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Keywords: Peer Effects, Tracking, Mixing, College attendance gap.

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Tracking can be more Equitable than Mixing: Peer effects and college attendance *

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Abstract

Parents and policy makers often wonder whether, and how, the choice between a tracked or a mixed educational system affects the efficiency and equity of national educational outcomes. This paper analyzes this question taking into account their impact on educational results at later stages and two main results are found. First, it shows that tracking can be the efficient system in societies where the opportunity cost of college attendance is high or the pre-school achievement distribution is very dispersed. Second, this paper shows that although conventional wisdom suggests that equality of opportunities is best guaranteed under mixing, this is not necessarily the case. In fact, tracking is the most equitable system for students with intermediate levels of human capital required to attend college.

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1 Introduction

Parents and policy makers often wonder whether, and how, the choice between a tracked or a mixed educational system affects the efficiency and equity of national educational outcomes. Under tracking, schools are hierarchically organized to accommodate a range of student performance levels, and students are placed in the school that best suits their ability level. By contrast, mixing works by grouping students of differing ability levels within the same school. When comparing these systems, it is critically important to recognize the existence of peer interactions and account for their impact on students' outcomes.

This paper analyzes the efficiency and equity of tracking versus mixing, within a theoretical framework, paying special attention to the impact of compulsory school peer effects on college attendance. I define an equitable system as one that gives students equal access to a college education, regardless of their family background. I define an efficient system as one in which the total human capital of the entire cohort is maximized by the end of the educational period (that is, upon college graduation).

To address these issues, a model is introduced with two educational stages: compulsory and college education. Students differ in parental background as well as pre-school achievement levels. Some positive dependence between these two defining variables is assumed, as wealthy parents have more resources to invest in their children, and also tend to be more educated and care more about education, factors that enhance their children's performance at school. The acquisition of human capital at compulsory level depends on both students' pre-school achievement and peer group characteristics. The latter also indirectly affects students' human capital accumulation in college. I also develop a computational model to illustrate the results.[1]

Two main findings result from my analysis. First, I find that maximizing human capital at one level (compulsory) does not immediately imply that human capital is maximized at the end of the whole educational process. The impact of the educa-

[1] While the influence of peer ability on individual educational achievement has been well documented (see Hoxby and Weingarth (2006), Ammermueller and Piscke (2006), Kim et al. (2006) and Ding and Lehrer (2007)), scholars are still debating key aspects of this relationship. The evidence for the existence of non-linearities in peer effects is particularly compelling. Ding and Lehrer (2007) and Kim et al. (2006) among others, suggest that peer effects and individual pre-school achievement are close complements. Thus, whereas in the theoretical model no assumption is imposed in this regard, in the computational model an specification of the human capital production function that captures this empirical evidence will be used.

tional system prevailing at compulsory level on college attendance rates, together with the properties of the human capital production at college must also be considered. Second, and more strikingly, I show that tracking may sometimes be more equitable than mixing.

If the government seeks to achieve efficiency, its best option will depend on the properties of the human capital production both at compulsory and college level, on the opportunity cost of college attendance and on the wealth level in the population. For example, assume that human capital production at college level is such that there are no congestion effects. Provided that tracking maximizes average human capital at compulsory level (because peer effects and individual achievement are close complements), it will also maximize average human capital across the population if the opportunity cost of college attendance is sufficiently high or the wealth level in the population is sufficiently low.[2] Observe that, in this case, most students with low levels of pre-school achievement are excluded from college under both systems. Therefore, intervention should be focused on those students with high pre-school achievement levels. Choosing tracking over mixing is one way for governments to intervene in favour of these students and maximize college attendance which, in turn, would maximize average human capital across the population.

I also find tracking to be the most equitable system in contexts where the opportunity cost of college attendance is neither too low nor too high. In this case, the set of individuals at the margin are those with intermediate levels of pre-school achievement who, under tracking, could join the high track where the peer effect is the strongest. Thus, family background does not critically determine the amount of human capital they can accrue after compulsory education. By contrast, family background matters more under mixing, since peer effects are weaker under this system for this group of students. The conclusion is that in this case tracking outperforms mixing when it comes to equalizing college attendance opportunities of students.

There are several theoretical papers related to this. Roemer and Wets (1994) and Streufert (2000), for example, focus on other kind of neighborhood effects as important explanatory factors behind individual schooling choices.[3] In Roemer and

[2]If peer effects matter more for high ability students than for low ability ones, then average human capital at compulsory level will be maximized under tracking since it is the system where high ability students enjoy a stronger peer effect.

[3]Role model effects are a good example here. According to this model, characteristics of older group members may influence the behaviour of other individual members of that group. See Durlauf (2004) for an in-depth analysis of these types of models.

Wets' model, individuals form rational beliefs about the return to education when they make schooling decisions. Students estimate the returns to education as the best linear regression of the income against education of the parents in their neighborhood. They find that incorrect beliefs (since the true returns are not linear) tend to cause widespread dispersion of the stationary distribution of talent at any income level. Streufert (2000) proposes a model in which students make inaccurate estimates of the marginal product of effort at school, after observing a biased sample population of adults. Their isolation depresses the level of schooling chosen by underclass youth. Brunello and Giannini (2004) study the efficiency of secondary school design by focusing on the degree of differentiation between vocational and general education. They show that neither a comprehensive nor a stratified system unambiguously outperforms the other in terms of efficiency. Finally, Hidalgo-Hidalgo (2008) compares the academic performance of compulsory school students under tracking and mixing.

This paper complements the existing literature by incorporating an optimal second stage of education (college), with educational achievement in the compulsory stage being an input to the second-stage education. This effect that has been neglected in the literature although some empirical studies have shown that the quality of students' peers at school can influence their college attendance and performance rates (see Betts and Morell (1999) and Hahn et al. (2008)).[4] Hence, the effects of tracking versus mixing on college choice and ultimate educational achievement are considered in the paper. Finally, this paper complements the theoretical literature on tracking by explicitly discussing the notion of equality of opportunities.

The rest of the paper is organized as follows. Section 2 describes the model and discusses the main features of human capital distribution under the two education systems at compulsory level. Section 3 compares the two systems under efficiency and equity and comments on the potential for a trade-off between efficiency and equity. Section 4 concludes.

[4] See Schofield (1995) for a discussion of the possible determinants of the impact of tracking on college attendance from a sociological point of view.

2 Model

2.1 Individuals

I consider an economy in which individuals live for two periods. Individuals in each generation differ in two aspects: their family background and their pre-school achievement, θ_0 where $\theta_0 \in [0,1]$. To make the model tractable, I assume that family background takes only two values, that is, individuals can have either poor or rich parents with probabilities $1-\lambda$ and λ, respectively.[5] Population size is 1. I denote by $G_b(\theta_0)$ the C.D.F. (cumulative distribution function) of θ_0 conditional on having family background b, where $b = p, r$ for poor and rich parents respectively. To capture the possibility that some level of positive dependence exists between parental background and pre-school achievement, the C.D.F. of θ_0 for rich parents is assumed to dominate the one for poor ones.[6] Finally, the aggregate C.D.F. of pre-school achievement, denoted by $G(\theta_0)$, can be expressed as:

$$G(\theta_0) = \begin{cases} (1-\lambda)G_p(\theta_0) + \lambda G_r(\theta_0) & if \quad \theta_0 \leq 1 \\ 1 & if \quad \theta_0 > 1. \end{cases} \tag{1}$$

In the first period of their lives, individuals accumulate human capital. At the beginning of this period, which takes a fraction of the period $1-\alpha$, where $\alpha \in [0,1]$, they attend compulsory school, which is free of charge, and they are not allowed to work. During the rest of the first period, α, some individuals attend college and some others work as unskilled workers. Those who attend college become skilled workers.[7]

During the second period of their lives, all individuals have one unit of time and all of them work. Those who attended college are now skilled workers, while those who did not remain as unskilled ones. Each worker receives a wage that is proportional to her level of human capital.

2.2 Production of Human Capital

At compulsory level, students are separated into different groups or classes. For the sake of simplicity, I consider only two groups here. The production of human capital is

[5] Alternatively we could interpret the two parent types as black or white, natives or immigrants, etc.

[6] That is, $G_r(\theta_0) \leq G_p(\theta_0)$ for any $\theta_0 \in [0,1]$ and $G_r(\theta_0) < G_p(\theta_0)$ for some $\theta_0 \in [0,1]$.

[7] Note that the parameter α can be interpreted as the opportunity cost of investment in human capital, or the fraction of earnings that would have been received in the absence of the investment.

assumed to depend on two factors: pre-school achievement (θ_0) and the "peer group" effect that depends on the characteristics of each student's specific group.[8] These characteristics are summarized by the mean achievement or "peer" effect of group j, denoted by $\overline{\theta}_0^j$.[9] An individual with pre-school achievement θ_0 will have human capital θ_1 upon graduation from compulsory school:

$$\theta_1 = \Phi(\theta_0, \overline{\theta}_0^j), \tag{2}$$

where $\Phi(\theta_0, \overline{\theta}_0^j)$ is a twice differentiable, increasing and concave function in each argument.

During the second part of the first period, each student decides whether or not to attend college and thereby add to the human capital acquired during compulsory school. I denote this increase by δ, which can be interpreted as the productivity of college education. Those who decide to attend college will end up with human capital θ_2:

$$\theta_2 = \theta_1(1 + \delta(\theta_1)). \tag{3}$$

As this paper focuses on comparing college attendance outcomes for students in mixed versus tracked compulsory educational systems, I assume that the acquisition of human capital at college is not directly affected by students' peers at this educational level. Rather, I assume that $\delta(\theta_1)$ is an increasing function only of that human capital acquired at compulsory school, and at a decreasing rate ($\delta_1 > 0, \delta_{11} < 0$).

It is important to note that the characteristics of a student's assigned peer group at compulsory level condition her final level of human capital θ_2 in two ways. It does so directly (one's compulsory school peers affect the amount of human capital that one acquires at that level) and also indirectly, since such human capital also determines the productivity of higher education and, thus, as we will see below, can influence the student's decision whether or not to attend college.[10]

[8] Observe that both individuals' characteristics, pre-school achievement and parental background, affect her final human capital, but in a different way. Whereas individual pre-school achievement has a direct effect on it (since further human capital build on previous achievement) parental background has an indirect effect through the positive dependence with individual pre-school achievement.

[9] See, among others, Bishop (2006), Epple and Romano (1998), Epple, Romano and Sieg (2003) and Epple, Newlon and Romano (2002) who also assume that peers affect an individual through the mean of their characteristics.

[10] Betts and Morell (1999) find a direct link between the quality of one's high-school peer group and one's college grade point average. Hahn et al. (2008) also find that peers' at high school level affect the student's decision regarding college attendance. In Section 5, I discuss the implications of

2.3 Educational Systems at Compulsory Level

This section describes the two contrasting educational systems, mixing and tracking, and analyzes the distribution of human capital at the end of compulsory level under each system.

2.3.1 Mixing

Under mixing, the pre-school achievement distribution is the same in both classrooms and the average pre-school achievement within each classroom, denoted $\overline{\theta}_0^m$, coincides with the average pre-school achievement in the population.

Under mixing, θ_1 will lie in the support $[\underline{m}, \overline{m}]$ where $\underline{m}$ and $\overline{m}$ denote the level of human capital θ_1 acquired under mixing by the "worst" (the lowest pre-school achiever) and the "best" (the highest pre-school achiever) student in the population.

Therefore, the C.D.F. of θ_1 under mixing, denoted $F_M(\theta_1)$, is:

$$F_M(\theta_1) = \begin{cases} (1-\lambda)G_p^m(\theta_1) + \lambda G_r^m(\theta_1) & if \quad \underline{m} \leq \theta_1 \leq \overline{m} \\ 1 & if \quad \theta_1 > \overline{m}, \end{cases} \tag{4}$$

where $G_b^m(\theta_1) = G_b(\Phi^{-1}(\theta_1, \overline{\theta}_0^m))$ for $b = p, r$ and Φ^{-1} denotes the inverse of the human capital production function.

It can be checked that, if in society A, parameter λ is higher than it is in society B, i.e. society A is wealthier than society B, then the distribution of human capital under mixing $F_M(\theta_1)$ in A dominates the one in B.

2.3.2 Tracking

Tracking students implies grouping them by their pre-school achievement level. For the sake of simplicity only two tracks are permitted and I use the median level of pre-school achievement as a threshold for grouping students into one track or the other. Thus, a student is assigned to the high (low) track when her pre-school achievement θ_0 is above (below) the median, denoted by $\eta(\lambda)$. Thus, $\eta(\lambda)$ is such that $G(\eta) = 1/2$.

I use $\overline{\theta}_0^l$ and $\overline{\theta}_0^h$ to denote average pre-school achievement levels for students in the low and high tracks, respectively. Thus, given the distributional assumptions on θ_0, I have that:

$$\overline{\theta}_0^l(\lambda) = (1-\lambda)\frac{\int_0^{\eta(\lambda)} \theta_0 g_p(\theta_0)d\theta_0}{\int_0^{\eta(\lambda)} g_p(\theta_0)d\theta_0} + \lambda\frac{\int_0^{\eta(\lambda)} \theta_0 g_r(\theta_0)d\theta_0}{\int_0^{\eta(\lambda)} g_r(\theta_0)d\theta_0}, \tag{5}$$

this specification on the different results.

and that:

$$\overline{\theta}_0^h(\lambda) = (1-\lambda)\frac{\int_{\eta(\lambda)}^1 \theta_0 g_p(\theta_0)d\theta_0}{\int_{\eta(\lambda)}^1 g_p(\theta_0)d\theta_0} + \lambda\frac{\int_{\eta(\lambda)}^1 \theta_0 g_r(\theta_0)d\theta_0}{\int_{\eta(\lambda)}^1 g_r(\theta_0)d\theta_0}. \tag{6}$$

where $g_b(\theta_0)$ denotes the p.d.f. (probability distribution function) of θ_0 conditional of having parental background b, for $b = r, p$.

In the low track, θ_1 lies within the interval $[\underline{l}, \overline{l}]$. We denote by $\underline{l}$ and $\overline{l}$ the human capital θ_1 acquired in the low track by the "worst" (lowest pre-school achiever) and the "best" (highest pre-school achiever) student respectively. Likewise, in the high track, θ_1 lies within the interval $[\underline{h}, \overline{h}]$. We denote by $\underline{h}$ and $\overline{h}$ the human capital θ_1 acquired in the high track by the "worst" (lowest pre-school achiever) and the "best" (highest pre-school achiever) student.

From the properties of the human capital production function, it can be checked that the support of θ_1 in the low track does not overlap the support of θ_1 in the high track, that is, $\underline{h} > \overline{l}$.

The C.D.F. of θ_1 under tracking, denoted by $F_T(\theta_1)$, is:

$$F_T(\theta_1) = \begin{cases} (1-\lambda)G_p^l(\theta_1) + \lambda G_r^l(\theta_1) & if \quad \underline{l} \leq \theta_1 \leq \overline{l} \\ 1/2 & if \quad \overline{l} \leq \theta_1 \leq \underline{h} \\ (1-\lambda)G_p^h(\theta_1) + \lambda G_r^h(\theta_1) & if \quad \underline{h} \leq \theta_1 \leq \overline{h} \\ 1 & if \quad \theta_1 > \overline{h}, \end{cases} \tag{7}$$

where $G_b^j(\theta_1) = G_b(\Phi^{-1}(\theta_1, \overline{\theta}_0^j))$ for $b = p, r$ and $j = l, h$. Observe that $G_b^j(\theta_1)$ is decreasing with $\overline{\theta}_0^j$ for $j = m, l, h$.

As under mixing, if society A is wealthier than society B, then the distribution of human capital under tracking $F_T(\theta_1)$ in A dominates the one in B.

2.4 College Attendance

Let us now look at how students decide whether or not to attend college. An important consideration to bear in mind here is the extent to which the choice between a tracked or mixed compulsory school system affects the demand for higher education, by exposing students to stronger or weaker peer effects. I assume that each individual wants to maximize her consumption, equal to her lifetime income, and that the latter is a linear function of her total human capital. Since those who do not attend college work as unskilled workers during a fraction α of the first period and throughout the second period, the lifetime income of any individual in this group can be expressed as $\theta_1(1+\alpha)$. At the same time, the lifetime income of those individuals who attend college is the skilled wage, that is, the increased level of human capital enjoyed by college graduates $\theta_2 = \theta_1(1+\delta(\theta_1))$. Therefore, for all individuals who decide to attend college the following condition must hold:

$$\theta_1(1+\delta(\theta_1)) \geq \theta_1(1+\alpha),$$

or,

$$\delta(\theta_1) \geq \alpha. \tag{8}$$

This condition determines the minimum level of human capital that students must acquire by the end of their compulsory education, θ_1^*, if they are to attend college. That is, $\theta_1^* \in (0, \overline{h})$ is the value that satisfies Equation (8) with equality.[11] For any given θ_1^*, let $\pi_s(\theta_1^*)$ denote the proportion of individuals attending college under educational system s, for $s = M, T$, that is $\pi_s(\theta_1^*) = 1 - F_s(\theta_1^*)$.

Finally, it is crucial to find out the interval where θ_1^* is placed, since it characterizes the composition of the college student body under each of the two education systems. I define two values for the opportunity cost of college attendance, corresponding to two compositional distributions of the college student body under mixing. Let α_M denote the opportunity cost such that $\delta(\underline{m}) = \alpha_M$. This value α_M implies that, when $\alpha < \alpha_M$, all students attend college under mixing. I denote by α^M the opportunity cost such that $\delta(\overline{m}) = \alpha^M$ and thus, $\alpha_M < \alpha^M$. This value α^M implies that, when $\alpha > \alpha^M$, no student attend college under mixing. Similarly I define two values for the opportunity cost of college attendance, corresponding to two compositional distributions of the college student body under tracking. Let α_T denote the opportunity cost such that $\delta(\bar{l}) = \alpha_T$. This value α_T implies that, when $\alpha < \alpha_T$, some low track students and all high track students attend college. Let α^T denote the opportunity cost such $\delta(\underline{h}) = \alpha^T$ and thus, $\alpha_T < \alpha^T$. This value α^T implies that, if $\alpha > \alpha^T$, only some of the high track students attend college.

For a given function $\delta(\theta_1)$, a rise in α will increase θ_1^*, meaning that a lower proportion of students will attend college. For a fixed α, an upward shift of $\delta(\theta_1)$ implies that a higher proportion of students will attend college.[12]

[11] To ensure that θ_1^* is interior we will assume that $\delta(\theta_1 = \underline{l}) < \alpha < \delta(\theta_1 = \overline{h})$.

[12] A rise in α can be interpreted as either the result of an increase in the difficulty of college studies or as an increase in the length of time spent at college. An upward shift of $\delta(\theta_1)$ can be interpreted as an improvement in the productivity of higher education.

3 Efficiency and Equity: Tracking vs Mixing

Having described the systems of tracking and mixing, we can now address the question posed at the beginning of the paper: which governmental grouping policy best supports the objectives of efficiency and/or equity?

3.1 An Efficient Educational System

The concept of efficiency is used to describe situations in which a given input leads to a maximum outcome. For the context at hand, an efficient educational system is the one that maximizes average human capital of the entire individual cohort by the end of second period. Let $E_{2s}(\theta_1^*)$ denote average human capital of the entire individual cohort by the end of second period under educational system s for $s = M, T$:

$$E_{2s}(\theta_1^*) = \int_0^{\theta_1^*} \theta_1 f_s(\theta_1) d\theta_1 + \int_{\theta_1^*}^{\theta_1^s} \theta_2 f_s(\theta_1) d\theta_1, \tag{9}$$

where θ_1^s is the human capital θ_1 acquired by the "best" student (the highest pre-school achiever) under education system s, that is, $\theta_1^M = \overline{m}$ and $\theta_1^T = \overline{h}$. Now, let E_{1s} denote average human capital at the end of the compulsory schooling phase under education system s, that is, $E_{1s} = \int_0^{\theta_1^s} \theta_1 f_s(\theta_1) d\theta_1$, and $\Delta_s(\theta_1^*)$ denote the increase in the human capital acquired by students who choose to attend college under education system s, that is, $\Delta_s(\theta_1^*) = \int_{\theta_1^*}^{\theta_1^s} \theta_1 \delta(\theta_1) f_s(\theta_1) d\theta_1$. Then, we can rewrite Equation (9) as follows:

$$E_{2s}(\theta_1^*) = E_{1s} + \Delta_s(\theta_1^*). \tag{10}$$

From Equation (10) above and the definition of $\Delta_s(\theta_1^*)$ it can be checked that the properties of human capital production at college, θ_2, must be considered when determining which is the efficient educational system. In particular, the congestion effects or public good aspects of college education are crucial here. This property is defined as follows:

Definition 1 *The production of human capital at college is congested if $\delta(\theta_1)$ is such that $\pi_s(\theta_1^*) > \pi_u(\theta_1^*)$ implies that $\Delta_s(\theta_1^*) < \Delta_u(\theta_1^*)$ for $s, u = M, T$ and $s \neq u$.*

Thus the production of human capital at college is congested if, regardless of the prevailing educational system at compulsory level, the higher the college attendance rates, the lower the increase in total human capital at college level. This might be due to high student-teaching staff ratios or low teaching instruction time, among other factors. Proposition 2 below shows that which of the two educational systems is efficient depends first on which is the one that maximizes average human capital at compulsory level and, second, on whether or not there are congestion effects at college level.

Proposition 2 *Let $E_{1T} > (<) E_{1M}$ then tracking (mixing) is efficient if any of the following conditions hold:*

(i) tracking (mixing) maximizes college attendance and human capital production at college is not congested.

(ii) tracking (mixing) minimizes college attendance and human capital production at college is congested.

Proof. It is immediate from Definition 1 and Equation (10). ■

Proposition 2 tells us that the education system that maximizes average human capital at compulsory level might also be the one that maximizes average human capital by the end of the second period under some conditions.[13] In particular, if in addition it maximizes the increase in total human capital at college level. In other words, if it maximizes college attendance and there are no congestion effects at college level, or if it does not maximize college attendance and there are congestion effects.

In all other cases, the final result regarding which system maximizes average human capital across the population depends on which of the two determining factors, E_{1s} or $\Delta_s(\theta_1^*)$, dominates the other. For example, consider the case where average human capital at compulsory level is higher under tracking than it is under mixing, but mixing maximizes college attendance and there are no congestion effects. Thus, if the increase in human capital brought on by college graduation is high enough to compensate for the lower average human capital earned at the compulsory level, then mixing maximizes average human capital across the population. Consider now the case where mixing maximizes average human capital at compulsory level but

[13] Hidalgo-Hidalgo (2008) finds that $E_{1T} > (<) E_{1M}$ if there is a high degree of complementarity (substitutability) between both factors. Arnott and Rowse (1987) and Benabou (1996) find a similar result.

college attendance is higher under tracking and there are no congestion effects. If the increase in human capital brought on by college graduation is high enough to compensate for the lower average human capital earned at the compulsory level, then tracking maximizes average human capital across the population.

To conclude, maximizing human capital at one level (compulsory) does not immediately imply that human capital is maximized at the end of the whole educational process. The properties of human capital production at college, together with college attendance rates might also be considered in this analysis.

I shall next consider which of the two educational systems maximizes college attendance. As we shall see, it crucially depends on the opportunity cost of college attendance and on the wealth level in the population. To compare tracking and mixing here we have to compare $F_T(\theta_1)$ and $F_M(\theta_1)$. Using Equation (4) for $F_M(\theta_1)$ and Equation (7) for $F_T(\theta_1)$, and since $G_b^j(\theta_1)$ is decreasing with $\overline{\theta}_0^j$ for $j = m, l, h$, we can check that for any $\theta_1 \in (0, \bar{l})$, $F_T(\theta_1) - F_M(\theta_1) > 0$ for every λ, whereas for any $\theta_1 \in (\underline{h}, \overline{h})$, $F_T(\theta_1) - F_M(\theta_1) < 0$ for every λ. That is, neither system dominates the other according to first order stochastic dominance. Thus, I can define $\widetilde{\theta}_1$ as the level of human capital such that $F_T(\widetilde{\theta}_1) = F_M(\widetilde{\theta}_1)$. We need this value for Proposition 3 below. We can conclude that $\widetilde{\theta}_1 \in (\bar{l}, \underline{h})$. As a result it is clear that, for any $\theta_1 \in (0, \widetilde{\theta}_1)$ then $F_T(\theta_1) - F_M(\theta_1) > 0$, whereas for any $\theta_1 \in (\widetilde{\theta}_1, \overline{h})$ then $F_T(\theta_1) - F_M(\theta_1) < 0$. That is, the density function of θ_1 under tracking accumulates more probability in the tails than under mixing, which shows that the distribution of θ_1 under tracking is more dispersed than it is under mixing.

Moreover, I find that $\widetilde{\theta}_1$ is an increasing function of λ.[14] When there are few wealthy individuals (λ is low), then F_M surpasses F_T for a low value of θ_1. As societal wealth increases, average human capital also rises, and the crossing point $\widetilde{\theta}_1$ moves to the right. In other words, the C.D.F. under mixing will fall below the C.D.F. under tracking for a larger interval of values of θ_1.

As the next Proposition shows, which of the two educational systems maximizes college attendance depends first on the opportunity cost of college attendance α, and second on the wealth level in the population, captured by λ, the proportion of rich individuals in the population.

Proposition 3 *The system that maximizes college attendance depends on the oppor-*

[14] Note that $\widetilde{\theta}_1$ is such that $F_M(\widetilde{\theta}_1) = 1/2$. From Equation (4) $\widetilde{\theta}_1$ is implicitly defined as follows: $(1-\lambda)G_p^m(\widetilde{\theta}_1) + \lambda G_r^m(\widetilde{\theta}_1) = 1/2$.

tunity cost of college attendance as follows:

(i) If $\alpha \leq \alpha_T$, then the system that maximizes college attendance is always mixing.

(ii) If $\alpha_T < \alpha < \alpha^T$, then the system that maximizes college attendance is tracking when λ is low and it is mixing when λ is high.

(iii) If $\alpha \geq \alpha^T$, then the system that maximizes college attendance is always tracking.

Proof. From the fact that F_M always cuts F_T from below, a necessary and sufficient condition to ensure that $\pi_M(\theta_1^*) > (<)\ \pi_T(\theta_1^*)$ is that $\widetilde{\theta}_1 > (<)\ \theta_1^*$. If $\alpha \leq \alpha_T$, then we have $\widetilde{\theta}_1 > \theta_1^*$ for all λ. Now assume that $\alpha \in (\alpha_T, \alpha^T)$ and, thus, $\theta_1^* \in (\bar{l}, \underline{h})$. For each value of θ_1^*, there is one value of λ, denoted by $\widetilde{\lambda}$, such that $\widetilde{\theta}_1(\widetilde{\lambda}) = \theta_1^*$. Thus, since $\widetilde{\theta}_1$ is increasing with λ we have that, if $\lambda < \widetilde{\lambda}$ then $\widetilde{\theta}_1 < \theta_1^*$ and when $\lambda > \widetilde{\lambda}$ then, $\widetilde{\theta}_1 > \theta_1^*$. Finally, if $\alpha \geq \alpha^T$, we have $\widetilde{\theta}_1 < \theta_1^*$ for every λ. ■

Here Figure 1 (College Attendance under both systems)

Figure 1 illustrates this result. The intuition is as follows. First, regardless of the wealth level in the population, most high pre-school achievers will attend college when the opportunity cost of college attendance is low ($\alpha \leq \alpha_T$). In this situation, intervention must be targeted toward those who performed poorly in pre-school. As the peer effect is stronger for these students under mixing than it is under tracking ($\overline{\theta}_0^m > \overline{\theta}_0^l$), college attendance is maximized by the former.[15] When the opportunity cost is high ($\alpha \geq \alpha^T$), the opposite result is obtained. In this context, most low pre-school achievers are excluded from college under either system. Intervention should target those who performed well during pre-school, as they are the only ones who will potentially attend college. Choosing tracking is the best way to meet this goal as the peer effect is stronger for these students under tracking than it is under mixing ($\overline{\theta}_0^m < \overline{\theta}_0^h$).[16]

[15] A look at the case of Spain during the 1980s may help to clarify this result. Faced with low college attendance rates, the priority of the government at that time was to increase the number of college students. The low opportunity cost of college attendance, together with a compulsory-level educational system based on mixing, yielded an extraordinary increase in the number of college students from the mid-1980s to the mid-1990s (from 744,115 in 1983/84 to 1,508,842 in 1995/96. See Estadística Universitaria (2003)).

[16] This result may explain the empirical evidence found by Hahn et al. (2008), in their study based on Korean data regarding high school graduates. They conclude that the number of high school

When the opportunity cost takes an intermediate value, it is the wealth level in the population (as captured by λ) that ultimately determines which educational system maximizes college attendance. If the wealth level is very low, the case is similar to that where α is high. In this situation, pre-school achievement levels are very low and thus most pre-school achievers will be excluded from college regardless of the educational systems prevailing at compulsory level. Thus, the appropriate choice in order to maximize college attendance consists of the system that enhances the peer effect. If the wealth level is very high, the situation resembles the one where α is low. In this case, the best system is the one that maximizes college attendance rates among low pre-school achievers, as most high pre-school achievers will attend college irrespective of which educational system is selected.

Note that as α increases, the proportion of students for whom mixing is better than tracking, that is, students with low pre-school achievement levels and wealthy parents, decreases. The population must therefore include a proportionally high number of wealthy students, enough to offset the lower human capital acquired by those high pre-school achievers who were also poor (for whom tracking is better than mixing).

In order to illustrate the results on the comparison between $\pi_M(\theta_1^*)$ and $\pi_T(\theta_1^*)$ I present and discuss numerical simulations. To get closed-form solutions, the model in Hidalgo-Hidalgo (2008) is adopted and extended to consider college attendance. Thus, regarding the distribution of pre-school achievement, I assume that $G_r(\theta_0) = \theta_0$ and $G_p(\theta_0) = \theta_0^\gamma$ where $\gamma \in (0, 1]$. That is, the lower is γ, the higher the gap in pre-school achievement between poor and rich students. With respect to the production of human capital at compulsory level $\Phi(\theta_0, \overline{\theta}_0^j)$, I assume that it is a CES of the two inputs, θ_0 and $\overline{\theta}_0^j$:[17]

$$\Phi(\theta_0, \overline{\theta}_0^j) = A(\rho(\theta_0)^\beta + (1-\rho)(\overline{\theta}_0^j)^\beta)^{1/\beta}, \tag{11}$$

where $A > 1$, $\rho \in [0, 1]$ and $\beta \in (0, 1]$. The parameter ρ captures the weight of pre-school achievement on θ_1. Observe that, for β close to 0, both θ_0 and $\overline{\theta}_0^j$ have a high level of complementarity and as β tends to 1, the two factors become perfect substitutes.

graduates who entered top universities (i.e., those universities for which θ_1^* is high) was higher under a tracking system than it was under a mixing system.

[17]See Hidalgo-Hidalgo (2008) for a detailed discussion of the properties of this education production function and how it captures the main empirical evidence.

The college attendance rates under each educational system are now compared for two societies that differ in the pre-school achievement gap between poor and wealthy students γ. In society A, γ is higher than it is in society B, and thus the gap in pre-school achievement in A is lower than it is in B. This difference may stem from the fact that A spends more resources in early childhood education than does B.

To perform this numerical exercise, I need to look for reasonable values of the parameters. However, scant empirical evidence exists on some crucial parameters, which must be kept in mind when interpreting the results. We need common values for λ, ρ and β for both societies and two levels of γ for each society. Table 1 shows the selected parameter values. This selection is briefly explained below.

Table 1: Parameter values

ρ	3/4
λ	5/6
β	3/4
A	2
γ (society B)	0.2
γ (society A)	0.8

As families, rather than schools, are mainly responsible for the inequalities in school performance (see the Coleman Report and more recent works such as those by Heckman (2006) and references therein), it seems appropriate to assign a high value to ρ. In particular, I fix $\rho = 3/4$.

The value for λ is drawn from OECD data. Recall that λ captures the proportion of rich individuals in the population. In most studies on poverty, the poor are all individuals living in households with income below the poverty line, which is fixed at 50% of national median adjusted income.[18] According to the OECD questionnaire on household income distribution (2002), those individuals whose equivalent disposable income in 2000 was less than 50% of the median for the population as a whole averaged 10%, with an increasing tendency (see OECD (2002)). Hence I set $\lambda = 5/6$, which also seems appropriate if we, alternatively, interpret λ as the proportion of natives in the population.[19]

[18] See Collado and Iturbe-Ormaetxe (2008) for an in-depth analysis of this topic.

[19] Immigrants accounted for just under 12% of the total population in OECD countries in 2006 (see OECD (2008)).

There is no empirical evidence on the degree of complementarity/substitutability between peer effects and individual pre-school achievement. However, recent empirical evidence (see Ding and Lehrer (2007) and Kim et al. (2006)) suggests that both factors are close complements. Thus, I set $\beta = 3/4$ which corresponds to an elasticity of substitution between θ_0 and $\overline{\theta}_0^j$ equal to 4.

Finally, I must assign two different values of γ in order to capture the disparities between the two societies with regard to the pre-school achievement gap. Specifically, I assume $\gamma = 0.2$ for society B, which means that the mean pre-school achievement level for poor students represents 33% of the achievement level for rich students. For society A, I assume $\gamma = 0.8$, thus raising the pre-school achievement gap between poor versus rich members of the population to 89% (see PISA 2003 Report).[20]

Once we have chosen appropriate values for all of our parameters, we can compute the values of $\pi_M(\theta_1^*)$ and $\pi_T(\theta_1^*)$ for both societies. Figure 2 represents these functions for any $\theta_1^* \in (0, \overline{h})$. Here, $\pi_M(\theta_1^*)$ is shown as a solid line and $\pi_T(\theta_1^*)$ as a dashed line:[21]

Here Figure 2 (College attendance under both systems)

Figure 2 shows similar results to the ones in Proposition 3 and Figure 1. That is, if θ_1^* is low (high) mixing (tracking) maximizes college attendance in both societies. For intermediate values of θ_1^*, the final result will depend here on the pre-school achievement gap γ. In particular, for some fixed θ_1^* (for example for any $\theta_1^* \in (0.9, 0.95)$ in Figure 2) mixing maximizes college attendance in society B ($\gamma = 0.2$) but tracking maximizes college attendance in society A ($\gamma = 0.8$). That is, the parameter γ plays the same role as λ in determining the educational system that maximizes college attendance. If γ is low the case is much as when θ_1^* is high and then mixing maximizes college attendance. If γ is high the situation resembles the one where θ_1^* is low and then tracking maximizes college attendance.

Finally, some conclusions may be drawn as to which of the two systems maximizes the population's average human capital by the end of the second period, $E_{2s}(\theta_1^*)$. If the government seeks to achieve efficiency, its best option will depend on the prop-

[20] According to the PISA 2003 results for OECD countries, the mean in math performance among immigrants represents about 90%, on average, of the mean in math performance for native students.

[21] The same result is obtained for different configurations of these parameters.

erties of the human capital production at compulsory level, the opportunity cost of college attendance and the wealth level in the population. Observe that, for these parameter values in Table 1, and in both societies, $E_{1T} > E_{1M}$. Assume now that there are no congestion effects at college level.[22] Thus, in this numerical example, tracking will also maximize average human capital across the population if the opportunity cost of college attendance is sufficiently high or the wealth level in the population is sufficiently low.[23]

3.2 Equality of Opportunities

Most governments care about equity issues in a broad sense, although there seems to be no single, widely-accepted definition of equity. To circumvent this problem, and for our purposes, I propose that an equal-opportunity policy should aim to equalize college entrance probabilities among students of differing family backgrounds but similar pre-school achievement.

For any given minimum level of human capital required to attend college θ_1^*, let $\pi_{b,s}(\theta_1^*)$ denote the probability of college attendance among students with parental background b, for $b = p, r$ under education system s for $s = M, T$. Thus:

$$\pi_{b,s}(\theta_1^*) = 1 - F_s(\theta_1^* \mid b) = 1 - G_b^j(\theta_1^*), \tag{12}$$

where $F_s(\theta_1^* \mid b)$ denotes the C.D.F. of θ_1 under education system s conditional on having parental background b, and $G_b^j(\theta_1^*) = G_b(\Phi^{-1}(\theta_1^*, \overline{\theta}_0^j))$ for $j = m, l, h$.

Thus, equality of opportunities implies that $\pi_{p,s}(\theta_1^*)$ should equal $\pi_{r,s}(\theta_1^*)$ and the grouping criteria is proposed as a policy instrument for guaranteeing it. Specifically, I suggest that governments choose the education system under which the college attendance gap between rich and poor students is the narrowest. The college attendance gap $\widehat{\pi}_s(\theta_1^*)$ under education system s, for $s = M, T$, is defined as the difference between the college attendance probabilities for rich and poor students:

$$\widehat{\pi}_s(\theta_1^*) = \pi_{r,s}(\theta_1^*) - \pi_{p,s}(\theta_1^*). \tag{13}$$

[22] Tertiary education systems in some European countries during the 2000s are a good example here. In particular, the student-teaching staff ratio in Italy and Spain has experienced a continuous fall during this period: from 24.8 and 16.4 in 1999 to 20.4 and 10.8 in 2006, respectively. See OECD Education at a Glance from 2001 to 2008.

[23] If the properties of the human capital production function at compulsory level are such that mixing maximizes average human capital at this level, then it will also maximize average human capital across the population provided that the opportunity cost is sufficiently low or the wealth level in the population is sufficiently high.

Thus, from Equations (4) and (12), the attendance gap under mixing is:

$$\widehat{\pi}_M(\theta_1^*) = G_p^m(\theta_1^*) - G_r^m(\theta_1^*), \tag{14}$$

for any $\theta_1^* \in [\underline{m}, \overline{m}]$. From Equations (7) and (12), the attendance gap under tracking is:

$$\widehat{\pi}_T(\theta_1^*) = \begin{cases} G_p^l(\theta_1^*) - G_r^l(\theta_1^*) & if \quad \underline{l} \leq \theta_1^* \leq \bar{l} \\ G_p(\eta) - G_r(\eta) & if \quad \bar{l} \leq \theta_1^* \leq \underline{h} \\ G_p^h(\theta_1^*) - G_r^h(\theta_1^*) & if \quad \underline{h} \leq \theta_1^* \leq \overline{h}. \end{cases} \tag{15}$$

Note that the comparison between $\widehat{\pi}_M(\theta_1^*)$ and $\widehat{\pi}_T(\theta_1^*)$ depends on the minimum level of human capital required to attend college θ_1^* or, reversibly, on the opportunity cost of college attendance α.

I resort to the computational model used above so that the results will provide at least suggestive evidence about the education system that better achieves equality of opportunities. Figure 3 represents the values $\pi_{r,s}(\theta_1^*)$ and $\pi_{p,s}(\theta_1^*)$ for societies A ($\gamma = 0.8$) and B ($\gamma = 0.2$). These values are represented in each of the three intervals where θ_1^* may lie. That is, first $\theta_1^* \in (\underline{m}, \bar{l})$, second $\theta_1^* \in (\bar{l}, \underline{h})$ and finally $\theta_1^* \in (\underline{h}, \overline{m})$.[24] Here, $\pi_{b,M}(\theta_1^*)$ is shown as a solid line and $\pi_{b,T}(\theta_1^*)$ as a dashed line for both poor (in black) and rich (in red).

Here Figure 3 (College attendance rates for poor and rich students)

We consider first the case where $\theta_1^* \in (\underline{m}, \bar{l})$, which implies that the opportunity cost of college attendance is low, i.e., that $\alpha < \alpha_T$. As we know from Proposition 3, in this case the probability that students, of any parental background, attend college is always higher under mixing than under tracking. Figure 3 shows this result. Observe also that in society A, the probability that a poor student in a mixed system will go on to attend college is even higher than it is for a rich student in a tracked system. In other words, as societies invest more resources in reducing the pre-school achievement gap, mixing promotes college attendance more effectively than does tracking provided that the human capital required to attend college is low.

[24] Recall that under mixing if $\theta_1^* < \underline{m}$ then every individual (regardless of her parental background) attend college. If $\theta_1^* > \overline{m}$ then no individual (again, regardless of her parental background) attend college. Thus, the cases where either $\theta_1^* < \underline{m}$ or $\theta_1^* > \overline{m}$ are excluded from the analysis since then $\pi_{r,M}(\theta_1^*) = \pi_{p,M}(\theta_1^*)$ by construction.

Observe now the case where $\theta_1^* \in (\bar{l}, \underline{h})$. From Equation (12) we know that, under tracking, the probability of college attendance for both rich and poor students coincides with their respective probability of being in the high track. Thus, their likelihood of attending college does not depend on having obtained the minimum level of human capital required in order to do so, as can be observed in Figure 3. Note also that $\theta_1^* \in (\bar{l}, \underline{h})$ implies that $\alpha \in [\alpha_T, \alpha^T]$. From Proposition 3 we know that, in this case and for the children of both parental types, the probability of attending college is higher under mixing than it is under tracking when α is low, and that the reverse occurs when α is high. Again, Figure 3 shows this result.

Finally, the case where $\theta_1^* \in (\underline{h}, \overline{m})$ implies that $\alpha > \alpha^T$. Again from Proposition 3 we know that, for children of any parental type, the probability of attending college is always higher under tracking than it is under mixing. Figure 3 displays this result. In addition, in society A the likelihood that a poor student educated under a tracked system will go on to attend college is higher than it is for a rich student educated under a mixed system. This reinforces the result of Proposition 3, above. That is, if the opportunity cost of college attendance is high, then tracking will outperform mixing when it comes to maximizing college attendance, and even more in homogeneous societies.

Figure 4 represents $\widehat{\pi}_s(\theta_1^*)$ under both mixing (in solid line) and tracking (in dashed line).

Here Figure 4 (The attendance gap)

Observe that, regardless of the opportunity cost of college attendance, both $\widehat{\pi}_T(\theta_1^*)$ and $\widehat{\pi}_M(\theta_1^*)$ levels are lower in society A than they are in B. That is, for both educational systems, and as expected, the lower the pre-school achievement gap, the lower the attendance gap between the rich and the poor. However, exactly which system minimizes the attendance gap depends on the minimum level of human capital required to attend college θ_1^* or, alternatively, on the opportunity cost of college attendance α.

Consider first the case where $\theta_1^* \in (\underline{m}, \bar{l})$. Let $\theta_1' \in (\underline{m}, \bar{l})$ be such that such that $\widehat{\pi}_T(\theta_1') = \widehat{\pi}_M(\theta_1')$. We observe that, in both societies $\widehat{\pi}_T(\theta_1^*) > (<) \widehat{\pi}_M(\theta_1^*)$ if θ_1^* is sufficiently low (high), in particular if $\theta_1^* < (>) \theta_1'$. Let now $\theta_1'' \in (\bar{l}, \underline{h})$ be such that $\widehat{\pi}_T(\theta_1'') = \widehat{\pi}_M(\theta_1'')$. Notice that if $\theta_1^* \in (\bar{l}, \underline{h})$, then the reverse occurs and, in both societies, $\widehat{\pi}_T(\theta_1^*) < (>) \widehat{\pi}_M(\theta_1^*)$ if $\theta_1^* < (>) \theta_1''$. Finally, observe that if $\theta_1^* \in (\underline{h}, \overline{m})$, then in both societies $\widehat{\pi}_T(\theta_1^*)$ and $\widehat{\pi}_M(\theta_1^*)$ decrease with θ_1^* and $\widehat{\pi}_T(\theta_1^*) > \widehat{\pi}_M(\theta_1^*)$ for any θ_1^* in this interval.

We will next analyze the relationship between the educational system that minimizes the attendance gap and the opportunity cost of college attendance. Equation (8) establishes that for any student willing to attend college, the increase in human capital at college $\delta(\theta_1)$ must be, at least, equal to the opportunity cost of college attendance α. I use α' and α'' to denote the opportunity cost such that $\delta(\theta_1') = \alpha'$ and $\delta(\theta_1'') = \alpha''$, respectively. From the definition of θ_1' and θ_1'' above, if the opportunity cost is equal to α' or α'', then the attendance gap under both educational systems coincides. However, the underlying student composition body under tracking differs between them. If $\alpha = \alpha'$, then some low track students and all high track students attend college under tracking (since $\alpha' < \alpha_T$), whereas if $\alpha = \alpha''$, then all of the high track students and none of the low track ones attend college (since $\alpha'' > \alpha_T$). In order to complete the numerical example we need to define a particular function for the productivity of college education and thus, $\delta(\theta_1) = \sqrt{\theta_1}/2$ is assumed here. Once we have values for all our parameters and $\delta(\theta_1)$, from Equation (8) we can compute α_T, α_M, α^M, α^T, α' and α'' for any given θ_1^* and for both societies.[25]

What I obtain is that the set of values of the opportunity cost of college attendance is split into three regions as represented in Figure 5. In addition, Figure 5 summarizes the results shown in Figure 4. It represents α_M and α^M in solid black lines, and α_T and α^T in dashed black lines. Finally, it represents α' and α'' in solid blue and green lines, respectively.

Here Figure 5 (Equality of Opportunities)

In both figures we observe that, if the opportunity cost of college attendance is low, in particular $\alpha < \alpha'$ (which implies that the minimum level of human capital required to attend college θ_1^* is very low, i.e. $\theta_1^* < \theta_1'$) then mixing is the most equitable system, i.e. $\widehat{\pi}_T(\theta_1^*) > \widehat{\pi}_M(\theta_1^*)$. The intuition could be as follows. For each α, we must focus on the individuals at the margin, that is on those whose decision whether or not to attend college depends critically on their family background and may be shaped by the educational system prevailing. If α is very low, then the group of individuals at the margin are those students with low levels of θ_0 who under tracking are placed in the low track. Since the peer effect is stronger under mixing than it is in the low track, then the family background plays also a less important role there. In this case,

[25] I obtained similar results using other specifications for $\delta(\theta_1)$.

the attendance gap will be narrower under mixing than it is under tracking.

Observe in Figure 5 that tracking is the most equitable system, i.e. $\widehat{\pi}_T(\theta_1^*) < \widehat{\pi}_M(\theta_1^*)$ if α takes intermediate values, i.e. $\alpha \in (\alpha', \alpha'')$. The group of individuals at the margin includes students with intermediate levels of θ_0. Under tracking, they would be placed into the high track where the peer effect is the strongest, and family background will not critically condition the total human capital that each student may acquire in compulsory school. By contrast, under mixing since the peer effect is lower than it is in the high track, family background has a higher relative weight. In this case, the attendance gap will be higher under mixing than it is under tracking.

Finally, if α takes very high values, particularly $\alpha > \alpha''$, then the set of individuals at the margin is comprised of those with very high levels of θ_0. Figure 4 shows that, in this case, $\widehat{\pi}_T(\theta_1^*) > \widehat{\pi}_M(\theta_1^*)$. Recall that advanced students experience a higher peer effect under tracking than they do under mixing and that the mean of θ_0 conditional on having poor parents is lower than the mean of θ_0 conditional on having rich parents. The difference in θ_1 for rich versus poor students will be higher under tracking than under mixing, therefore, due to the complementarity between peer effects and individual achievement.

Figure 5 represents three regions where α might lie that yield to tracking or mixing being the most equitable system. One final remark is worth mentioning: Recall that in this example, the set of parameter values λ, γ and β were such that $E_{1T}(\theta_1) > E_{1M}(\theta_1)$. It is important to highlight that similar qualitative results were obtained for different configurations of the parameters. In particular for sets of parameters values λ, γ and β such that $E_{1T}(\theta_1) < E_{1M}(\theta_1)$ (e.g. $\lambda = 1/5$, $\beta = 0.99$ and $\gamma = .2$ or $\gamma = .3$).

To conclude, contrary to the general belief that equality of opportunities is best achieved under mixing, I find that tracking may be a more effective means of achieving that goal in some cases. In effect, my study suggests that switching from tracking to mixing will not automatically further each student's access to equal opportunities. Indeed, it will actively work against that goal for students with intermediate levels of θ_0. This result is quite surprising and contrasts with the main conclusions heretofore reported in the empirical literature on the subject, including studies by Schuetz et al. (2008), Hanushek and Woessmann (2007) and Brunello and Checchi (2007).[26] However these studies suffer from two main limitations, which may explain

[26]Schuetz et al. (2008) find that early tracking increases the impact of family background on test scores and exacerbates inequalities. Hanushek and Woessmann (2006) find, based on interna-

the difference between their conclusions and my own. On the one hand, Schuetz et al. (2008) and Hanushek and Woessmann (2006) only look at compulsory level outcomes, which impedes them from observing the long-term effects of either system. On the other hand, while Brunello and Checchi (2007) analyze later outcomes, they fail to consider the distributional impact of family background on educational outcomes and instead focus solely on mean impacts. My study goes a step further, estimating not only mean impacts but also the distributional outcomes of different grouping policies, and determining how those policies may alter the composition of such outcomes by hindering or enhancing the college attendance possibilities for individuals.

Finally, this result is consistent with observed stylized facts. Some European countries are experiencing a decline in college attendance and an increase in college drop-out rates. The most notable example is Spain where, even without explicitly mentioning it, the most recent education reform during the 1990s (known as LOGSE), entailed a mixing grouping system. There, both of the effects commented above are particularly strong among those students with intermediate levels of achievement, who might have graduated from college under a different grouping policy.[27]

3.3 On the trade-off between efficiency and equity

Finally I would like to comment on the possibility of a trade-off between efficiency and equity. If, in addition to complementarity between peer effects and individual pre-school achievement, we assume that there are no congestion effects at college level, then the presence of trade-offs between efficiency and equity will depend solely on the opportunity cost of college attendance and the societal wealth.

First, tracking can be both efficient and equitable in some situations. For example, if the opportunity cost of college attendance takes intermediate values and the wealth level in the population is low or the distribution of pre-school achievement is

tional comparisons of early outcomes, that early tracking increases educational inequality. Brunello and Checchi (2007), who look at later outcomes as employability and earnings, find that tracking reinforces family background effects on labour market outcomes.

[27]LOGSE is the Spanish abbreviation for Ley de Ordenación General del Sistema Educativo. Among other things, this reform raised the compulsory schooling age to 16 and softened the requirements for grade advancement. Today we observe a decrease in the entry rates into tertiary-type A programmes from 47% in 2000 to 43% in 2006 (see Education at a Glance 2008). In addition, the proportion of college students among those in the corresponding age group whose parents hold a secondary education degree dropped from 60% in 1998 to 45% in 2007 (see EPA 2006 and Albert (2008)).

sufficiently dispersed (γ is low), then tracking will not only be the efficient system but also the most equitable one according to Propositions 2 and 3 and Figure 5.

Second, if the opportunity cost of college attendance is low, then mixing might achieve both efficiency and equity. In this case, Proposition 3 implies that college attendance is maximized under mixing, which Figure 5 also shows to be the most equitable system. Yet mixing does not maximize the average human capital obtained at the compulsory level. However, if the increase in the level of human capital brought about by college attendance is high enough to compensate for the lower average human capital achieved at the compulsory level, then mixing will maximize average human capital across the population and will be both the efficient system and the one that better guarantees equality of opportunities among students.

Finally, a trade-off between efficiency and equity will clearly take place when the opportunity cost of college attendance is high. According to Propositions 2 and 3, tracking is the efficient system in this case, since it maximizes both the average human capital at compulsory level and college attendance. Yet we showed above that, for this case, mixing does better than tracking at guaranteeing equality of opportunities among students. In all other cases we can not conclude that there is not a trade-off between efficiency and equity.

4 Discussion and final Comments

This paper analyzes the public intervention in education when the government, taking into account the existence of peer effects at compulsory education level and its impact at college level, has to decide how to group compulsory school students. Two different education systems (tracking and mixing) are examined. Efficiency and equity are assumed to be two central governmental concerns.

Conventional wisdom suggests that equality of opportunities is best guaranteed under mixing. My study shows that this is not necessarily the case, and that the impact on educational results at later stages (i.e., college attendance rates) must be taken into account when weighing the pros and cons of either educational system. In this context, I find tracking to be the most equitable system for students with intermediate levels of human capital required to attend college.

The paper abstracts from variation in schooling public expenditure in compulsory and college levels, previously considered by Arnott and Rowse (1987), Benabou (1996) and Epple and Romano (1998) among others. Abstracting from this concern enables me to isolate the role of compulsory school peer effects on college attendance, which has not been considered in the prior literature.

The paper allows for some extensions. An important one is the introduction of prices which are omitted in this paper under the assumption of free education in both levels. This would imply modelling parental income explicitly and could enable second-best analysis to be introduced in the comparison between tracking and mixing. The crucial assumption in this analysis would be on the degree of complementarity/substitutability between parental income and peer group effects. In addition, we might consider the effect on wages of the number of college graduates. I think that introducing this assumption would not change qualitatively the main results of the paper. Note that, this would make the opportunity cost of college attendance an endogenous variable, $\alpha(\pi_s)$. Thus, the equilibrium proportion of college students under education system s, π_s, would be given by $\pi_s = 1 - F_s(\delta^{-1}(\alpha(\pi_s)))$. If we just consider the conventional supply effect on the skilled wage, it can be checked that π_s exists and it is unique. Finally, it might also be interesting to compare the two education systems in a dynamic setup, or to consider alternative governmental criteria with respect to equity. In this regard, we might assume that the government wishes to maximize the probability of college attendance among only the worst-off individuals in the population, assuming that by "worst-off" we mean children of poor parents. The results in this case would be quite similar to the ones found above (see also Hidalgo-Hidalgo (2005)): when the opportunity cost of college attendance is low, college attendance is maximized under mixing, and the reverse is true when the opportunity cost of college attendance is high.

Finally, I believe my results on compulsory school peers' impact on college outcomes are of value and seem relevant to several key issues currently under debate among economists of education. In addition these theoretical results yield two hypothesis to be tested empirically: the impact of grouping policies on the deceleration in college entry rates recently observed in some European countries (see Education at a Glance (2008) and Hahn et al. (2008)) and the distributional impact of these grouping policies on students with different background.

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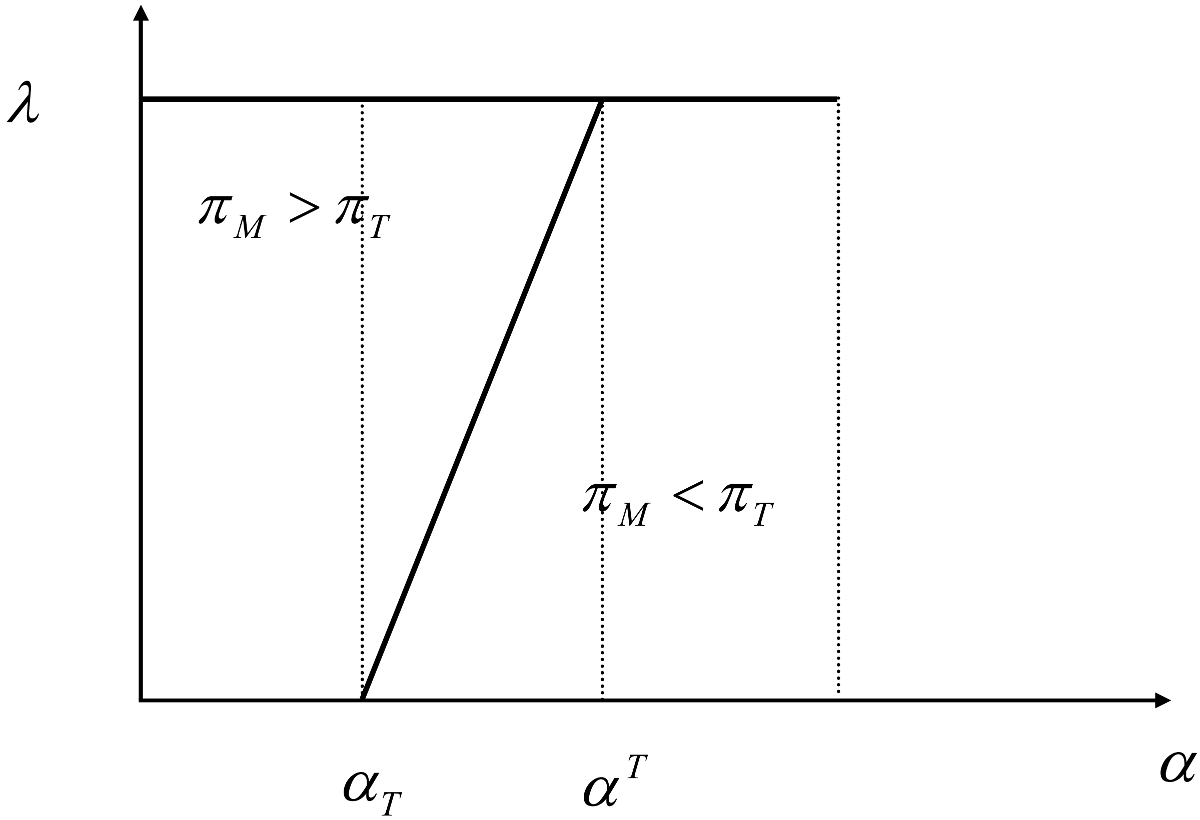
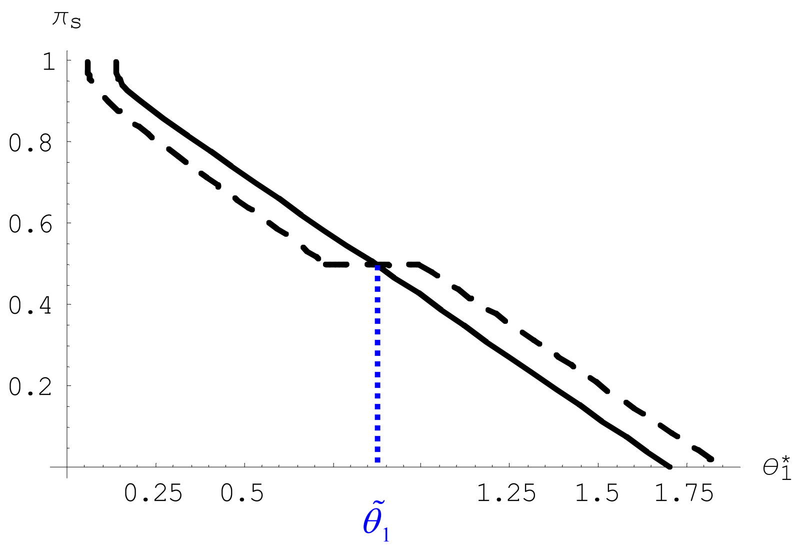
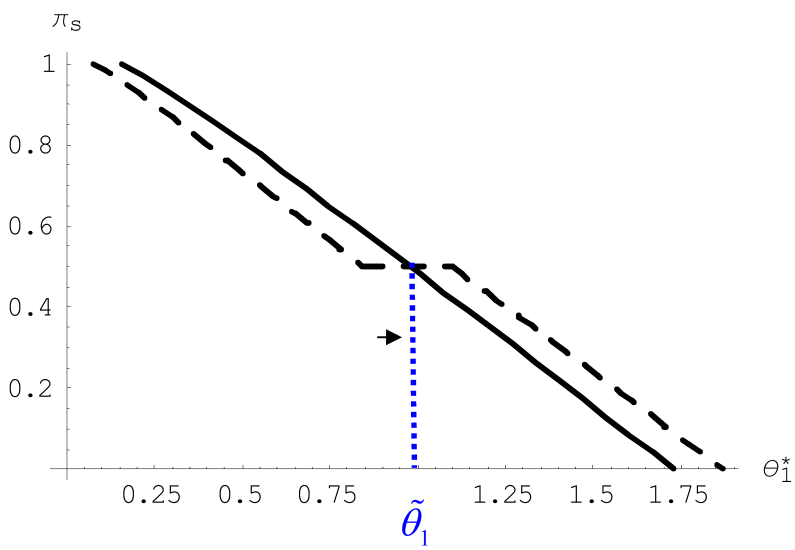


Figure 1: College attendance under both systems



Society B



Society A

Note: $\pi_M(\theta_1^*)$ (solid line) $\pi_T(\theta_1^*)$ (dashed line)

Figure 2: College attendance under both systems

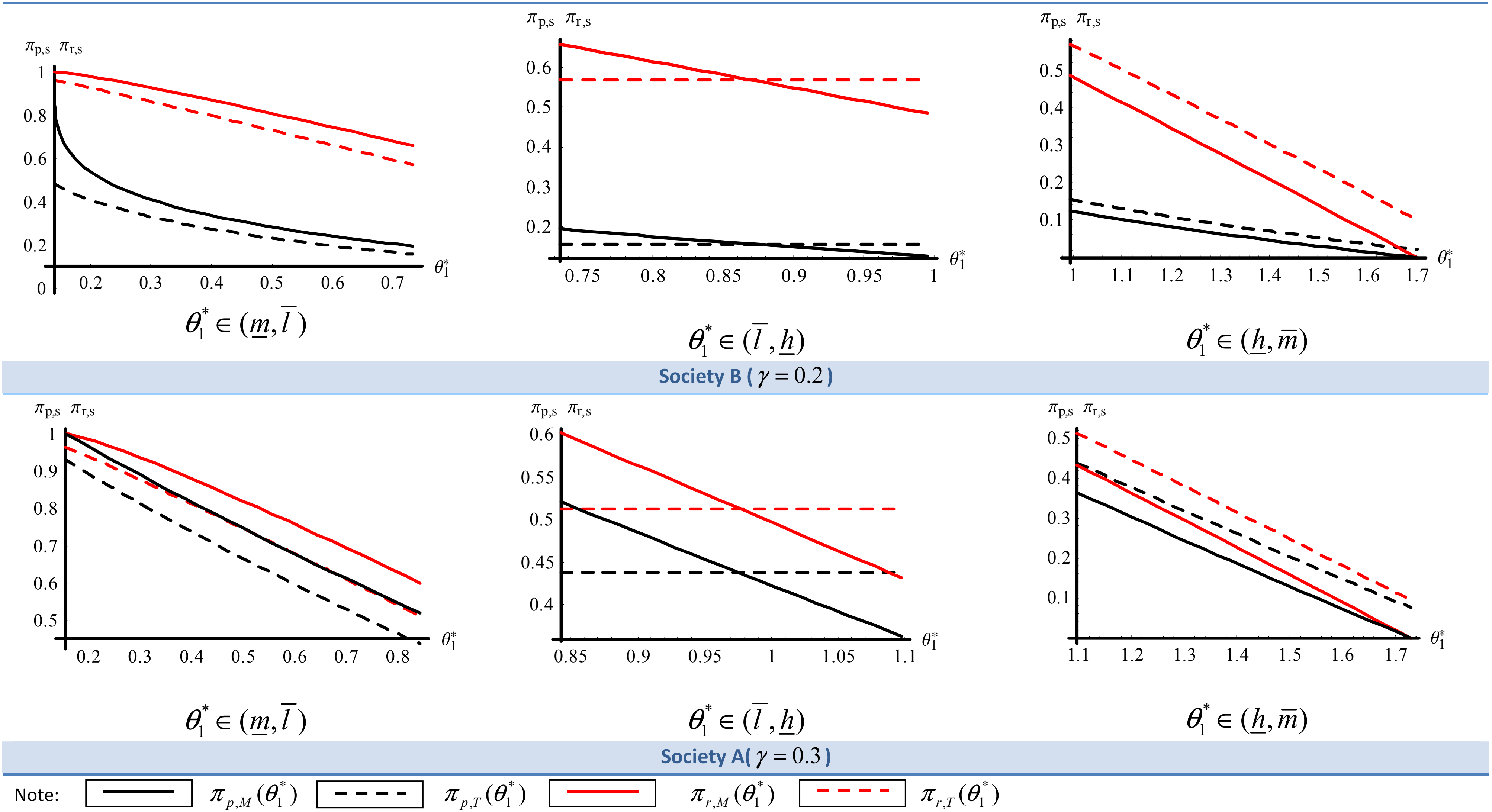


Figure 3: College attendance for poor and rich students

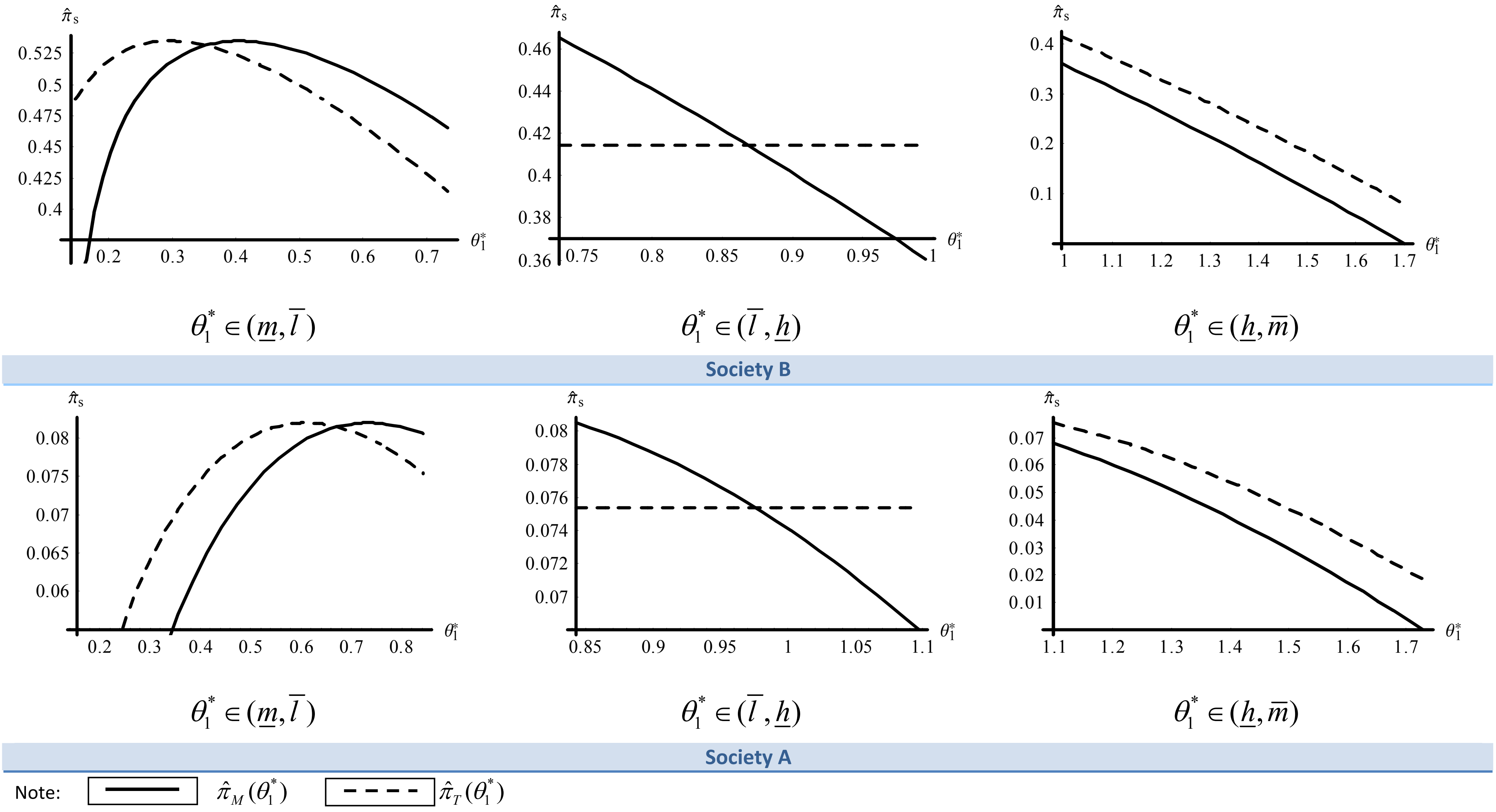


Figure 4: The attendance gap

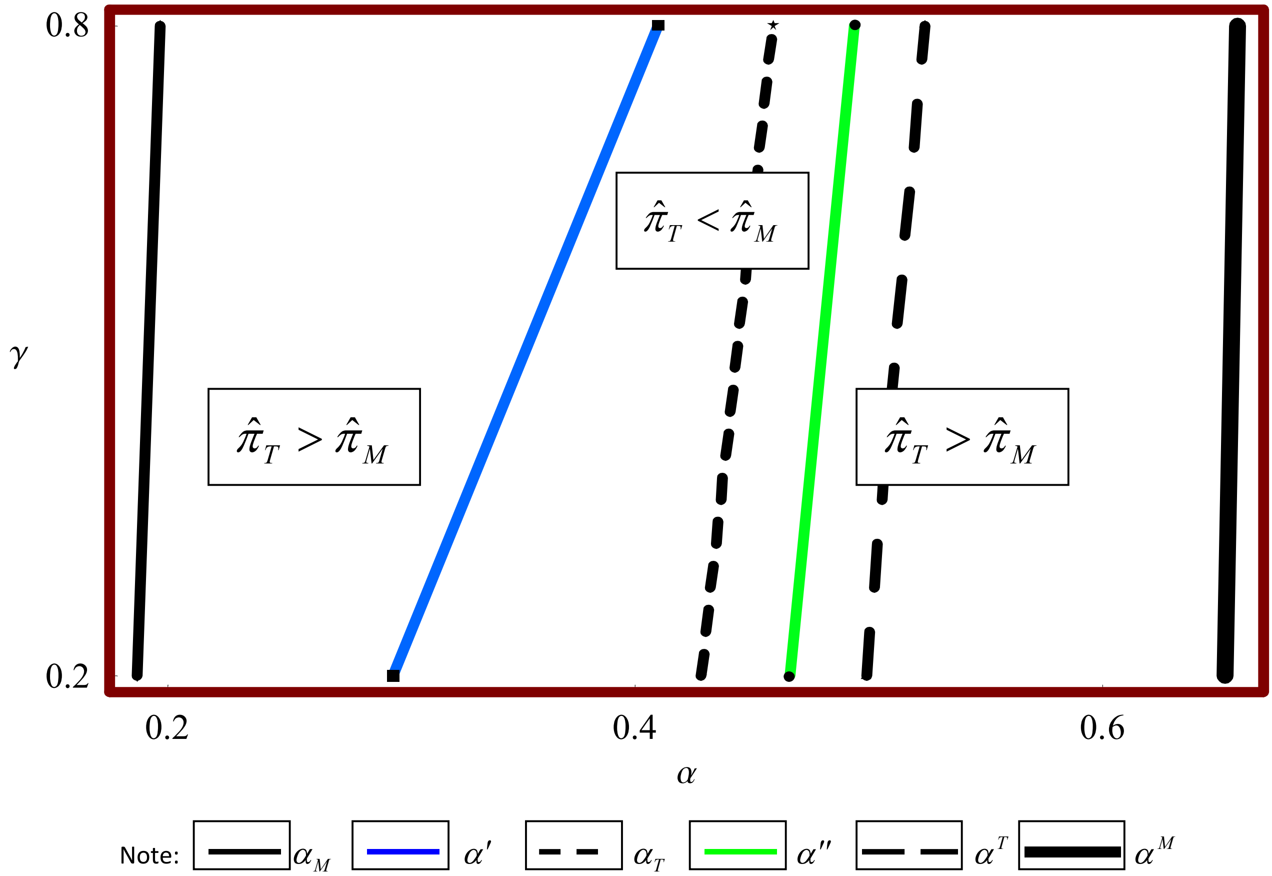


Figure 5: Equality of Opportunities