theta_M^2 - f + \sqrt{\Delta}$ where $\Delta = 2f\theta_M^2 + \theta_M^4 - \theta_M f^2 - 4\theta_M^3 + 2\theta_M^2$.

Observe Figure 1 where θ_M is on the horizontal axis and the blue (red) curve denotes $t_2(t_1)$. We define $\bar{\theta}_M = \frac{\sqrt{2\sqrt{2}f - 2f - 2\sqrt{2} + 3}}{\sqrt{2}} - \frac{1}{\sqrt{2}} + 1$ as the average ability such that $\Delta = 0$. In this case, $t_1 = t_2 = \bar{\theta}_M^2 - f$. This is the point in which the blue curve and red curve meet in Figure 1. $\bar{\theta}_M$ takes value 0.5858 when f=0 and 1 when f=1. Above this level of ability, the solution is a complex number.

$\underline{\theta}_M = \frac{1}{4}\left(\sqrt{8f+1} + 1\right)$ is the level of ability such that t_1 is 0 (below this value it turns out to be negative). When $\theta_M < \underline{\theta}_M$, t can be greater than θ_M or negative. Both situations are ruled out by assumption. In particular, if $t > \theta_M$, it is not worth it for any individual to face the transportation cost and commute from B to A. Accordingly, the average ability in A would be only given by the average ability of people living there. Notice that $\underline{\theta}_M$ takes value 1/2 if no fee is charged, whereas it becomes maximal and equal to 1 if the fee is equal to 1. $\bar{t}$ if found plugging $\underline{\theta}_M$ into t_2 and is given by:

$$\bar{t} = \frac{1}{8}\left(\sqrt{2}\sqrt{8f^2 - 4\sqrt{8f+1}f + \sqrt{8f+1} + 1} - 4f + \sqrt{8f+1} + 1\right) \tag{16}$$

■

Proof of Proposition 2

***(i)* Symmetric Scenario.** Assume that $\theta_A^d = \theta_B^d = \tilde{\theta}$. The symmetric equilibrium is straightforward by construction because when both average abilities and fees equalise, all individuals remain in their city, i.e.,

$$\tilde{\theta} = \frac{\int_{\frac{f}{\tilde{\theta}}}^1 \theta d\theta}{\int_{\frac{f}{\tilde{\theta}}}^1 d\theta} = \frac{\sqrt{4f+1}+1}{4} < 1 \tag{17}$$

***(ii)* Asymmetric Scenario.** Assume that $\theta_A^d > \theta_B^d$. In this case, all agents living in A choose university A, whereas individuals in B choose to move to university A if their ability is such that the condition in (7) is satisfied. Moreover, since no individuals in A switch to B, we set $\frac{t}{\theta_B^d - \theta_A^d} = 1$ in (9) and (10).

$$\theta_A^d = \frac{\int_{\frac{f}{\theta_A^d}}^1 \theta d\theta + \int_{\frac{t}{\theta_A^d - \theta_B^d}}^1 \theta d\theta}{\int_{\frac{f}{\theta_A^d}}^1 d\theta + \int_{\frac{t}{\theta_A^d - \theta_B^d}}^1 d\theta} \tag{18}$$

$$\theta_B^d = \frac{\int_{\frac{f}{\theta_B^d}}^{\frac{t}{\theta_A^d - \theta_B^d}} \theta d\theta}{\int_{\frac{f}{\theta_B^d}}^{\frac{t}{\theta_A^d - \theta_B^d}} d\theta} \tag{19}$$

We are not able to find explicit solutions to the system of the two equations above, but we can give qualitative results by setting a specific value for the fee. In particular, we study the two extreme cases in point 2.(a) and 2.(c) of the proposition. In the first, the fee is assumed to be negligible and in the second one maximal (i.e., f_{max}).

2.(a) If $f = 0$, equations (18) and (19) reduce to:

$$\theta_A^d = \frac{\int_0^1 \theta d\theta + \int_{\frac{t}{\theta_A^d - \theta_B^d}}^1 \theta d\theta}{\int_0^1 d\theta + \int_{\frac{t}{\theta_A^d - \theta_B^d}}^1 d\theta} \tag{20}$$

$$\theta_B^d = \frac{\int_0^{\frac{t}{\theta_A^d - \theta_B^d}} \theta d\theta}{\int_0^{\frac{t}{\theta_A^d - \theta_B^d}} d\theta} \tag{21}$$

and the solution of the system gives two possible equilibria:

(i) $\underline{\theta}_A^d = \frac{1+t}{2}$ and $\underline{\theta}_B^d = \frac{1+t}{4} - \sqrt{t^2 - 6t + 1}$

(ii) $\underline{\theta}_A^d = \frac{1+t}{2}$ and $\underline{\theta}_B^{d'} = \frac{1+t}{4} + \sqrt{t^2 - 6t + 1}$ with $t^2 - 6t + 1 > 0$ for $t < 3 - 2\sqrt{2}$. Inverting the subscripts A and B will give the other two equilibria discussed in the proposition.

2.(b) If $f = f_{max}$, equations (18) and (19) reduce to:

$$\theta_B^d = \frac{t}{\theta_A^d - \theta_B^d} \tag{22}$$

and

$$\theta_A^d = -\frac{2\left(\theta_A^d\right)^2 (\theta_A^d - \theta_B^d)^2 - t^2\left(\left(\theta_A^d\right)^2 + \left(\theta_B^d\right)^2\right)}{2\theta_A^d(\theta_A^d - \theta_B^d)(2\theta_A^d(\theta_B^d - \theta_A^d) + t(\theta_A^d + \theta_B^d))} \tag{23}$$

The solution of the system between equations (22) and (23) will give always a $\theta_A^d > 1$; therefore, we obtain the corner solution $\bar{\theta}_A^{d*} = 1$. Plugging $\theta_A^d = 1$ into (22), we get (i) $\bar{\theta}_B^{d*} = \frac{1}{2}\left(1 - \sqrt{1-4t}\right)$ and (ii) $\bar{\theta}_B^{d**} = \frac{1}{2}\left(1 + \sqrt{1-4t}\right)$.

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