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# Three essays on the economic theory of justice : equalisation, intergenerational transfers, and education

Gaëlle Aymeric

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# THÈSE POUR OBTENIR LE GRADE DE DOCTEUR DE L'UNIVERSITÉ DE MONTPELLIER

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**Three Essays on the Economic Theory of Justice:  
Equalisation, Intergenerational Transfers and Education**

**Trois Essais sur la Théorie Economique de la Justice :  
Egalisation, Transferts Intergénérationnels et Education**

**Présentée par Gaëlle AYMERIC**

**Le 12 Décembre 2023**

**Sous la direction de Brice MAGDALOU  
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**UNIVERSITÉ  
DE MONTPELLIER**

**UNIVERSIDAD COMPLUTENSE DE MADRID**  
**FACULTAD DE CIENCIAS ECONÓMICAS Y EMPRESARIALES**



**TESIS DOCTORAL**

Three Essays on the Economic Theory of Justice:  
Equalisation, Intergenerational Transfers and Education

Tres Ensayos sobre la Teoría Económica de la Justicia:  
Igualación, Transferencias Intergeneracionales y Educación

MEMORIA PARA OPTAR AL GRADO DE DOCTORA

PRESENTADA POR

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PRESENTADA PARA OBTENER EL TÍTULO DE DOCTOR**

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## General Summary (English)

Higher level of income inequality leads to lower income mobility across generations. This phenomenon is called the Great Gatsby Curve, and it brings us to question inequality in the light of the notion of justice. Indeed, who is to consider fair a society where incomes, like privileges in other times, are inherited? If the driving force behind rising inequality is highly controversial in the economic literature, a consensus seems to have been reached on the necessity to promote equality of opportunity: A reduction of the correlation between people's outcomes and their socioeconomic backgrounds, can be viewed as a social improvement. This thesis aims at contributing to the literature on economic justice through two different approaches: snapshot and long-run analysis. It is made up of three publishable papers, each of them dealing with a different aspect of the economic theory of justice: Equalisation, intergenerational transfers and education.

In a first chapter, we try to define what is a reduction of inequalities, using a web experiment on a representative sample of the French population. We test the acceptability of the Pigou-Dalton principle of transfers, according to which a mean-preserving transfer of income from one individual to another who is relatively poorer, reduces inequality. We also test three alternative principles that impose restriction at the bottom and/or the top of the distribution. At the bottom of the distribution, if an individual receives a certain amount of income, the same amount must be received by those poorer than him (uniformity on the left). At the top of the distribution, if an individual is a donor, all those richer

than him must contribute as much (uniformity on the right). Non-uniform transfers are rejected by a majority of respondents (over 60%), which calls into question all the inequality indices consistent with the Pigou-Dalton principle (including the Gini). Uniform transfers are significantly more approved, with greater acceptance of uniform transfers on the left. We also estimate, for each respondent, two classes of social welfare functions (utilitarianism and extended Gini) that represent their ethical preferences. In particular, for the extended Gini class, we find that the median level of inequality aversion obtained is well above that of the Gini coefficient, suggesting that French society is more sensitive to poverty than commonly configured in the Gini coefficient.

In a second chapter, we investigate the impact of the parental environment on the student's academic performance in mathematics, literature and English (as a foreign language), using a new database covering all children aged 8 to 15 of the Madrid community, from 2016 to 2019. Parental environment refers here to the parents' level of education (i.e. the skills they acquired before bringing up their children), and parental investment (the effort made by parents to bring up their children). We distinguish the persistent effect of the parental environment from the so-called Matthew effect, which describes a possible tendency for the impact of parental environment to increase as the child grows up. Whatever the subject, our results are in line with most studies concerning the persistent effect: a favourable parental environment goes hand in hand with better results for the children. As regards the Matthew effect, the results differ between subjects: while the impact of the parental environment tends to diminish from age 11 in mathematics and literature, it increases in English. Those results are interesting and shed light on the social discrimination that can be intensified depending on the weight put on the different subjects at the time of selecting students.

Finally, the third chapter analyses the link between student's academic performance, student's grade retention probability and her date of birth. If being



part of the youngest of the group has a well-known negative impact on school achievement in early grade levels, it remains unclear whether this impact persists over time or disappears. Empirical studies differ according to countries, due to scholar system's particularities. In this chapter we show that relative age effect is high in Grade 3 in Madrid Community (Spain) in mathematics, literature, and English (second language) among all social backgrounds. This effect declines sharply as children grow and even disappears in mathematics in Grade 10. We also show that grade retention is high among children born in Q4 in Grade 3 compared to those born in Q1 (+123%). But this strong disequilibrium evolves to more balanced ratios in Grade 10 (+43% more likely to have repeated in Grade 10 if born in Q4 compared to Q1). Contrary to other countries like Canada, England, USA or Japan, the Madrilenian scholar system is not facing the challenge of the persistence of relative age effect over time.

## Résumé Général (Français)

Un plus haut niveau d'inégalité de salaire entraîne une plus faible mobilité salariale d'une génération à l'autre. Ce phénomène est appelé la courbe de Gatsby le Magnifique, et nous amène à questionner l'inégalité à la lumière de la notion de justice. En effet, qui peut considérer comme juste une société où les salaires, comme les privilèges à une autre époque, sont hérités des générations antérieures? Si les explications à l'augmentation des inégalités sont très controversées dans la littérature économique, un consensus semble avoir été trouvé sur la nécessité de promouvoir l'égalité des chances: Une réduction de la corrélation entre la réussite/l'échec des gens et leur milieu socio-économique, peut-être perçue comme une amélioration sociale. Cette thèse a pour but de contribuer à la littérature sur la théorie économique de la justice à travers deux approches différentes: une vision instantanée et une vision long-terme. Elle est composée de trois articles publiables, chacun traitant d'un aspect différent de la théorie économique de la justice: l'égalisation, les transferts intergénérationnels et l'éducation.

Dans un premier chapitre, nous essayons de définir ce qu'est une réduction des inégalités, en utilisant une expérience web sur un échantillon représentatif de la population française. Nous testons l'acceptabilité du principe des transferts à la Pigou-Dalton, selon lequel un transfert de revenu, qui préserve la moyenne, d'un individu vers un autre qui est relativement plus pauvre, réduit les inégalités. Nous testons également trois principes de transferts alternatifs qui imposent une restriction en queue et/ou en tête de distribution. En queue

de distribution, si un individu reçoit une certaine quantité de revenu, la même quantité doit être reçue par ceux plus pauvres que lui (uniformité à gauche). En tête de distribution, si un individu est donneur, tous ceux plus riches que lui doivent contribuer à hauteur du même montant (uniformité à droite). Les transferts non-uniformes sont rejetés par la majorité des répondants (plus de 60%), ce qui interroge la pertinence des indices de mesure des inégalités en accord avec le principe de Pigou-Dalton (l'indice de Gini inclus). Les transferts uniformes sont significativement plus acceptés, avec un plus fort taux d'acceptation pour les transferts uniformes à gauche. Nous avons également estimé, pour chaque répondant, deux classes de fonctions de bien-être social (utilitarisme et Gini étendu) qui représentent leurs préférences éthiques. En particulier, pour la classe de Gini étendu, nous trouvons que le niveau médian obtenu de l'aversion aux inégalités est bien au-dessus de celui du coefficient de Gini, suggérant que la société française est plus sensible à la pauvreté que ce qui est communément paramétré dans le coefficient de Gini.

Dans le second chapitre, nous étudions l'impact de l'environnement parental sur la réussite scolaire de l'élève en mathématiques, littérature et anglais (LV2), grâce à l'exploitation d'une nouvelle base de données regroupant les élèves de *CE2* (8 ans), *6<sup>ème</sup>* (11 ans) et *2<sup>nde</sup>* (15 ans) de toute la Communauté de Madrid, pour les années 2016 à 2019. L'environnement parental se réfère ici au niveau de formation des parents (les compétences qu'ils ont acquises avant d'élever leurs enfants) et à l'investissement des parents (l'effort fait par les parents pour élever leurs enfants). Nous distinguons l'effet de persistance de l'environnement parental du dénommé effet Matthieu, qui décrit la possible tendance de l'impact de l'environnement parental à augmenter avec l'âge de l'enfant. Quelque soit la matière, nos résultats sont en ligne avec la plupart des études concernant l'effet de persistance: un environnement parental favorable va de pair avec une meilleure réussite scolaire de l'enfant. En ce qui concerne l'effet Matthieu, les résultats diffèrent selon les matières: alors que l'impact de l'environnement familial tend à diminuer à partir de 11 ans en mathématiques

et en littérature, il augmente en anglais. Ces résultats sont intéressants et apporte un éclairage sur l'intensification possible de la discrimination sociale selon le poids qui est mis sur les différentes matières à l'heure de sélectionner les élèves.

Finalemment, le troisième chapitre analyse le lien entre la réussite scolaire des élèves, leur probabilité de redoubler une classe et leur date de naissance. S'il est bien connu qu'être né en fin d'année a un impact négatif sur la réussite scolaire dans les premières années d'école, il est peu clair si cet impact persiste dans le temps ou disparaît. Les études empiriques diffèrent selon les pays, en raison des particularités de chaque systèmes scolaires. Dans ce chapitre nous montrons que l'effet de l'âge relatif est important en *CE2* dans la Communauté de Madrid (Espagne) en mathématiques, littérature, et anglais (LV2) dans tous les milieux sociaux. Cet effet décline nettement à mesure que l'enfant grandit et va jusqu'à disparaître en mathématiques en *2<sup>nde</sup>*. Nous montrons aussi que la probabilité de redoubler est élevée parmi les enfants nés au *4<sup>ème</sup>* Trimestre en *CE2* comparativement à ceux nés au *1<sup>er</sup>* Trimestre (+123%). Mais ce fort déséquilibre évolue vers des ratios plus équilibrés en *2<sup>nde</sup>* (probabilité d'avoir redoublé au moins une classe 43% plus élevée si l'enfant est né au *4<sup>ème</sup>* Trimestre plutôt qu'au *1<sup>er</sup>* Trimestre en *2<sup>nde</sup>*). Contrairement à d'autres pays comme le Canada, l'Angleterre, les Etats-Unis ou le Japon, le système scolaire madrilène ne fait pas face au défi de la persistance de l'effet de l'âge relatif dans le temps.

## Resumen General (Castellano)

Un nivel más alto de desigualdad de sueldo genera una movilidad salarial más baja entre una generación y la otra. Ese fenómeno se llama la curva del Gran Gatsby, y nos lleva a cuestionar la desigualdad a la luz de la noción de justicia. ¿Pues, quién puede considerar justa una sociedad donde los sueldos, al igual que los privilegios en otros tiempos, se heredan? Si las explicaciones al aumento de las desigualdades son muy controvertidas en la literatura económica, un consenso parece haber sido encontrado sobre la necesidad de promover la igualdad de oportunidades: Una reducción de la correlación entre el éxito/el fracaso de una persona y su entorno socioeconómico puede considerarse como una mejora social. Esa tesis doctoral tiene como objetivo contribuir a la literatura sobre la teoría económica de la justicia a través de dos enfoques diferentes: una visión instantánea y una visión a largo plazo. Se compone de tres artículos publicables, cada uno tratando un aspecto diferente de la teoría económica de la justicia: la igualación, las transferencias intergeneracionales y la educación.

En el primer capítulo, intentamos definir lo que es una reducción de desigualdades, usando una experiencia web sobre una muestra representativa de la población francesa. Probamos la aceptabilidad del principio de transferencias Pigou-Dalton, según las cuales una transferencia de ingresos, que mantenga la media, de un individuo hacia otro individuo relativamente más pobre, reduce la desigualdad. Probamos también tres principios de transferencias alternativos que imponen una restricción en la cola y/o en la cabeza

de la distribución. En la cola de la distribución, si un individuo recibe una cierta cantidad de ingreso, la misma cantidad debe ser recibida por todos los más pobres que el (uniformidad a la izquierda). En la cabeza de la distribución, si un individuo es donante, todos los más ricos que el deben contribuir a la misma altura (uniformidad a la derecha). Las transferencias no-uniformas están rechazadas por la mayoría de los encuestados (más del 60%), lo que cuestiona la pertinencia de los índices de medida de la desigualdad en acuerdo con el principio de Pigou-Dalton (el índice de Gini incluido). Las transferencias uniformas están significativamente más aceptadas, con una tasa de aceptación más alta para las transferencias uniformas a la izquierda. Estimamos también, para cada encuestado, dos clases de funciones de bienestar social (utilitarismo y Gini extendido) que representan sus preferencias éticas. En particular, para la clase de Gini extendido, encontramos que el nivel mediano obtenido de aversión a la desigualdad está muy por encima al del coeficiente de Gini, sugiriendo que la sociedad francesa es más sensible a la pobreza de lo que es comúnmente definido en los parámetros del coeficiente de Gini.

En el segundo capítulo, estudiamos el impacto del entorno parental sobre el rendimiento escolar del alumno en matemáticas, literatura e inglés (lengua extranjera), mediante la explotación de una nueva base de datos agrupando alumnos de 3<sup>ro</sup> de Primaria (8 años), 6<sup>to</sup> de Primaria (11 años) y 4<sup>to</sup> de la ESO (15 años) de toda la Comunidad de Madrid, para los cursos 2016 hasta 2019. El entorno parental se refiere aquí al nivel de formación de los padres (las competencias que adquirieron antes de criar a sus hijos) y a la inversión de los padres (el esfuerzo hecho por los padres para criar a sus hijos). Distinguimos el efecto de persistencia del entorno parental del denominado efecto Mateo, que describe la posible tendencia del impacto del entorno parental a aumentar con la edad del hijo. Independientemente de la asignatura, nuestros resultados están alineados con la mayoría de los estudios en cuanto al efecto de persistencia: Un entorno parental favorable va de la mano con un mejor rendimiento escolar del hijo. Respecto al efecto Mateo, los resultados difieren

dependiendo de la asignatura: mientras el impacto del entorno familiar tiende a disminuir a partir de los 11 años en matemáticas y en literatura, aumenta en inglés. Esos resultados son interesantes y aclaran la posible intensificación de la discriminación social según el peso puesto en las diferentes asignaturas a la hora de seleccionar a los alumnos.

Finalmente, el tercer capítulo analiza el vínculo entre el rendimiento escolar del alumno, su probabilidad de repetir curso y su fecha de nacimiento. Si está bien conocido el hecho de que haber nacido a final de año tiene un impacto negativo sobre el rendimiento escolar durante los primeros años de escolarización, queda menos claro si ese impacto persigue en el tiempo o desaparece. Los estudios empíricos difieren según los países, debido a las particularidades de cada sistema escolar. En este capítulo mostramos que el efecto de la edad relativa es importante en 3<sup>ro</sup> de Primaria en la Comunidad de Madrid (España) en matemáticas, literatura, e inglés (lengua extranjera) en todos los entornos sociales. Ese efecto disminuye claramente a medida que el alumno crece y llega a desaparecer en matemáticas en 4<sup>to</sup> de la ESO. Mostramos también que la probabilidad de repetir curso es alta entre los alumnos nacidos en el 4<sup>to</sup> Trimestre en 3<sup>ro</sup> de Primaria comparativamente a los nacidos en el 1<sup>er</sup> Trimestre (+123%). Pero ese fuerte desequilibrio evoluciona hacia ratios más equilibradas en 4<sup>to</sup> de la ESO (probabilidad de haber repetido al menos una vez 43% más elevada si el alumno ha nacido en el 4<sup>to</sup> Trimestre en vez del 1<sup>er</sup> Trimestre). A diferencia de otros países como Canadá, Inglaterra, los Estados-Unidos o Japón, el sistema escolar madrileño no se enfrenta al desafío de la persistencia del efecto de la edad relativa con el tiempo.

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## General Introduction

There is now evidence that income and wealth inequalities have significantly increased over the last three decades in most OECD countries. It is illustrated by the statistical series collected in Thomas Piketty's successful book *Capital in the Twenty-First Century* (Piketty, 2014) and in the World Inequality Database (WID.World). In addition, there is an emerging literature suggesting that "more inequality of incomes in the present is likely to make family background play a stronger role in determining the adult outcomes of young people" (Corak, 2013), which include income but also educational outcomes. Hence high income and wealth inequality seem to be associated with low inter-generational mobility, a relationship that has been called "The Great Gatsby Curve".

If the driving force behind rising inequality is highly controversial in the economic literature, a consensus seems to have been reached on the necessity to promote equality of opportunity: A reduction of the correlation between people's outcomes and their socioeconomic backgrounds, can be viewed as a social improvement.

The fact that higher level of inequality implies smaller social mobility, as shown by the Great Gatsby Curve, sheds light on the strong link between inequality and justice. If, in a society, the best predictor of a child's future is her parents present, and if less equality today rhymes with more determinism tomorrow, one may question the notion of justice in this society. How are we to accept a society where privileges are inherited and where determinism

supplants freedom? As a consequence, the first academic field which started to study justice and inequalities is philosophy.

[Rawls \(1971\)](#) was the first to propose a theory of justice in opposition to welfarism. The objective was not to maximize the welfare of individuals but to maximize the situation of the worst-off individuals in terms of primary goods. His liberal egalitarian theory assesses the situation based on the means individuals have to achieve their own objectives and not on the final wealth distribution. In his theory, equality of opportunity replaces equality of outcomes.

[Sen \(1980, 1985\)](#) enriches Rawls' theory saying that what is important is not the good in itself, but the ability of such a good to produce satisfaction, or welfare, for the individual. He defines capabilities as a set of functioning vectors an individual has access to. And, to him, justice lies in the equalization of the individual capabilities.

[Dworkin \(1981a,b\)](#), building on Rawls, defines justice as the equal treatment of the individuals. He distinguishes equalization of welfare, which is not ethically relevant, and equalization of resources, which need to be separated between internal and external resources. He goes further than Rawls and Sen in the implication of the dimension which relates to individual responsibility. To him, justice needs to compensate for the aspects of the individual's situation which prevent him from achieving his objectives, but only when he is not responsible for. All dimensions related to individual choices and acts are not relevant for justice.

Based on the works of Rawls, Sen, Dworkin and others, most of the modern theories of justice focus now on the equality of opportunity. In economics, there is a growing literature on equality of opportunity (see [Roemer and Trannoy, 2016](#); [Ramos and Van de Gaer, 2016](#), for exhaustive surveys). According to the equality of opportunity framework, inequality due to responsibility or freedom of choice is not considered as unfair. In return, inequality related to

factors beyond the individual's control, called circumstances, is described as socially undesirable. In such cases, full compensation is required. In the standard literature, all the dimensions which come into play in the early childhood, and which affect positively outcomes as an adult (parents' earnings, achievements in primary education, etc.) are called circumstances as they are not a consequence of the own, deliberate, individual's choices.

This PhD presentation aims at contributing to the literature on the notion of justice, using two main different approaches: snapshot and long-run analysis.

In the snapshot approach, we try to define what is a transfer that reduces inequalities, with a social planner able to consider individual preferences. We do not adopt an equality of opportunity's perspective, asking ourselves whether the income distribution is fair regarding the effort supplied by the individuals, or their social background. In this chapter, all individuals are supposed to be identical in every respects other than their income, and we want to question what is, according to the subjects in the society (experimental approach), a reduction of existing inequalities. Indeed, in the literature of inequality measurement, it is accepted that a Pigou-Dalton transfer unambiguously decreases inequality. Yet, those progressive transfers are not widely accepted by the subjects as reducing inequality. They do not convey a common sense of justice. Through an experiment, we test different types of transfers and see which of them are the most accepted as inequality reducers. Each subject is considered as an ethical observer and her answers to the questions as a revealing of her preferences. From that experiment we see that individuals do not accept widely the Pigou-Dalton transfers and approve more demanding ones. This result leads us to question the use of common indices like the Gini index, which has close links with the Pigou-Dalton transfer, to measure inequality.

In the long-run approach, we ask ourselves how to make future societies fairer, focusing on intergenerational transfers and the education area. In a first part we study the evolution of the impact of parental environment (par-

ents' highest education and parental investment) on their child's academic performance. In a second part we analyse the persistence of date of birth's disadvantage along the schooling process through academic performance and grade retention probability. Given the fact that both parental environment and date of birth are two circumstances for the child (something she cannot be held responsible for, and which should be compensated according to the equality of opportunity theory), we would expect those effects to disappear with age, or at least to decrease, if we want the society to be fair. In those two chapters, we adopt a long-term vision in the light of the equality of opportunity theory. We are no more in a static vision. On the contrary, we study the impact of chosen circumstances on students' achievement at different grade levels. Even if we do not have panel data (we are not able to follow a specific student over time), we have homogenous data of all the Madrid Community students, which enables us to isolate general trends. What interests us here are not the academic discrepancies among the students but the part of those discrepancies that is explained by the student's specific circumstances. If equality of opportunity is ensured, circumstances should not play a role at explaining academic gaps. Our data, for the two circumstances studied, prove it wrong. Which implies that equality of opportunity is broken for those two circumstances (parental environment and date of birth). Building on the richness of our unique database, we then study the evolution of those circumstances' impact through age. We find interesting and balanced results for the first circumstance (parental environment): Depending on the subject under analysis, a Matthew effect is observed (English as foreign-language) or not (mathematics and literature). For the second circumstance (date of birth), results show a clear decreasing of the impact as the child ages, proving the good functioning of the Madrilenian scholar system as for that aspect.

The PhD presentation is organized as followed: Each chapter corresponds to a publishable paper that I arranged to fit a chapter format. The first chapter deals with snapshot approach of justice testing the acceptability of

different types of transfers, based on a web experiment on a representative sample of the French population. The second chapter considers the question of intergenerational transfers through a dynamic analysis of the impact of parents' highest education on their child's academic performance at different grade levels. The third chapter studies the evolution of the impact of the date of birth on student's academic performance and grade retention probability in the Madrilenian community. Finally, a general conclusion on the PhD's contribution ends the presentation.

## Chapter 1

### Does a progressive transfer really reduce income inequalities?

This paper<sup>1</sup> reports the results of a web experiment on a representative sample of the French population. We test the acceptability of the Pigou-Dalton principle of transfers, according to which a mean-preserving transfer of income from one individual to another who is relatively poorer, reduces inequality. We also test three alternative principles that impose restriction at the bottom and/or the top of the distribution. At the bottom of the distribution, if an individual receives a certain amount of income, the same amount must be received by those poorer than him (uniformity on the left). At the top of the distribution, if an individual is a donor, all those richer than him must contribute as much (uniformity on the right). Non-uniform transfers are rejected by a majority of respondents (over 60%), which calls into question all the inequality indices consistent with the Pigou-Dalton principle (including the Gini). Uniform transfers are significantly more approved, with greater acceptance of uniform transfers on the left. We also estimate, for each respondent, two classes of social welfare functions (utilitarianism and extended Gini) that represent their ethical preferences. In particular, for the extended Gini class, we find that the median level of inequality aversion obtained is well above that of the Gini coefficient.

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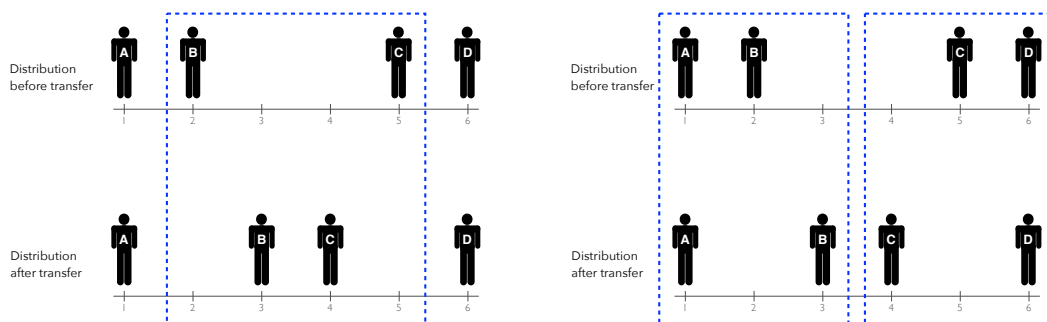
<sup>1</sup> This paper is co-written with Brice Magdalou, University of Montpellier, CNRS, AMSE, Marseille, France.

### 1.1. Introduction

Since the seminal work of [Kolm \(1969\)](#) and [Atkinson \(1970\)](#), the *Pigou-Dalton principle of transfers* is the cornerstone of the theory of income inequality measurement. According to this normative principle, a mean-preserving transfer of income from one individual to another who is relatively poorer, without reversing the initial positions on the income scale, always reduces inequality. All the income inequality indices used today, both in (most) academic research and by national and international statistical institutes, are consistent with this principle.

Clearly, income inequality is reduced between the two people involved in a progressive transfer. However, the effect of such a transfer on the overall inequality in the distribution may be open to discussion. By way of illustration, let's consider a society consisting of 4 individuals who are perfectly identical, apart from their income. Let's call these individuals A, B, C and D and say that they have, respectively, 1, 2, 5 and 6 income units. Suppose a transfer of 1 unit of income is made from individual C to B. The left-hand side of [Figure 1.1](#) illustrates the fact that these two individuals get closer on the income scale. The (relative) situation of the individuals not concerned by the

Figure 1.1: *Impact of a progressive transfer on the global distribution*





transfer is highlighted in the right-hand side. After the transfer, the poorest individual (A) is left behind. Even if she can be considered a priority target for redistribution, her situation remains unchanged, whereas it is improved for individual B, who was already richer than her before the transfer. On the other side of the distribution, individual C contributes to the transfer, while the richest individual (D) does not. Such arguments may be enough to convince people that a distribution obtained by means of certain progressive transfers is not necessarily more equal than the distribution before transfer.

The previous example illustrates a deep-seated problem with the principle of transfers: It associates the notion of ‘reduction of a partial statistic distance’ to the notion of ‘reduction in global inequality’. As inequality is a normative concept, the equivalence between these two notions is not immediate. [Amiel and Cowell \(1992\)](#) were the first to observe, through a questionnaire experiment with students, the low approval of certain progressive transfers, particularly those not involving individuals at the extremes of the distribution. Despite the fact that this finding has been confirmed by numerous subsequent experiments ([Amiel and Cowell, 2002](#); [Gaertner and Namazie, 2003](#); [Amiel \*et al.\*, 2012](#), to name a few), few studies have sought to find an alternative to this principle that is more in line with people’s ethical preferences.

This low approval rate of the Pigou-Dalton principle of transfers may be explained by the way people assess their own position in the income distribution. Although individuals attach importance to the absolute level of their income, it is now generally accepted that they attach as much, if not more, importance to their *relative position* on the income scale ([Clark \*et al.\*, 2008](#)). They are also sensitive to changes in their own situation, relative to individuals in their *reference group*, which can be defined on the basis of social, professional or neighborhood considerations. In various branches of economic literature (macroeconomics, finance, labour economics, etc.), this robust fact has been referred to the *keeping up with the Joneses* effect ([Abel, 1990](#)). Comparable

considerations are also found in sociology through, for example, the notion of *deprivation* (Runciman, 1966). In the example given above, we can see that the distribution is in some sense polarised, with a homogeneous group of two individuals at the bottom of the distribution, and the same at the top. After the transfer, individual B's income gain is associated with a deterioration in the relative situation of individual A in the bottom group, and individual C in the top group. These cumulative changes may therefore not be seen as reducing overall inequality.

Chateauneuf and Moyes (2006) proposed three possible alternatives to the principle of transfers and identified the preorder relations, to compare pairs of income distributions and comparable to the Lorenz curve criterion, which are compatible with these different principles. The Pigou-Dalton principle imposes no restrictions on the income transfers, other than the fact that the transfer must be mean-preserving, and that the donor must be and remain richer than the recipient. The alternative principles impose a form of solidarity (or uniformity) at the bottom and/or the top of the distribution. At the bottom of the distribution, if an individual receives a certain amount of income, the same amount at least must be received by those poorer than him. This is called a *uniform-on-the-left* transfer (UL). At the top of the distribution, if an individual is a donor, all those richer than him must contribute, at least as much. This is called a *uniform-on-the-right* transfer (UR). A transfer that combines the two restrictions is called a *uniform-on-the-right-and-left* transfer (URL).

This paper proposes a web experiment to test the acceptability of the Pigou-Dalton principle of transfers, and of the three alternatives described above. The experiment has been conducted in January 2021 with a sample of 1028 respondents, representative of the French population. We constructed pairs of income distributions the respondents had to compare (in terms of inequality), for a fictive society consisting of 5 individuals presented as per-

fectly identical apart from their income. In each pair of distributions, one was obtained from the other by a progressive transfer, uniform or not. On the basis of the responses to the questionnaire as a whole, we were able to assess each respondent's acceptance of the four principles tested (URL, UL, UR and non-uniform transfers, noted PT). We were also able to estimate two classes of social welfare functions for each of them, in order to best represent their ethical preferences. We first estimated the parametric form of the utilitarian functions underlying the *Atkinson-Kolm-Sen inequality indices* (Kolm, 1969; Atkinson, 1970; Sen, 1973). We then estimated the parametric form of the functions underlying the *extended Gini indices* (Donaldson and Weymark, 1980).

Our first important result confirms the disapproval of non-uniform progressive transfers. This means that the Pigou-Dalton principle of transfers, defined in the usual sense, is not in line with respondents' ethical preferences. Uniform transfers receive significantly more support. If uniformity of transfer is imposed on only one side of the distribution, then uniformity on the left (solidarity among the poor) seems to be preferred. This overall trend is robust, whatever the initial distribution considered before transfer, and whatever the socio-economic characteristics of the respondents (gender, level of education, political orientation, etc.). The estimation of social welfare functions also provides interesting information. While the inequality aversion parameter estimated within the utilitarian approach is identical to that obtained in other comparable studies (Amiel *et al.*, 1999, in particular), the estimation of this parameter within the extended Gini framework (which has never been estimated to our knowledge) reveals an aversion to inequality that is significantly stronger than that captured by the Gini coefficient. Just like the Pigou-Dalton principle of transfers, and probably for the same reasons, this index is also being called into question.

The rest of the paper is organised as follows. In Section 1.2, we outline

the normative theory of inequality measurement, based on the Pigou-Dalton principle of transfers. We set out the notation, the main income inequality measurement tools and the alternatives to this principle. We also discuss some experimental results which, although they do not address precisely the same issues as we do, seem to confirm the empirical relevance of the new principles. We present our experimental design in Section 1.3. We describe the sample of respondents, we detail the various stages of the experiment, and we show how the pairs of income distributions, that the respondents had to compare, were constructed. All our results are centralised and discussed in Section 1.4. We first present the acceptance rates for the different transfer principles. We then look at whether the initial distributions, or the socio-economic characteristics of the respondents, have an influence on the results. We then outline the method used to estimate the social welfare functions for each subject, and we present the values of the estimated coefficients. Finally, the Section 1.5 concludes.

## 1.2. The normative theory of inequality measurement

### 1.2.1. The framework

NOTATION. We consider a population consisting of  $n \geq 2$  individuals, identical in every respects other than their income. Income of individual  $i$  is denoted by  $x_i \in \mathcal{D}$ , where  $\mathcal{D}$  is an interval of the non-negative real numbers, and an income distribution is a list  $\mathbf{x} = (x_1, x_2, \dots, x_n)$ . We restrict attention to non-decreasingly ordered distributions, and the set of these distributions is denoted  $\mathcal{D}^n$ .<sup>2</sup> The mean income of distribution  $\mathbf{x}$  is indicated by  $\mu(\mathbf{x}) = \sum_{i=1}^n x_i/n$ .

---

<sup>2</sup> This framework is deliberately simplified, and it is defined without loss of generality. The inequality measures we present in this paper are all consistent with the symmetry axiom (invariance with respect to a permutation of the distribution) and Dalton's principle of populations (invariance to an identical replication of the population).

INEQUALITY REDUCTION. In the inequality measurement literature, it is usually assumed that a mean-preserving transfer of income from one individual to another who is relatively poorer, without reversing the initial positions on the income scale, always reduces inequality. Such a transfer is known as a Pigou-Dalton progressive transfer, and is formally defined as follows:

**Definition 1.2.1** (Pigou-Dalton Transfer). *Given two income distributions  $\mathbf{x}, \mathbf{y} \in \mathcal{D}^n$ , we say that  $\mathbf{x}$  is obtained from  $\mathbf{y}$  by means of a Pigou-Dalton (progressive) transfer, if there exists  $\delta > 0$  and two individuals  $1 \leq h < k \leq n$  such that  $\mathbf{x} = \mathbf{y} + \mathbf{t}$  and:*

---

INDIVIDUAL =	1	...	$h-1$	$h$	$h+1$	...	$k-1$	$k$	$k+1$	...	$n$
$\mathbf{t} =$	(0	...	0	$\delta$	0	...	0	$-\delta$	0	...	0)

---

Acceptance of the inequality-reducing nature of such a transfer is known as the (Pigou-Dalton) principle of transfers.

SOCIAL WELFARE FUNCTIONS. According to the so-called ethical approach to measuring inequality (Blackorby *et al.*, 1999), it is used to assess the inequality of a distribution  $\mathbf{x} \in \mathcal{D}^n$  on the basis of a social welfare function  $W : \mathcal{D}^n \rightarrow \mathbb{R}$ . Traditionally two subclasses of the *rank-dependent expected utility model* popularized by Quiggin (1993) are considered in the literature. Firstly, there is the *utilitarian approach*, which assumes that social welfare is the average of the utilities obtained by individuals, denoted by:

$$W_u(\mathbf{x}) = \frac{1}{n} \sum_{i=1}^n u(x_i), \quad \forall \mathbf{x} \in \mathcal{D}^n, \quad (1.2.1)$$

where  $u \in \mathcal{U} = \{u : \mathcal{D} \rightarrow \mathbb{R} \mid u \text{ continuous and non-decreasing}\}$  is the utility function (defined up to an increasing affine transformation). Secondly, there

is the *extended Gini approach*, with a social welfare function defined by:

$$W_f(\mathbf{x}) = \sum_{i=1}^n \left[ f\left(\frac{n-i+1}{n}\right) - f\left(\frac{n-i}{n}\right) \right] x_i, \quad \forall \mathbf{x} \in \mathcal{D}^n, \quad (1.2.2)$$

where  $f \in \mathcal{F} = \{f : [0, 1] \rightarrow [0, 1] \mid f \text{ continuous, non-decreasing, } f(0) = 0, f(1) = 1\}$  is the weighting function.

**EQUIVALENCE RESULT.** The main result in the literature on income inequality measurement is the Hardy-Littlewood-Polya theorem (see [Magdalou, 2021](#)), which establishes the equivalence between several statements. To be precise, each statement defines a preorder relation (incomplete ranking) which describes a situation where a distribution  $\mathbf{x}$  provides more social welfare than a distribution  $\mathbf{y}$ . Because the averages of the two distributions are equal, this also means that the first distribution is less unequal. Formally, we have:<sup>3</sup>

**Proposition 1.2.1.** *Let  $\mathbf{x}, \mathbf{y} \in \mathcal{D}^n$  such that  $\mu(\mathbf{x}) = \mu(\mathbf{y})$ . The following statements are equivalent:*

- (a)  $\mathbf{x}$  is obtained from  $\mathbf{y}$  by means of a sequence of Pigou-Dalton transfers,
- (b1)  $W_u(\mathbf{x}) \geq W_u(\mathbf{y})$ , for all concave functions  $u \in \mathcal{U}$ ,
- (b2)  $W_f(\mathbf{x}) \geq W_f(\mathbf{y})$ , for all convex functions  $f \in \mathcal{F}$ ,
- (c)  $\frac{1}{n} \sum_{i=1}^h x_i \geq \frac{1}{n} \sum_{i=1}^h y_i$ , for all  $h = 1, \dots, n-1$ .

The first statement describes an unambiguous reduction of inequality, in the sense of the principle of transfers view on inequality. The second statement presents the condition to be placed on the utility function to obtain an utilitarian social ranking of the distributions, consistent with the principle of transfers.

---

<sup>3</sup> In fact, the Hardy-Littlewood-Polya theorem is the equivalence between statements (a), (b1) and (c). The equivalence with statement (b2) can be derived from Theorem 2 in [Yaari \(1987\)](#).

The third statement is the same, but within the extended Gini framework. Finally, statement (c) corresponds to the well-known Lorenz criterion, implementable in practice.

Two specific classes of, respectively, concave utility functions  $u \in \mathcal{U}$  and convex weighting functions  $f \in \mathcal{F}$  have been considered. In the utilitarian framework, we have:

$$u_\rho(x_i) = \begin{cases} \frac{1}{\rho} x_i^\rho, & \text{if } \rho \neq 0, \\ \ln x_i, & \text{if } \rho = 0, \end{cases} \quad (1.2.3)$$

where  $\rho \leq 1$  is the inequality aversion parameter: the lower it is, the greater the aversion ( $\rho = 1$  indicates neutrality to inequality). In the extended Gini framework, we have:

$$f_\eta(t) = t^\eta, \quad \eta \geq 1. \quad (1.2.4)$$

The higher  $\eta$  is, the greater the inequality aversion ( $\eta = 1$  indicates neutrality).

**INEQUALITY INDICES.** Ethical inequality indices can be derived from such social welfare functions. For a distribution  $\mathbf{x} \in \mathcal{D}^n$ , the *equally distributed equivalent income*  $\Xi(\mathbf{x})$  is the income which, if received by each individual, gives rise to a distribution socially indifferent to  $\mathbf{x}$ , so that  $W(\mathbf{x}) = W(\Xi(\mathbf{x}), \dots, \Xi(\mathbf{x}))$ . A relative inequality index can be written as  $I(\mathbf{x}) = 1 - \Xi(\mathbf{x})/\mu(\mathbf{x})$ . In the utilitarian approach, the equally-distributed-equivalent-income is equal to  $\Xi_\rho(\mathbf{x}) = u_\rho^{-1}(\frac{1}{n} \sum_{i=1}^n u_\rho(x_i))$ , with  $u_\rho$  as defined in (1.2.3). We obtain the so-called *Atkinson-Kolm-Sen class of inequality indices* (Kolm, 1969; Atkinson, 1970; Sen, 1973). In the extended Gini approach, we simply have  $\Xi_\eta(\mathbf{x}) = \sum_{i=1}^n [f_\eta(\frac{n-i+1}{n}) - f_\eta(\frac{n-i}{n})]x_i$ , with  $f_\eta$  as defined in (1.2.4). We obtain the *Donaldson-Weymark class of inequality indices* (Donaldson and Weymark, 1980). The Gini index is obtained with  $\eta = 2$ .

### 1.2.2. Alternatives to the principle of transfers

While a progressive transfer indisputably reduces inequality between the individuals concerned by the transfer, it is less clear that inequality is reduced in the entire distribution, as illustrated in Figure 1.1. Chateauneuf and Moyes (2006) have proposed three possible restrictions to be applied to a transfer to be considered as inequality reducing.

The first one is *uniform transfers on the right and on the left* (URL). According to this alternative view, an income transfer reduces the inequality only if three conditions are satisfied. First, when an amount of income is taken to one individual, the same amount has to be taken to all the individuals richer than her. Symmetrically, when an individual receives an amount of income, the same amount has to be received by all the individuals poorer than her. Moreover, the mean income must be preserved after transfer. By definition, an URL transfer is a (sequence of) progressive transfer(s), but most of the progressive transfers are not URL transfers. Hence, URL transfers are more ethically demanding.

**Definition 1.2.2** (URL Transfer). *Given two income distributions  $\mathbf{x}, \mathbf{y} \in \mathcal{D}^n$  such that  $\mu(\mathbf{x}) = \mu(\mathbf{y})$ , we say that  $\mathbf{x}$  is obtained from  $\mathbf{y}$  by means of a uniform-on-the-right-and-left (progressive) transfer, if there exist  $\delta, \epsilon > 0$  and two individuals  $1 \leq h < k \leq n$  such that  $\mathbf{x} = \mathbf{y} + \mathbf{t}$  and:*

---

INDIVIDUAL =	1	...	$h-1$	$h$	$h+1$	...	$k-1$	$k$	$k+1$	...	$n$
$\mathbf{t} =$	$(\delta$	...	$\delta$	$\delta$	$0$	...	$0$	$-\epsilon$	$-\epsilon$	...	$-\epsilon)$

---

The second restriction refers to *uniform transfers on the right* (UR). In this case, only the mean-preserving condition and the condition related to the right-hand side of the distribution (solidarity among the rich) need to be applied. By definition, an URL transfer is an UR transfer, but the converse is not true.



**Definition 1.2.3** (UR Transfer). *Given two income distributions  $\mathbf{x}, \mathbf{y} \in \mathcal{D}^n$  such that  $\mu(\mathbf{x}) = \mu(\mathbf{y})$ , we say that  $\mathbf{x}$  is obtained from  $\mathbf{y}$  by means of a uniform-on-the-right (progressive) transfer, if there exist  $\delta, \epsilon > 0$  and two individuals  $1 \leq h < k \leq n$  such that  $\mathbf{x} = \mathbf{y} + \mathbf{t}$  and:*

---

INDIVIDUAL =	1	...	$h-1$	$h$	$h+1$	...	$k-1$	$k$	$k+1$	...	$n$
$\mathbf{t} =$	(0	...	0	$\delta$	0	...	0	$-\epsilon$	$-\epsilon$	...	$-\epsilon$ )

---

*Uniform transfers on the left* (UL) are the symmetric counterpart of UR transfers. The mean-preserving condition is associated to the condition related to the left-hand side of the distribution (solidarity among the poor). Hence, an URL transfer is also an UL transfer (converse not true), but an UR transfer and an UL transfer are of different nature (neither is implied by the other).

**Definition 1.2.4** (UL Transfer). *Given two income distributions  $\mathbf{x}, \mathbf{y} \in \mathcal{D}^n$  such that  $\mu(\mathbf{x}) = \mu(\mathbf{y})$ , we say that  $\mathbf{x}$  is obtained from  $\mathbf{y}$  by means of a uniform-on-the-left (progressive) transfer, if there exist  $\delta, \epsilon > 0$  and two individuals  $1 \leq h < k \leq n$  such that  $\mathbf{x} = \mathbf{y} + \mathbf{t}$  and:*

---

INDIVIDUAL =	1	...	$h-1$	$h$	$h+1$	...	$k-1$	$k$	$k+1$	...	$n$
$\mathbf{t} =$	( $\delta$	...	$\delta$	$\delta$	0	...	0	$-\epsilon$	0	...	0)

---

[Chateauneuf and Moyes \(2006\)](#) have established equivalence results comparable to Proposition 1, but by substituting the Pigou-Dalton transfers with the various alternatives presented here. First, they demonstrated that the utilitarian model is not flexible enough to distinguish between different principle of transfers. In each case, an equalising transfer (of whatever type) implies an increase in social welfare if and only if the utility function  $u \in \mathcal{U}$  is concave. Hence, they obtain equivalence results between comparable statements

(a), (b2) and (c), but not with (b1). For each equalising transfer (Definitions 1.2.2, 1.2.3 and 1.2.4), they identified the restriction to be placed on the weighting function  $f \in \mathcal{F}$ , and the corresponding implementation preorder (to be used instead of the Lorenz criterion).

The theory presented in this section can be used to replace the traditional theory based on the Pigou-Dalton principle of transfers. Nevertheless, the question of the relevance of the different definitions of what we call an equalising transfer, is purely normative. The aim of this paper is to check whether these views on inequality are in line with people's preferences.

### 1.2.3. An overview of some existing experimental results

The Pigou-Dalton principle of transfers has already been explored in the experimental literature (initiated by Amiel and Cowell, 1992). When the questions asked to the respondents are pairwise comparisons of income distributions (one before transfer, the other after, as in Figure 1.1), asking which is less unequal, the acceptance rates are generally little more than 50%. At the opposite, the alternative principles of transfers, as presented in the previous section, have never been directly tested. We report here the results of several papers in the same series, in which the respondents were asked the same list of numerical questions (with some nuances between papers, mainly on the description of the context presented to the subject). Even if this was not the direct objective of these studies, some questions were compatible with the different principles. These papers are: Amiel and Cowell (2002), Gaertner and Namazie (2003), Amiel *et al.* (2004), Amiel *et al.* (2009) and Amiel *et al.* (2012).

The common questions asked to the respondents are presented in Table 1.1. The initial distribution, denoted A, represents the income of 5 individuals, presented as identical in every respect other than their incomes. Incomes range from 2 units to 30. We also note that distribution B is always obtained from distribution A by a Pigou-Dalton transfer. The questionnaire, which included

Table 1.1: *The questionnaire*

QUESTIONS	Is the inequality higher in A or in B?									
	DISTRIBUTION A					DISTRIBUTION B				
<b>Q1</b>	2	5	9	20	30	2	6	8	20	30
<b>Q2</b>	2	5	9	20	30	3	5	9	20	29
<b>Q3</b>	2	5	9	20	30	2	6	9	20	29
<b>Q4*</b>	2	5	9	20	30	2	10	9	15	30
<b>Q5</b>	10	10	10	10	30	10	10	10	20	20
<b>Q6</b>	2	5	9	20	30	2	6	9	19	30

\*: Distribution B does not preserve the ranks of distribution A.

other questions depending on the specific theme of each experiment, was distributed to a group of students at different universities. The particularities of each experiment are briefly presented in Table 1.2.

Table 1.2: *Details on the experimental studies*

PAPERS	YEAR OF THE EXPE.	SUBJECTS (country & number)	COMMENTS
A & C (2002)	98/99	587 stds, 7 countries	Comparison inequality vs. risk perceptions
G & N (2003)	99/00	159 stds from Germany	Inequ. vs. risk, plus ‘income gap’ perceptions
A, C & S (2004)	94	510 stds, 17 univ. in USA	Impact of socio-demo characteristics
A, C & G (2009)	from 03 to 06	653 stds, Germany, Israel, UK	Position (involved or not) of the respondent
A, C & G (2012)	03	134 stds, Germany, Israel, UK	7 presentations for the same distrib. problem

The results are reported in Table 1.3. We also indicate the types of transfer with which each question is compatible. Only UL transfers are not represented.

Table 1.3: *The results for all the experiments*

QUESTIONS* TRANSFERS	PERCENTAGE OF ANSWER A**						ANSWER A TO ALL QUESTIONS
	<b>Q2</b> URL	<b>Q5</b> UR	<b>Q3</b> UR	<b>Q4</b> PT	<b>Q6</b> PT	<b>Q1</b> PT	
Amiel, and Cowell (2002)	74%	72%	61%	60%	48%	40%	17%
Gaernter and Namazie (2003)	63%	70%	57%	54%	40%	33%	13%
Amiel, Cowell and Slottje (2004)	54%	54%	47%	45%	Not tested	34%	10%
Amiel, Cowell and Gaertner(2009)	80%	77%	71%	61%	58%	58%	26%
Amiel, Cowell and Gaertner (2012)	80%	75%	59%	57%	44%	36%	13%

\*: Questions are ordered according to decreasing acceptance rates in Amiel and Cowell (2002).

\*\* : For all studies but A, C & G (2009), we only report the results of the inequality questionnaire;

For A, C & G (2009), we only report the results of the “respondent as external observer” scenario.

Then, we know that URL, UR and PT transfers are not independent. When

PT is written in the table, it refers to a transfer that is not of a UR or URL type (hence, without any restriction on the right or on the left). Similarly, UR is not a URL type transfer. We can immediately see that the acceptance rates vary greatly between the questions, in an order that is compatible with the ethical requirements described above: On average, URL transfers are considered to be more equalising than UR transfers, and UR transfers more than (standard) PT transfers. We can conclude that the distinctions made between the different types of transfer in the previous section are echoed in the population of respondents (in this case, students).

Strictly speaking, individuals with ethical preferences compatible with the Pigou-Dalton principle of transfers should answer A to all the questions. We note that the percentage of subjects in this case is very low: it never exceeds a quarter of the population (last column in the table). Even if uniform transfers were not formally defined and directly tested in these experiments, the intuition was already there. In [Amiel and Cowell \(2002\)](#) it is written, pages 90 and 91: *‘Accordingly it may also be useful to consider a weaker version of same idea (namely, the principle of transfers) that allows for the possibility that more complex criteria could be applied by individuals to inequality or risk comparison. An obvious example would be this criterion . . . If ceteris paribus a small amount of income is transferred from the person with the lowest income to the person with the highest income inequality must rise’.*

### 1.3. Experimental design

SAMPLE OF RESPONDENTS. The aim of this paper is to test, in a broader and rigorous way, the public’s acceptability of the uniform transfers. The experiment was conducted over the web in January 2021, with a sample of 1,028 respondents. The sample was representative of the French population, taking into account the following selection criteria: gender, age (16 and over, including retired people), professional statuses and income. Sampling was

carried out by a private company and the respondents were paid approximately €2 for their participation.<sup>4</sup>

AN EXPERIMENT IN THREE PARTS. The experiment was divided into three parts. In the first part, the respondents were presented with a list of (numerical) questions, in which they had to compare a pair of distributions A and B. They were asked to indicate which distribution they thought was less unequal. A brief justification of the existence of the distributions was proposed in the instructions. The questions were presented one by one on the screen. In the second part, the acceptability of the uniform transfers was tested on the basis of questions in literal terms. The last part was a socio-demographic questionnaire. Detailed instructions can be found in Appendix 1.6.1.

CONSTRUCTION OF DISTRIBUTION PAIRS. The pairs of distributions under comparison were constructed as follows. First, we considered 5 initial distributions, denoted  $\mathbf{x}^0$ ,  $\mathbf{y}^0$ ,  $\mathbf{z}^0$ ,  $\mathbf{u}^0$  and  $\mathbf{v}^0$  in Table 1.4. Each distribution is an

Table 1.4: *Initial distributions*

DISTRIB.	INCOME SCALE								
	2	4	6	8	10	12	14	16	18
$\mathbf{x}^0$	2	-	6	-	10	-	14	-	18
$\mathbf{y}^0$	2	4	-	-	-	-	14	16	18
$\mathbf{z}^0$	2	4	6	-	-	-	-	16	18
$\mathbf{u}^0$	2	-	-	8	10	12	-	-	18
$\mathbf{v}^0$	2	4	-	-	10	-	-	16	18

income list for 5 individuals, presented as perfectly identical apart from their income. The income scale was between 2 and 18 income units. These 5 distributions were designed to consider different distribution profiles, with a uniform distribution ( $\mathbf{x}^0$ ) and different unimodal, skewed, and/or polarised distribu-

<sup>4</sup> In order not to promote a private company, more details are available upon request. The experiment was made possible thanks to the financial support of the research project *RediPref* (Contract ANR-15-CE26-0004). A comparable methodology, but on a different research topic can be found, for example, in [Attema et al. \(2023\)](#).

tions ( $\mathbf{y}^0$ ,  $\mathbf{z}^0$ ,  $\mathbf{u}^0$  and  $\mathbf{v}^0$ ). The objective was to find out whether the initial distributional structure could affect the acceptance of the various transfers.

We then considered all possible transfers of each type, limited to transfers between two individuals and of a single unit of income, as detailed in Table 1.5. Once again, an ‘UR transfer’ indicates a uniform-on-the-right transfer, which

Table 1.5: *Equalising transfers*

TRANSFERS		$e_1$	$e_2$	$e_3$	$e_4$	$e_5$
T1	URL	+1	0	0	0	-1
T2	UR	0	+1	0	0	-1
T3	UR	0	0	+1	0	-1
T4	UR	0	0	0	+1	-1
T5	UL	+1	0	0	-1	0
T6	UL	+1	0	-1	0	0
T7	UL	+1	-1	0	0	0
T8	PT	0	0	+1	-1	0
T9	PT	0	+1	-1	0	0
T10	PT	0	+1	0	-1	0

is not uniform-on-the-right-and-left. Equivalently, a ‘PT transfer’ is a progressive transfer that is neither uniform on the right nor on the left. At the end, one obtains one URL transfer and three transfers for all the other types (hence a total of 10 possible transfers). Finally, we have considered all possible combinations of initial distributions and transfers, so that the final distribution can be written as, for example,  $\mathbf{x}^1 = \mathbf{x}^0 + \mathbf{t}$ .

For each initial distribution, we have also added a *test question*. In each case, the final distribution was the perfectly egalitarian distribution resulting from the initial distribution. For example, for  $\mathbf{x}^0 = (2, 6, 10, 14, 18)$ , the final distribution was  $\mathbf{x}^1 = (10, 10, 10, 10, 10)$ . the objective was as follows. As control is non-existent in a web-experiment, we wanted to ensure that respondents did not answer completely randomly. In the case of the test questions, it seemed obvious that the most egalitarian distribution was the one after

transfer(s). We therefore used the results to these questions as a filter (see Section 1.4.1). The full list of distribution pairs is shown in Table 1.13 in Appendix 1.6.2.

SEQUENCE OF QUESTIONS. The initial distribution, before transfer, was always indicated as distribution A, and placed on the left of the screen. The idea was not to generate too much confusion among respondents, as numerical questions are already complex enough for some people. In the same vein, the questions corresponding to the same initial distribution were presented in a single block. Including the 10 transfers and the test question, each block consisted of 11 questions. Within each block, the questions appeared on the screen (one per screen) in a random order.

The block corresponding to the initial distribution  $\boldsymbol{x}^0$  always appeared first. This distribution being uniform, the answers to the corresponding questions could not be ‘altered’ by the degree of polarisation of this distribution. Also, as this block appeared first, the answers to the other blocks could not affect the answers to this one (controlling for a possible learning effect). Consequently, the acceptance rate of the transfers in this block can be considered as the best representation of respondents’ ethical preferences.

The order of the other initial distributions was randomly selected. In order to limit the number of questions, we presented the respondent with only 4 of the 5 initial distributions: distributions  $\boldsymbol{x}^0$ ,  $\boldsymbol{y}^0$  and  $\boldsymbol{z}^0$  and, by a 50/50 draw, either  $\boldsymbol{u}^0$  or  $\boldsymbol{v}^0$ . In total, the respondent had to answer 44 questions. After each block of 11 questions, the respondent saw a screen, summarising their answers to that block. They could then modify their answers to the questions in that block.

## 1.4. Results

### 1.4.1. Acceptance rates of the principle of transfers

FULL SAMPLE. First, we present in Table 1.6 the results for the full sample, i.e. 1028 people representative of the French population. We distinguish between four types of transfer: URL transfers, UR transfers, UL transfers and the standard PT transfers. We recall that, in all the tables presented below, a ‘PT transfer’ indicates a progressive transfer that is neither uniform on the right nor on the left. An ‘UR transfer’ is a uniform-on-the-right transfer, which is not uniform-on-the-left. Finally, an ‘UL transfer’ indicates a uniform-on-the-left transfer, which is not uniform-on-the-right. We make a distinction between

Table 1.6: *Acceptation rates (all the subjects)*

TRANSFERS	ACCEPTED	REJECTED	NEUTRALITY
Test questions	61,75%	21,45%	16,80%
URL	45,06%	16,76%	38,18%
UL	41,67%	19,33%	39,00%
UR	38,36%	19,64%	42,00%
PT	31,75%	22,05%	46,20%
All transfers	38,04%	19,98%	41,98%

strict acceptance, neutrality and rejection. Strictly speaking, as transfers are generally defined in a weak sense, neutrality is consistent with the underlying principle of transfers. To avoid any ambiguity, we have nevertheless chosen to separate acceptance and neutrality. All transfers (uniform or not) being progressive transfers, the rate of acceptance of the principle of transfers is 38.04%. This is relatively low compared to comparable studies, particularly those summarised in Table 1.3. If we focus on non-uniform progressive transfers (PT transfers in the table), the acceptance rate is even lower (31.75%). This indicates that transfers involving neither the poorest nor the richest are



perceived as the most ambiguous in terms of reducing inequality. Such a low rate can be partly explained by the results obtained for the test questions: On average, respondents answered 61.75% of these questions correctly. This low success rate is easy to understand. The questions asked, involving income distributions presented numerically, may have been perceived as complex by some respondents (the sample included people aged from 16 to 70, from very diverse backgrounds).

Detailed results for the test questions (one per initial distribution) are presented in Table 1.7. Respondents are allocated according to the number of errors they made on the test questions. We note that 43.58% of them

Table 1.7: *Number of errors on test questions*

	4 ERRORS	3 ERRORS	2 ERRORS	1 ERRORS	0 ERROR
NUMBER OF SUBJECTS	205	136	106	133	448
PERCENTAGE OF SUBJECTS	19,94%	13,23%	10,31%	12,94%	43,58%

answered the 4 questions correctly (one per initial distribution). This result is relatively satisfactory, as it means that the average 61.75% success rate does not apply to all respondents, individually. In other words, the wrong answers are concentrated on certain respondents. For the following analyses, we propose to keep only the 448 respondents who made no errors.<sup>5</sup>

NO ERRORS IN THE TEST QUESTIONS. The results for the sample of 448 people are presented in Table 1.8. We note that the overall rate of acceptance of the principle of transfers has increased considerably (51.88%), which makes it more comparable to that of the studies in Table 3. Despite this, acceptance of non-uniform progressive transfers (PT) remains low, at less than 40%. Overall,

<sup>5</sup> The aim here is not to exclude people on the basis of criteria such as mathematical reasoning ability. Of all the subjects, some may not have answered the questions seriously. In this case, their answers turned out to be totally uncorrelated with their preferences. Our only means of control is therefore to exclude the subjects who failed the test questions.

Table 1.8: *Acceptation rates (no errors in the test questions)*

TRANSFERS	ACCEPTED	REJECTED	NEUTRALITY
URL	66,80%	8,43%	24,78%
UL	59,30%	12,02%	28,68%
UR	51,97%	14,08%	33,95%
PT	39,38%	18,47%	42,15%
All transfers	51,88%	14,21%	33,91%

acceptance rates differ between the types of transfer. First, uniform transfers are much widely accepted than non-uniform transfers. By far, the most widely accepted transfers are those that combine uniformity on the right and left (URL). While this result seems fairly intuitive, the comparison of UR and UL transfers is not. We find that respondents perceive uniform transfers to the left as having a greater capacity to reduce inequalities. This is an important result of our analysis: when a reduction in inequality is suitable, it seems preferable to give priority to reducing poverty, rather than reducing the gap with the rich. All the differences between the acceptance rates are significant ( $\chi^2$  statistics), as shown in Table 1.9.

Table 1.9: *Equality tests of the acceptance rates*

$\chi^2$ STATISTICS	DL	VALUE	PROB.
Global	3	614.8611	< 0.0001
URL versus UR	1	119.7001	< 0.0001
URL versus UL	1	31.7983	< 0.0001
URL versus P	1	406.4503	< 0.0001
UR versus UL	1	58.4948	< 0.0001
UR versus P	1	171.7946	< 0.0001
UL versus P	1	426.8010	< 0.0001

*Notes.* Null hypothesis  $\rightarrow$  equality of the acceptance rates.

IMPACT OF INITIAL DISTRIBUTIONS. In the table 1.10, we distinguish the results for the five initial distributions (before transfers). The aim was to see whether the acceptability of the various transfers could be affected by the

structure, more or less polarised, of the initial distribution. No clear trend

Table 1.10: *Acceptation rates by initial distribution*

TRANSFERS	$x^0$	$y^0$	$z^0$	$u^0$	$v^0$
URL	66,96%	66,74%	66,29%	67,42%	66,96%
UL	58,04%	60,71%	57,89%	60,48%	60,65%
UR	47,84%	52,68%	54,84%	51,58%	53,45%
PT	31,62%	42,71%	41,29%	42,08%	41,70%
All transfers	47,95%	53,50%	52,83%	52,99%	53,44%

emerges from this table. The results are fairly similar to those in Table 1.8. We simply note that the lowest acceptance rates concern the uniform initial distribution. The fact that the initial distribution has no impact on acceptability is consistent with the theory, which always defines a transfer that reduces inequality, independently of the initial distribution.

SOCIO-ECONOMIC VARIABLES. The influence of socio-economic variables on the results is presented in the various tables in Appendix 1.6.3. The results by *gender* are shown in Table 1.14. The first observation is that the ranking of acceptance rates  $URL > UL > UR > PT$  is found for both men and women (the differences are significant, see Table 1.15). Another interesting result is that, whatever the type of transfer, apart from non-uniform transfers (PT), the acceptance rate is always significantly higher for men than for women (see Table 1.16).

In Tables 1.17 to 1.19, we distinguish results by *level of education*. A first signal is the low acceptance rate for people with a ‘before high school’ level of education, for all transfers. One possible explanation is that these people may have difficulty understanding the questions, as they may not be at ease with the mathematical formalism. Such an interpretation seems plausible, especially if we focus on URL transfers. Indeed, it is difficult to consider that such transfers (involving only the richest and the poorest in this study), are

not perceived as reducing inequality. We note here that the acceptance rate increases significantly with the degree (ranging from 45.83% to 71.18%). For UR and URL transfers, we also note an increase in acceptance with the degree, except between the last two levels ('short tertiary education' and 'university degree'). On the other hand, for PT transfers, although the differences are significant (Table 1.19), the differences are smaller. This confirms the fact that non-uniform transfers are perceived as having an ambiguous effect on overall inequality. Finally, in Table 1.18, we note that the ranking  $URL > UL > UR > PT$  is significant whatever the level of education, except for 'before high school'.

*Political opinions* also have a significant influence on results. Whatever the type of transfer, the acceptance rates are significantly different (see Table 1.22). If we look in detail, the ranking  $URL > \dots > PT$  is again found, for all political opinions (sometimes non-significant differences, see Table 1.21). A first strong result is a decrease in the acceptance of URL transfers, as we move from 'far left' opinions to 'far right' opinions (Table 1.20). Another interesting result is the comparison of UR and UL transfers. For UR transfers, which include a form of solidarity among the rich (who are donors) but which do not involve solidarity among the poor (who are receivers), acceptance is higher among 'far right' people than among 'far left' people (54.58% vs. 47.78%). On the other hand, for UL transfers (which imply solidarity in the other direction), the result is reversed (65.00% for 'far left' vs. 55.83% for 'far right').

The latest analyses, in Tables 1.23 to 1.25, focus on professional status. Here, the results are much more ambiguous. For instance, for many statuses, the difference between URL and UL, or between UR and UL, is not significant. The only really striking result is the greater acceptance of all transfers, except PT, by 'part-timers' compared with 'full-timers'.

### 1.4.2. Social welfare functions estimation

ESTIMATION METHODOLOGY. The theory of inequality measurement assumes that ethical preferences can be represented by a social welfare function  $W$ . The two models considered in this paper are the utilitarian approach  $W_u$  and the extended Gini approach  $W_f$  (see Section 1.2.1). To the best of our knowledge, attempts to estimate the utility model have been proposed by Amiel *et al.* (1999) and Carlsson *et al.* (2005), but no paper has studied the extended Gini approach. The paper closest to ours is Hey and Orme (1994)'s, concerning individual decisions under risk.

In each of the 40 numerical questions (test questions are excluded), the respondent has to compare two distributions  $\mathbf{x}$  and  $\mathbf{y}$ . By indicating which distribution she considers to be more egalitarian, she tells us the value of her  $\Delta(\mathbf{x}, \mathbf{y})$ , defined as follows:

$$\Delta(\mathbf{x}, \mathbf{y}) = W(\mathbf{x}) - W(\mathbf{y}). \quad (1.4.1)$$

If distribution  $\mathbf{x}$  (resp.  $\mathbf{y}$ ) is strictly preferred, then  $\Delta(\mathbf{x}, \mathbf{y}) > 0$  (resp.  $< 0$ ). If she considers that the level of inequality is the same in both distributions, then  $\Delta(\mathbf{x}, \mathbf{y}) = 0$ .<sup>6</sup> Although preferences are assumed to be deterministic—and therefore representable by a social welfare function—some errors are possible when the respondent makes her choice. To this end we add a white noise, normally distributed around a zero-mean. We obtain a stochastic specification for the estimation model:

$$\Delta_W^*(\mathbf{x}, \mathbf{y}) = \Delta_W(\mathbf{x}, \mathbf{y}) + \varepsilon, \quad \text{where } \varepsilon \sim N(0; 1).$$

---

<sup>6</sup> We note that the comparison in terms of social welfare or inequality is equivalent here, because the distributions under comparisons have the same mean. Indeed, by definition of an inequality index  $I$ ,  $W(\mathbf{x}) \geq W(\mathbf{y}) \Leftrightarrow I(\mathbf{x}) \leq I(\mathbf{y})$  when the means are equal (see Section 1.2.1).

Whereas  $\Delta_W(\mathbf{x}, \mathbf{y})$  is positive if the distribution  $\mathbf{x}$  is preferred by the respondent, we only observe  $\Delta_W^*(\mathbf{x}, \mathbf{y})$ , which is positive if  $\mathbf{x}$  is chosen. Then, given that only the ordinal information of  $\Delta$  is meaningful here (the intensity of the difference in social welfare cannot be interpreted) we replace, for econometric estimation purposes,  $\Delta$  by a discrete variable  $\gamma$ , such as:

$$\begin{cases} \gamma = 0 & \text{if } \Delta_W^* < 0, \\ \gamma = 1 & \text{if } \Delta_W^* = 0, \\ \gamma = 2 & \text{if } \Delta_W^* > 0. \end{cases}$$

In this paper, we propose to estimate only the parametric social welfare functions presented in Section 1.2.1, hence  $W_u$  with  $u = u_\rho$  for the utilitarian model, and  $W_f$  with  $f = f_\eta$  for the extended Gini one. For the utilitarian model, the estimation is based on:

$$\Delta_{W_{u_\rho}}(\mathbf{x}, \mathbf{y}) = \frac{\alpha}{5} \left[ \sum_{i=1}^5 u_\rho(x_i) - \sum_{i=1}^5 u_\rho(y_i) \right],$$

with  $\alpha > 0$  a free parameter. Equivalently, by letting  $d_i = (x_i - x_{i-1}) - (y_i - y_{i-1})$  one observes that, after simple manipulations, the estimation of the extended Gini model is based on:

$$\Delta_{W_{f_\rho}}(\mathbf{x}, \mathbf{y}) = \alpha \sum_{i=2}^5 \left[ f_\rho \left( \frac{6-i}{5} \right) - \left( \frac{6-i}{5} \right) \right] d_i,$$

with, again,  $\alpha > 0$  a free parameter to be estimated.

For each respondent, the parameters are obtained by applying *maximum log-likelihood estimation*. For this purpose, we apply a quasi-Newton method, called *Limited-memory BFGS* (Broyden-Fletcher-Goldfarb-Shanno), that iteratively adjusts an approximation of the inverse Hessian matrix to minimize the objective function (in our case, the opposite of the log-likelihood function). At each step, the algorithm computes the gradient of the objective function.

This method is called ‘Limited-memory’ because it retains only a limited approximation of the inverse Hessian matrix, significantly reducing the memory required for calculations. Note that this is an unconstrained optimization technique. Hence, when initialising the algorithm, we did not specify any bounds for the parameters. Even if it is not perfectly in line with the theoretical models ( $u$  and  $f$  have to be non-decreasing, for instance), our estimates are consistent to the theory.

ESTIMATION RESULTS. In Table 1.11, we give some information on the  $\rho$  parameter of the utilitarian model. The first important information is what is

Table 1.11: *Estimation of  $\rho$  in the utility function  $u_\rho$*

MEAN	MEDIAN	MINIMUM	MAXIMUM	STANDARD-DEVIATION	CONVERGENCE RATE
0.73	<b>0.74</b>	0.63	0.78	0.03	43.75%

presented as the *convergence rate*. Specifically, this indicates the proportion of respondents for whom the algorithm has converged, enabling the parameters to be estimated. In the case of the utilitarian model, the parameters could be obtained for only 43.75% of respondents. This rate is relatively low, which is an indicator of the model’s poor ability to represent respondents’ preferences.<sup>7</sup> The other presented values summarise the information for respondents whose algorithm has converged. Table 1.11 shows that the median  $\rho$  parameter is 0.74. A value of less than 1 implies a concavity of the utility function, and therefore reflects a certain level of aversion to inequality. The precise value is difficult to interpret, as there is no reference: the choice of such a value in an empirical application is purely normative. However, such a level of inequality aversion is quite comparable to that found in other studies. For example, the value estimated by [Amiel \*et al.\* \(1999\)](#) on experimental data is perfectly

<sup>7</sup> As this is a web-experiment, the quality of responses from some respondents may be low, with, for example, very high rates of indifference between the two distributions in comparison. This is also an explanatory factor for this low convergence rate.

identical.<sup>8</sup> Another feature is a very low standard deviation, which suggests that the respondents' preferences are very similar.

In Table 1.12, we provide similar information for the  $\eta$  parameter of the extended Gini model. We note that the results are very different. Firstly,

Table 1.12: *Estimation of  $\eta$  in the weighting function  $f_\eta$*

MEAN	MEDIAN	MINIMUM	MAXIMUM	STANDARD-DEVIATION	CONVERGENCE RATE
3.72	<b>3.13</b>	-220.61	68.14	21.73	72.99%

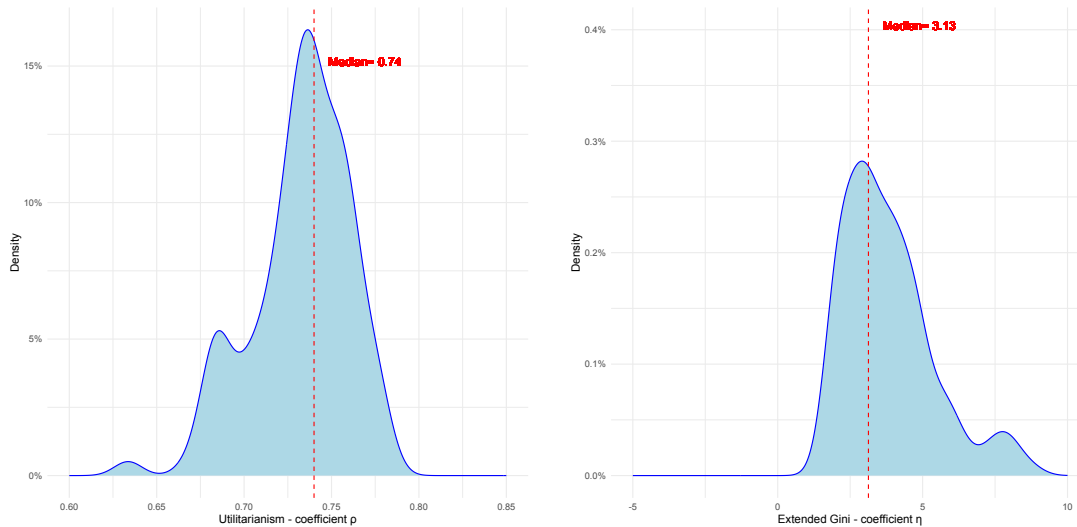
the convergence rate is relatively high, at over 70%. Although this model has exactly the same number of parameters as the utilitarian model, it seems to be more effective at representing preferences. Unfortunately, this comes at the cost of greater variability in the estimated  $\eta$  parameter (with a small number of extreme values, but with estimated  $\eta$  very far from the median). Then, the value obtained for the median  $\eta$  parameter is quite interesting: a value of 3.13 indicates a relatively strong inequality aversion. That is, for instance, much stronger than that of the Gini coefficient, for which  $\eta = 2$ .

In order to get a clearer idea of the estimated parameters for all the respondents, we present in Figure 1.2 a Kernel density estimation of, respectively,  $\rho$  (utilitarianism) and  $\eta$  (extended Gini). We also indicate on the graphs the median value of each parameter. We first note that the distributions are (more or less) unimodal and symmetrical, with a median very close to the mode (but also to the mean). Such representations, with parameter values that are consistent with those found in the literature, suggest that the quality of the estimates is acceptable.

A final question concerns the goodness-of-fit of each of the models, in order to obtain a statistical view of the best of the two models. There are various

<sup>8</sup> Unlike us, they estimate  $\alpha = 1 - \epsilon$ . In all but one of their samples, they find  $\alpha \approx 0.25$ , hence  $\epsilon \approx 0.75$ .



Figure 1.2: *Kernel density estimation of the parameters*

approaches in the literature for measuring the loss of information when a particular model is chosen, bearing in mind that the true model (generating the data) is not known. One possibility is to apply the *Akaike Information Criterion* (AIC). If  $k$  denotes the number of parameters in the model and  $L$  the maximised likelihood value, we have  $AIC = 2k - \ln(L)$ . The best model is the one with the lowest  $AIC$ . Unfortunately, such a criterion is of no use here. On the one hand, our estimation method is that of maximum log-likelihood, and the values obtained for the maximised log-likelihood remain very low (close to 0), for all the respondents and for the two estimated models. Also, the two models each have two parameters. So, whatever the estimate, we always have  $AIC \approx 4$ . The application of the *Bayesian Information Criterion*, which also takes into account the number of observations, does not change the problem ( $BIC \approx 7, 38$ ).

### 1.5. Discussion

Our study is based on a web experiment with a representative sample of the French population. Our results show a fairly clear rejection of progressive transfers in the ‘middle of’ the distribution, i.e. involving neither the poorest nor the richest in the distribution: such transfers are not considered, by a large majority of the subjects in our study, to have a reducing effect on overall inequality. This result confirms a trend already observed in other existing experimental analyses, although a real distinction between uniform and non-uniform transfers was never formally mentioned in these studies. On the contrary, transfers imposing solidarity at the top and bottom of the distribution (URL transfers) are significantly, and by far, the most approved in our sample. The second interesting result is the stronger approval of solidarity among the poor (UL) than among the rich (UR), thus giving priority to reducing poverty rather than to reducing very great wealth. The theoretical distinction between uniform and non-uniform transfers therefore seems to make sense in the light of our experiment.

These trends remain identical when we decompose the overall sample on the basis of the socioeconomic characteristics of the subjects, further reinforcing our initial findings. Two additional results stand out here. Firstly, the acceptance rates for all transfers are significantly higher among men than among women, except for non-uniform transfers (PT transfers). The subject’s level of education also appears to influence the acceptance rate. Subjects with an education level below ‘high school’ approve all the transfers less than those with higher education. This latter result should be interpreted with caution as it may be a bias, related to the difficulty in understanding questions presented in numerical form.

We then estimated, for each subject, the social welfare function that best represents their ethical preferences. We estimated the function, underlying the class of Atkinson-Kolm inequality indices, and the function underlying the

extended Gini class. For the first class, we found results comparable to those already estimated in the experimental literature. To our knowledge, the second class has never been tested. Our main finding here is that the estimated level of aversion to inequality (median value of  $\eta$  equal to 3.13) is significantly higher than that of the Gini coefficient ( $\eta = 2$ ). This observation may explain why, in 2020, 60% of French people considered that inequality had increased over the last 10 years,<sup>9</sup> while the Gini index has remained stable or even fallen slightly (from 0.302 to 0.293, according to INSEE Data).

On the basis of these results, several avenues of research can be envisaged. Firstly, the greater acceptance of principles of transfers which, unlike the Pigou-Dalton principle, impose a form of solidarity among donors and/or recipients, needs to be confirmed by different experimental designs and subject populations. Another project, both theoretical and empirical, would be to consider classes of extended Gini social welfare functions, compatible with the various transfer principles mentioned above. While the class of convex functions in  $\mathcal{F}$  is the class of  $f$  weighting functions compatible with the Pigou-Dalton principle, Chateauneuf and Moyes (2006) have identified the key role of the so-called *star-shaped functions* (a class larger than the class of convex functions) for the alternative principles. However, no parametric form for such functions has yet been identified. As a result, there is currently no function that could serve as a basis for new indices of inequality. This open question seems to be an interesting one for future investigations.

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<sup>9</sup> OECD Report, 2021: *Does inequality matter? How people perceive economic disparities and social mobility*, <https://doi.org/10.1787/3023ed40-en>.

## 1.6. Appendix

### 1.6.1. Instructions provided to respondents (translated from French)

#### **SCREEN 1: General description of the study.**

The study you have agreed to take part in is being carried out by several French university research centres, specialised in the study of inequality. Our aim is to construct inequality indicators in order to measure the impact on income distribution of government interventions in the economic sphere. These interventions may concern areas as diverse as taxation, family policy, the pension system, housing subsidies and the financing of the healthcare system, to name but a few.

These different government interventions are likely to modify the incomes of members of society. We believe that the indicators used to assess the impact of these interventions on income distribution should reflect, as far as possible, the point of view of members of society, who are the first to be affected. Your participation in this study will enable us to gather a range of opinions representative of the different points of view on inequality within French society.

#### **SCREEN 2: This study is in three parts.**

The first part consists of 44 questions. For each question, we will present you with two income distributions and ask you to indicate which of these two distributions you think is the least unequal.

After each group of 11 questions, you will be able to consult your answers and, if you wish, modify them. We would like to stress that there are no right or wrong answers: we are only interested in your personal opinion.

In the second part, we will ask you whether you agree or disagree with a number of statements about the impact on inequality of different types of income redistribution between individuals. Again, there is no right or wrong answer: you are free to agree or disagree with the statements.

In the third part, we will ask you a series of personal questions to help us situate you in French society. The aim here is to ensure that all the people who took part in this study are as faithful a representation of French society as possible.

We would like to stress that your answers will remain anonymous. Similarly, all personal information collected will remain confidential. It will only be used for our research work

and it will not be possible to identify you from the information collected. It is imperative for the success of this study that you take the utmost care when reading the questions and answering them. It is also important that you complete the questionnaire to the end. We estimate that the average time spent answering the questionnaire should not exceed 30 minutes. When we have completed our survey, you will receive an e-mail with a link to the results.

**SCREEN 3: Part One.**

Imagine a society consisting of 5 perfectly identical individuals: there are no personal characteristics to distinguish them from one another. There is no reason why they should be treated differently.

We are interested in the level of inequality in this society by considering only the income of individuals, expressed in thousands of euros. In each question in this first part, two competing economic policies are considered, each leading to a particular income distribution: Distribution A and Distribution B.

The sum of distributed income is the same in both distributions.

You are asked to compare these two distributions from the point of view of inequality:

- If you consider that Distribution A is less unequal than Distribution B, then tick the 'Distribution A' box.
- If you consider that Distribution B is less unequal than Distribution A, then tick the 'Distribution B' box.
- Finally, if you are unable to decide, or if you consider that the two distributions are equivalent, then tick the 'Equivalent' box.

Sample question:

In your opinion, which distribution is the least unequal?

Distribution A	Equivalent	Distribution B
(2,6,10,14,18)		(3,6,10,14,17)

Reading: Distribution A gives an income of €2,000 to the 1st person, €6,000 to the 2nd person, €10,000 to the 3rd person, €14,000 to the 4th person and €18,000 to the 5th person.

The questionnaire will now begin (then, presentation of the 44 questions, one screen for each question).

**SCREEN 4: Part Two.**

Here again we are considering a fictive society consisting of perfectly identical individuals: there is still no reason to favour one individual over another. You are asked to indicate the extent to which you agree with a number of statements concerning the impact on inequality of different ways of redistributing income between individuals.

# To the following statement: 'a transfer of income from individual X to individual Y (who is poorer than the first) always reduces inequality in society as a whole', do you...?

Strongly disagree / Somewhat disagree / No opinion / Somewhat agree / Strongly agree

# To the following statement: 'a transfer of income from individual X to individual Y (poorer than the former) reduces inequality in society as a whole, on the sole condition that individuals poorer than Y receive at least the same amount of income as that received by Y', do you :

Strongly disagree / Somewhat disagree / No opinion / Somewhat agree / Strongly agree

# To the following statement: 'a transfer of income from an individual X to an individual Y (poorer than the former) reduces inequalities in society as a whole, on the sole condition that individuals richer than X give at least the same amount of income as that given by X', do you :

Strongly disagree / Somewhat disagree / No opinion / Somewhat agree / Strongly agree

# To the following statement: 'a transfer of income from an individual X to an individual Y (poorer than the former) reduces inequality in society as a whole, on the sole conditions that (a) individuals poorer than Y receive at least the same amount of income as that received by Y and (b) individuals richer than X give at least the same amount of income as that given by X', do you :

Strongly disagree / Somewhat disagree / No opinion / Somewhat agree

## 1.6.2. List of the numerical questions

Table 1.13: List of the 55 possible questions

BLOCK	QUESTION	DISTRIBUTION A					DISTRIBUTION B					TRANSFER				
B1 ( $x^0$ )	B1-T1	2	6	10	14	18	3	6	10	14	17	+1	0	0	0	-1
	B1-T2	2	6	10	14	18	2	7	10	14	17	0	+1	0	0	-1
	B1-T3	2	6	10	14	18	2	6	11	14	17	0	0	+1	0	-1
	B1-T4	2	6	10	14	18	2	6	10	15	17	0	0	0	+1	-1
	B1-T5	2	6	10	14	18	3	6	10	13	18	+1	0	0	-1	0
	B1-T6	2	6	10	14	18	3	6	9	14	18	+1	0	-1	0	0
	B1-T7	2	6	10	14	18	3	5	10	14	18	+1	-1	0	0	0
	B1-T8	2	6	10	14	18	2	6	11	13	18	0	0	+1	-1	0
	B1-T9	2	6	10	14	18	2	7	9	14	18	0	+1	-1	0	0
	B1-T10	2	6	10	14	18	2	7	10	13	18	0	+1	0	-1	0
	B1-TEST	2	6	10	14	18	10	10	10	10	10					
B2 ( $y^0$ )	B2-T1	2	4	14	16	18	3	4	14	16	17	+1	0	0	0	-1
	B2-T2	2	4	14	16	18	2	5	14	16	17	0	+1	0	0	-1
	B2-T3	2	4	14	16	18	2	4	15	16	17	0	0	+1	0	-1
	B2-T4	2	4	14	16	18	2	4	14	17	17	0	0	0	+1	-1
	B2-T5	2	4	14	16	18	3	4	14	15	18	+1	0	0	-1	0
	B2-T6	2	4	14	16	18	3	4	13	16	18	+1	0	-1	0	0
	B2-T7	2	4	14	16	18	3	3	14	16	18	+1	-1	0	0	0
	B2-T8	2	4	14	16	18	2	4	15	15	18	0	0	+1	-1	0
	B2-T9	2	4	14	16	18	2	5	13	16	18	0	+1	-1	0	0
	B2-T10	2	4	14	16	18	2	5	14	15	18	0	+1	0	-1	0
	B2-TEST	2	4	14	16	18	10	10	10	10	10					
B3 ( $z^0$ )	B3-T1	2	4	6	16	18	3	4	6	16	17	+1	0	0	0	-1
	B3-T2	2	4	6	16	18	2	5	6	16	17	0	+1	0	0	-1
	B3-T3	2	4	6	16	18	2	4	7	16	17	0	0	+1	0	-1
	B3-T4	2	4	6	16	18	2	4	6	17	17	0	0	0	+1	-1
	B3-T5	2	4	6	16	18	3	4	6	15	18	+1	0	0	-1	0
	B3-T6	2	4	6	16	18	3	4	5	16	18	+1	0	-1	0	0
	B3-T7	2	4	6	16	18	3	3	6	16	18	+1	-1	0	0	0
	B3-T8	2	4	6	16	18	2	4	7	15	18	0	0	+1	-1	0
	B3-T9	2	4	6	16	18	2	5	5	16	18	0	+1	-1	0	0
	B3-T10	2	4	6	16	18	2	5	6	15	18	0	+1	0	-1	0
	B3-TEST	2	4	6	16	18	10	10	10	10	10					
B4 ( $w^0$ )	B4-T1	2	8	10	12	18	3	8	10	12	17	+1	0	0	0	-1
	B4-T2	2	8	10	12	18	2	9	10	12	17	0	+1	0	0	-1
	B4-T3	2	8	10	12	18	2	8	11	12	17	0	0	+1	0	-1
	B4-T4	2	8	10	12	18	2	8	10	13	17	0	0	0	+1	-1
	B4-T5	2	8	10	12	18	3	8	10	11	18	+1	0	0	-1	0
	B4-T6	2	8	10	12	18	3	8	9	12	18	+1	0	-1	0	0
	B4-T7	2	8	10	12	18	3	7	10	12	18	+1	-1	0	0	0
	B4-T8	2	8	10	12	18	2	8	11	11	18	0	0	+1	-1	0
	B4-T9	2	8	10	12	18	2	9	9	12	18	0	+1	-1	0	0
	B4-T10	2	8	10	12	18	2	9	10	11	18	0	+1	0	-1	0
	B4-TEST	2	8	10	12	18	10	10	10	10	10					
B5 ( $v^0$ )	B5-T1	2	4	10	16	18	3	4	10	16	17	+1	0	0	0	-1
	B5-T2	2	4	10	16	18	2	5	10	16	17	0	+1	0	0	-1
	B5-T3	2	4	10	16	18	2	4	11	16	17	0	0	+1	0	-1
	B5-T4	2	4	10	16	18	2	4	10	17	17	0	0	0	+1	-1
	B5-T5	2	4	10	16	18	3	4	10	15	18	+1	0	0	-1	0
	B5-T6	2	4	10	16	18	3	4	9	16	18	+1	0	-1	0	0
	B5-T7	2	4	10	16	18	3	3	10	16	18	+1	-1	0	0	0
	B5-T8	2	4	10	16	18	2	4	11	15	18	0	0	+1	-1	0
	B5-T9	2	4	10	16	18	2	5	9	16	18	0	+1	-1	0	0
	B5-T10	2	4	10	16	18	2	5	10	15	18	0	+1	0	-1	0
	B5-TEST	2	6	10	14	18	10	10	10	10	10					

### 1.6.3. Acceptation rates by socio-economic characteristics

Table 1.14: *Acceptation rates by gender*

TRANSFERS		ACCEPTED	REJECTED	NEUTRALITY	<i>N</i>
URL	Women	61.31%	8.19%	30.50%	928
	Men	72.69%	8.68%	18.63%	864
UR	Women	47.59%	12.79%	39.62%	2784
	Men	56.67%	15.47%	27.85%	2592
UL	Women	56.18%	10.09%	33.73%	2784
	Men	62.65%	14.08%	23.26%	2592
PT	Women	39.66%	15.63%	44.72%	2784
	Men	39.08%	21.53%	39.39	2592
All transfers	Women	49.16%	12.37%	38.47%	9280
	Men	54.79%	16.19%	29.02%	8640

Table 1.15: *Equality tests of the acceptance rates by gender*

$\chi^2$ STATISTICS		DL	VALUE	PROB.
Global	Women	3	213.0872	< 0.0001
	Men	3	438.3331	< 0.0001
URL versus UR	Women	1	52.4372	< 0.0001
	Men	1	69.6195	< 0.0001
URL versus UL	Women	1	7.5125	0.006
	Men	1	28.7213	< 0.0001
URL versus PT	Women	1	131.8889	< 0.0001
	Men	1	293.4294	< 0.0001
UR versus UL	Women	1	41.0937	< 0.0001
	Men	1	19.2573	< 0.0001
UR versus PT	Women	1	35.6669	< 0.0001
	Men	1	160.7339	< 0.0001
UL versus PT	Women	1	152.2759	< 0.0001
	Men	1	288.1432	< 0.0001

Notes. Null hypothesis  $\rightarrow$  equality of the acceptance rates.



Table 1.16: *Equality tests of the acceptance rates between gender*

$\chi^2$ STATISTICS		DL	VALUE	PROB.
URL	(Men/Women)	1	26.0825	< 0.0001
UR	(Men/Women)	1	44.3453	< 0.0001
UL	(Men/Women)	1	23.3256	< 0.0001
PT	(Men/Women)	1	0.1849	<b>0.667</b>

*Notes.* Null hypothesis  $\rightarrow$  equality of the acceptance rates.

Table 1.17: *Acceptation rates by schooling*

TRANSFERS		ACCEPTED	REJECTED	NEUTRALITY	<i>N</i>
URL	Before high school	45.83%	19.79%	34.38%	96
	High school	60.98%	11.38%	27.64%	492
	Short tertiary educ.	70.15%	8.93%	20.92%	392
	University degree	71.18%	5.05%	23.77%	812
UR	Before high school	35.42%	21.18%	43.40%	288
	High school	47.09%	17.75%	35.16%	1476
	Short tertiary educ.	56.04%	14.46%	29.51%	1176
	University degree	54.93%	10.84%	34.24%	2436
UL	Before high school	45.14%	20.83%	34.03%	288
	High school	53.73%	15.51%	30.76%	1476
	Short tertiary educ.	63.61%	13.27%	23.13%	1176
	University degree	62.27%	8.25%	29.47%	2436
PT	Before high school	34.72%	24.31%	40.97%	288
	High school	36.11%	23.17%	40.72%	1476
	Short tertiary educ.	42.94%	17.86%	39.20%	1176
	University degree	40.19%	15.23%	44.58%	2436
All transfers	Before high school	39.17%	21.88%	38.96%	960
	High school	47.17%	18.07%	34.76%	4920
	Short tertiary educ.	55.79%	14.57%	29.64%	3920
	University degree	54.33%	10.80%	34.86%	8120

Table 1.18: *Equality tests of the acceptance rates by schooling*

$\chi^2$ STATISTICS		DL	VALUE	PROB.
Global	Before high school	3	10.1894	0.017
	High school	3	135.5295	< 0.0001
	Short tertiary educ.	3	140.6426	< 0.0001
	University degree	3	351.5800	< 0.0001
URL versus UR	Before high school	1	3.3153	<b>0.069</b>
	High school	1	28.4758	< 0.0001
	Short tertiary educ.	1	24.3223	< 0.0001
	University degree	1	66.5251	< 0.0001
URL versus UL	Before high school	1	0.0140	<b>0.906</b>
	High school	1	7.8531	0.005
	Short tertiary educ.	1	5.5582	0.018
	University degree	1	21.1058	< 0.0001
URL versus PT	Before high school	1	3.7926	<b>0.051</b>
	High school	1	93.4534	< 0.0001
	Short tertiary educ.	1	87.0771	< 0.0001
	University degree	1	234.3994	< 0.0001
UR versus UL	Before high school	1	5.6584	0.017
	High school	1	13.0144	< 0.0001
	Short tertiary educ.	1	14.0117	< 0.0001
	University degree	1	27.1082	< 0.0001
UR versus PT	Before high school	1	0.0305	<b>0.861</b>
	High school	1	36.5941	< 0.0001
	Short tertiary educ.	1	40.3375	< 0.0001
	University degree	1	106.0667	< 0.0001
UL versus PT	Before high school	1	6.5142	0.011
	High school	1	92.5548	< 0.0001
	Short tertiary educ.	1	100.8559	< 0.0001
	University degree	1	237.7830	< 0.0001

*Notes.* Null hypothesis  $\rightarrow$  equality of the acceptance rates.

Table 1.19: *Equality tests of the acceptance rates between schooling level*

$\chi^2$ STATISTICS		DL	VALUE	PROB.
URL	(Before high school/High school/.../Univ. degree)	3	35.5717	< 0.0001
UR	(Before high school/High school/.../Univ. degree)	3	62.0388	< 0.0001
UL	(Before high school/High school/.../Univ. degree)	3	60.8895	< 0.0001
PT	(Before high school/High school/.../Univ. degree)	3	16.1429	0.001

*Notes.* Null hypothesis  $\rightarrow$  equality of the acceptance rates.

Table 1.20: *Acceptation rates by political views*

TRANSFERS		ACCEPTED	REJECTED	NEUTRALITY	<i>N</i>
URL	Wish not to answer	59.34%	12.37%	28.28%	396
	Far Left	73.33%	3.33%	23.33%	60
	Left	70.25%	5.58%	24.17%	484
	Centre	70.83%	8.33%	20.83%	480
	Right	64.38%	7.53%	28.08%	292
	Far Right	62.50%	13.75%	23.75%	80
UR	Wish not to answer	46.72%	15.82%	37.46%	1188
	Far Left	47.78%	5.56%	46.67%	180
	Left	54.89%	12.47%	32.64%	1452
	Centre	53.96%	15.00%	31.04%	1440
	Right	51.14%	13.01%	35.84%	876
	Far Right	54.58%	20.00%	25.42%	240
UL	Wish not to answer	54.38%	14.90%	30.72%	1188
	Far Left	65.00%	4.44%	30.56%	180
	Left	60.95%	9.64%	29.41%	1452
	Centre	60.90%	13.19%	25.90%	1440
	Right	60.39%	10.73%	28.88%	876
	Far Right	55.83%	15.42%	28.75%	240
PT	Wish not to answer	33.75%	18.86%	47.39%	1188
	Far Left	48.33%	7.22%	44.44%	180
	Left	38.36%	17.29%	44.35%	1452
	Centre	40.90%	20.83%	38.26%	1440
	Right	42.81%	15.98%	41.21%	876
	Far Right	45.00%	27.08%	27.92%	240
All transfers	Wish not to answer	46.39%	16.11%	37.50%	3960
	Far Left	55.67%	5.50%	38.83%	600
	Left	53.29%	12.38%	34.34%	4840
	Centre	53.81%	15.54%	30.65%	4800
	Right	52.74%	12.67%	34.59%	2920
	Far Right	52.88%	20.13%	27.00%	800

Table 1.21: *Equality tests of the acceptance rates by political views*

$\chi^2$ STATISTICS		DL	VALUE	PROB.
Global	Wish not to answer	3	133.5122	< 0.0001
	Far left	3	22.4033	< 0.0001
	Left	3	221.6474	< 0.0001
	Centre	3	181.6458	< 0.0001
	Right	3	72.0061	< 0.0001
	Far Right	3	10.0716	< 0.0001
URL versus UR	Wish not to answer	1	18.9395	< 0.0001
	Far left	1	11.8378	0.001
	Left	1	35.3254	< 0.0001
	Centre	1	42.1331	< 0.0001
	Right	1	15.4835	< 0.0001
	Far Right	1	1.5305	<b>0.216</b>
URL versus UL	Wish not to answer	1	2.9676	<b>0.085</b>
	Far left	1	1.4152	<b>0.234</b>
	Left	1	13.5035	< 0.0001
	Centre	1	15.2970	< 0.0001
	Right	1	1.4749	<b>0.225</b>
	Far Right	1	1.0912	<b>0.296</b>
URL versus PT	Wish not to answer	1	80.9311	< 0.0001
	Far left	1	11.3453	0.001
	Left	1	148.4356	< 0.0001
	Centre	1	129.1354	< 0.0001
	Right	1	40.8302	< 0.0001
	Far Right	1	7.3511	0.007
UR versus UL	Wish not to answer	1	13.9427	< 0.0001
	Far left	1	10.8550	0.001
	Left	1	10.9412	0.001
	Centre	1	14.2026	< 0.0001
	Right	1	15.1813	< 0.0001
	Far Right	1	0.0758	<b>0.783</b>
UR versus PT	Wish not to answer	1	41.5089	< 0.0001
	Far left	1	0.0111	<b>0.916</b>
	Left	1	79.7019	< 0.0001
	Centre	1	49.2189	< 0.0001
	Right	1	12.2114	< 0.0001
	Far Right	1	4.4084	0.036
UL versus PT	Wish not to answer	1	102.4960	< 0.0001
	Far left	1	10.1810	0.001
	Left	1	148.1944	< 0.0001
	Centre	1	115.2376	< 0.0001
	Right	1	54.2015	< 0.0001
	Far Right	1	5.6337	0.018

Notes. Null hypothesis  $\rightarrow$  equality of the acceptance rates.

Table 1.22: *Equality tests of the acceptance rates between political views*

$\chi^2$ STATISTICS	DL	VALUE	PROB.
URL (No answer/Far Left/.../F. right)	5	18.6330	0.002
UR (No answer/Far Left/.../F. right)	5	22.5370	< 0.0001
UL (No answer/Far Left/.../F. right)	5	19.1485	0.002
PT (No answer/Far Left/.../F. right)	5	31.3137	< 0.0001

*Notes.* Null hypothesis  $\rightarrow$  equality of the acceptance rates.

Table 1.23: *Acceptation rates by professional status*

TRANSFERS		ACCEPTED	REJECTED	NEUTRALITY	N
URL	Full-time	66.76%	6.39%	26.85%	704
	Part-time	76.39%	5.56%	18.06%	72
	Self-employed	50.93%	12.96	36.11%	108
	Seeking employment	70.00%	14.00%	16.00%	100
	Student	55.15%	12.50%	32.35%	136
	Unempl. not seeking	58.93%	8.93%	32.14%	112
	Retired	72.50%	8.39%	19.11%	560
UR	Full-time	50.05%	14.54%	35.42%	2112
	Part-time	61.11%	14.35%	24.54%	216
	Self-employed	33.64%	16.67%	49.69%	324
	Seeking employment	53.00%	17.67%	29.33%	300
	Student	43.14%	16.67%	40.20%	408
	Unempl. not seeking	49.40%	13.39%	37.20%	336
	Retired	59.23%	11.85%	28.93%	1680
UL	Full-time	57.58%	11.08%	31.34%	2112
	Part-time	69.91%	7.41%	22.69%	216
	Self-employed	47.53%	16.05%	36.42%	324
	Seeking employment	62.00%	17.67%	20.33%	300
	Student	49.02%	15.69%	35.29%	408
	Unempl. not seeking	55.06%	10.42%	34.52%	336
	Retired	65.24%	11.43%	23.33%	1680
PT	Full-time	37.64%	17.19%	45.17%	2112
	Part-time	35.65%	25.93%	38.43%	216
	Self-employed	28.70%	20.37%	50.93%	324
	Seeking employment	42.00%	22.67%	35.33%	300
	Student	31.37%	21.08%	47.55%	408
	Unempl. not seeking	46.13%	15.77%	38.10%	336
	Retired	44.23%	17.92%	37.86%	1680
All transfers	Full-time	50.26%	13.48%	36.26%	7040
	Part-time	57.64%	14.86%	27.50%	720
	Self-employed	38.06%	17.22%	44.72%	1080
	Seeking employment	54.10%	18.80%	27.10%	1000
	Student	42.57%	17.28%	40.15%	1360
	Unempl. not seeking	51.07%	12.77%	36.16%	1120
	Retired	57.86%	13.20%	28.95%	5600

Table 1.24: *Equality tests of the acceptance rates by professional status*

$\chi^2$ STATISTICS		DL	VALUE	PROB.
Global	Full-time	3	256.4400	< 0.0001
	Part-time	3	67.5299	< 0.0001
	Self-employed	3	34.6267	< 0.0001
	Seeking employment	3	35.5551	< 0.0001
	Student	3	36.7189	< 0.0001
	Unempl. not seeking	3	8.5611	0.036
	Retired	3	216.0933	< 0.0001
URL versus UR	Full-time	1	59.4250	< 0.0001
	Part-time	1	5.5352	0.019
	Self-employed	1	10.2745	0.001
	Seeking employment	1	8.8562	0.003
	Student	1	5.9201	0.015
	Unempl. not seeking	1	3.0515	<b>0.081</b>
	Retired	1	31.5890	< 0.0001
URL versus UL	Full-time	1	18.5430	< 0.0001
	Part-time	1	1.1139	<b>0.291</b>
	Self-employed	1	0.3738	<b>0.541</b>
	Seeking employment	1	2.0833	<b>0.149</b>
	Student	1	1.5320	<b>0.216</b>
	Unempl. not seeking	1	0.5104	<b>0.475</b>
	Retired	1	10.0258	0.002
URL versus PT	Full-time	1	180.9503	< 0.0001
	Part-time	1	36.1026	< 0.0001
	Self-employed	1	17.7602	< 0.0001
	Seeking employment	1	23.5294	< 0.0001
	Student	1	24.6474	< 0.0001
	Unempl. not seeking	1	5.5040	0.019
	Retired	1	134.3907	< 0.0001
UR versus UL	Full-time	1	24.0803	< 0.0001
	Part-time	1	3.6984	<b>0.054</b>
	Self-employed	1	12.9594	< 0.0001
	Seeking employment	1	4.9719	0.026
	Student	1	2.8410	<b>0.092</b>
	Unempl. not seeking	1	2.1531	<b>0.142</b>
	Retired	1	12.9171	< 0.0001
UR versus PT	Full-time	1	66.0041	< 0.0001
	Part-time	1	28.0387	< 0.0001
	Self-employed	1	1.8413	<b>0.175</b>
	Seeking employment	1	7.2782	0.007
	Student	1	12.0789	0.001
	Unempl. not seeking	1	0.7217	<b>0.396</b>
	Retired	1	75.6902	< 0.0001
UL versus PT	Full-time	1	168.2266	< 0.0001
	Part-time	1	50.8607	< 0.0001
	Self-employed	1	24.3441	< 0.0001
	Seeking employment	1	24.0385	< 0.0001
	Student	1	26.4278	< 0.0001
	Unempl. not seeking	1	5.3579	0.021
	Retired	1	149.6848	< 0.0001

Notes. Null hypothesis  $\rightarrow$  equality of the acceptance rates.

Table 1.25: *Equality tests of the acceptance rates between professional status*

$\chi^2$ STATISTICS	DL	VALUE	PROB.
URL (Full-time/Part-time/.../Retired)	6	35.3769	< 0.0001
UR (Full-time/Part-time/.../Retired)	6	103.1642	< 0.0001
UL (Full-time/Part-time/.../Retired)	6	77.0865	< 0.0001
PT (Full-time/Part-time/.../Retired)	6	54.1671	< 0.0001

*Notes.* Null hypothesis  $\rightarrow$  equality of the acceptance rates.



## Chapter 2

### Parental environment and student achievement: Does a Matthew effect exist?

This paper<sup>1</sup> investigates the impact of the parental environment on the student's academic performance in mathematics, literature and English (as a foreign language), using a new database covering all children aged 8 to 15 of the Madrid community, from 2016 to 2019. Parental environment refers here to the parents' level of education (i.e. the skills they acquired before bringing up their children), and parental investment (the effort made by parents to bring up their children). We distinguish the *persistent effect* of the parental environment from the so-called *Matthew effect*, which describes a possible tendency for the impact of the parental environment to increase as the child grows up. Whatever the subject, our results are in line with most studies concerning the persistent effect: a favourable parental environment goes hand in hand with better results for the children. As regards the Matthew effect, the results differ between subjects: while the impact of the parental environment tends to diminish from the age of 11 in mathematics and literature, it increases in English. This result, which is encouraging for mathematics and literature, confirms the social dimension involved in learning a foreign language compared to more academic subjects.

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<sup>1</sup> This paper is co-written with Brice Magdalou, University of Montpellier, CNRS, AMSE, Marseille, France and Emmanuelle Lavaine, CEE-M, University of Montpellier, CNRS, INRAE, Institut Agro, Montpellier, France.

## 2.1. Introduction

It is now well-documented that the cognitive and non-cognitive abilities developed in the early childhood drive the educational, social and professional success of people throughout their entire life. It is also well-recognized that the social background and the investment of parents in their own children impact ability acquisition, which partly explains the inequalities in academic performance across children. According to the Matthew effect<sup>2</sup>, in many spheres of life, ‘the rich get richer and the poor get poorer’. In the education field, this effect describes a possible tendency of initial advantages, on early life, to accumulate through time. Whereas the *persistent effect* of the parental environment on student achievement is now admitted, the theoretical and empirical literatures are more balanced on the existence of a possible *Matthew effect*. This paper aims at contributing to this debate.

Different channels can explain the impact of parental environment on children academic performance. The first is a possible *intergenerational transmission of cognitive skills*, which implies that the association between parents and children abilities can be partly driven by genetic.<sup>3</sup> A second is through the *parent’s level of education*. The children can benefit from the knowledge and diplomas acquired by their parents, but also from the related positive spillovers.<sup>4</sup> A third channel is *parental investment*, which can be a major in-

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<sup>2</sup> The Matthew effect, a standard concept in sociology, has been popularized by Merton (1968). Rigney (2010) proposes a review of applications in several (social) sciences, including education.

<sup>3</sup> Hanushek *et al.* (2021) identify a causal connection between cognitive skills of the parents and their children, based on a Dutch survey on math and language skills. Sacerdote (2007) uses Korean American adoptees data to show that genetic factors explain 44% of the variation in educational attainment and 33% of the variation in income.

<sup>4</sup> The survey proposed by Holmlund *et al.* (2011) concludes that the estimates of the causal effect of parent’s schooling on child’s schooling differ across studies, but also that selection is the main component of the intergenerational association. At the opposite, by using original Finnish data, Suhonen and Karhunen (2019) find a strong positive causal effect (of around 0.5) from parent’s to child’s attained years of education.

put in the child production of skills. In that case, a distinction has to be drawn between cognitive and non-cognitive skills. [Cunha \*et al.\* \(2010\)](#) found that the productivity of parental investment for cognitive skills is high in the early stages of education (before 6), but tends to significantly decrease after. At the opposite, the productivity of parental investment on non-cognitive skills is found to be higher at later stages. Finally, these channels can be exacerbated by a possible *assortative mating* of the parents.<sup>5</sup>

The literature on the technology of skills formation, initiated by [Cunha and Heckman \(2007\)](#) and [Cunha \*et al.\* \(2010\)](#), tends to support the hypothesis of cumulative advantages. The authors propose and estimate a model where, at each stage of the child development, the inputs and the production technology can differ. They find that *self-productivity* (the stock of skills produced at one stage augment the skills attained at later stages), for both cognitive and non-cognitive skills, becomes stronger as the child becomes older. They also observe *dynamic complementary* (the productivity of an investment can be raised by skills produced at previous stages), but with a decrease in substitutability between investment in one period and the existing stock of skills. Hence, it is more and more difficult to compensate for initial endowment differences, which can imply an increasing attainment gap between advantaged and disadvantaged children.<sup>6</sup>

On the other hand, the equality of opportunity literature suggests that, in moving towards adulthood, the child is able to free herself (at least partially) from some external factors that have determined her previous achievements. In the same vein of the age of sexual consent or the age of criminal responsibility, this theory refers to what we can call an *age (of consent) for responsible*

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<sup>5</sup> [Bingley \*et al.\* \(2022\)](#) find that 75% of the correlation in education attainment between parents and their children is driven by the joint contribution of the parents (as compared to the contribution of each parent independently).

<sup>6</sup> One main policy recommendation resulting from these estimations is that successful adolescent remediation strategies for disadvantaged children should focus on fostering non-cognitive skills.

*choices* (Roemer and Trannoy, 2016; Hufe *et al.*, 2017). In early childhood, the child cannot be held responsible for her behaviors and achievements as they result from *circumstances* not under her control.<sup>7</sup> In contrast, one can assume that an adult is able to set out personal objectives and to take free and enlightened decisions (whatever her background), such as the level of effort she decides to put at work. This prerequisite is actually necessary for the existence of freedom in itself, by considering that the life trajectory is not fully deterministic. Of course the age of consent is a normative concept here, not a precise age threshold, and it is debatable to fix it before adulthood.<sup>8</sup> But with this concept in hands, one can hypothesize that initial disadvantages or the parental influence can be partially mitigated, throughout schooling, by the emancipation of the child as she grows up.<sup>9</sup>

In this paper, we investigate a rich and never exploited database on the Madrid Community (Spain) to analyse the impact of parental environment (including parental highest schooling and parental investment) on their child's academic performance in three subjects (mathematics, literature and English as foreign language) and its change at three different education grades (Grades 3, 6 and 10, respectively about 8, 11 and 15 years old), over four academic years (from 2016 to 2019). We have combined data from various sources, provided by the Ministry of Education and Research of the Community of

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<sup>7</sup> Laziness at school, for instance, might be explained by a home environment which is neither stimulating nor rewarding.

<sup>8</sup> Roemer and Trannoy (2016) emphasize that it is controversial to use years of education as an effort variable (hence after the age of consent) until the end of secondary education, and consider that only tertiary education is immune to this criticism. Hufe *et al.* (2017) fix this age between 12 and 16, and recalculate the fraction of income inequality due to circumstances in the US and the UK, by considering that all the childhood achievements before the age of consent is a circumstance.

<sup>9</sup> By studying the academic performance of students who are the first in their family to attend university, Edwards *et al.* (2022) establish that some non-cognitive skills such as conscientiousness or extraversion, predict academic performance almost as strongly as standardised university admissions test scores. One can assume that such skills do not necessarily result from parental investment.

Madrid. We first have, for each grade, the scores of the students in each subject. The scores are normalised following a method comparable to the one used by the OECD's Programme for International Student Assessment (PISA). We complement these data by the information collected from two questionnaires, one sent to the students and another sent to the parents. We obtain various descriptive observations for the students and the parents (gender, country of birth, ...) as well as behavioral observations, which can be used as proxy of the parental investment and child's effort. Even if the database is not a panel because we cannot follow the student performance over the successive years, it covers the overall Madrid Community, including private and public schools. By focusing on students whose parents have answered the questionnaire, we gather data for more than 320.000 students.

Our empirical results contribute to the literature in three main directions. *First*, through a linear regression with fixed effects (for academic year and student's school, to control for a possible impact of the school environment), we observe that the parental highest schooling (precisely, the education level attained by the highest educated parent) is a strong predictor of the child's score, for each of the three subjects and for the three observed grades. Hence, our results confirm an inequality of opportunity in educational achievement, as already established in many studies. *Second*, we supplement the regression with interaction components between parental highest schooling and grade level, to observe the evolution of parental influence on child's score, throughout schooling. Here we obtain mixed, but informative results: Whereas the parental influence on child's score is significantly decreasing after 11 years old in mathematics and literature,<sup>10</sup> the influence is continuously and significantly increasing in English (foreign language), over the whole period studied. These results (never established in the applied econometric literature, to the best of our knowledge) find some echoes in a related literature, as detailed in

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<sup>10</sup> Precisely, one observes a *bell curve*: The influence is increasing from grade 3 to 6 (8 to 11 years old), and then decreasing.

Section 2.5. *Third*, we focus on the impact of parental investment and child's effort with, respectively, as proxy variables, 'how frequently parents talk about school to their child' and 'time devoted to homework'. As regards child's effort, the results are clear, and the same for each subject: While more time spent on homework seems to go hand in hand with academic difficulties in the lowest grade (Grade 3), the positive impact of effort on results is strengthening as the child grows, but slightly less so in English. The impact of parental investment is in line with our previous results: Whereas it is mixed in mathematics (but not increasing), it is decreasing in literature and increasing in English.

To sum up, we confirm the persistent effect of the parental environment (parental highest schooling, parental investment) on the child's academic performance. Nevertheless, our data suggest a mixed pattern on a possible Matthew effect. Whereas the impact seems to be, globally, decreasing in mathematics and literature as the child grows, it is unambiguously increasing in English. This result confirms the specific status of a second language learning process (Gardner, 1968): The acquisition of a new language is a highly social process, determined by the environment in which the child lives, and which can be a source of important inequality of opportunity. In contrast, remediation programs for adolescent could be effective in mathematics or literature with a focus, for instance, on fostering non-cognitive skills (Bahr, 2007, 2008). Such optimism is supported by the clear indication, obtained from our data, that effort is more and more successful after some age (for all the disciplines).

The rest of the paper is organized as follows. We present in Section 2.2 our data and we present some preliminary results. Section 2.3 investigates the impact of parental highest schooling on student achievement, on the basis of two regression strategies (with or without interaction components). In Section 2.4, we focus on the impact of parental investment and child's effort. Finally, we discuss in Section 2.5 our main results, in the light of a related literature, mainly in psychology. We also present some implications in terms

of educational policies.

## 2.2. Data and preliminary observations

From 2016 to 2019, the Ministry of Education and Research of Madrid Community (Spain)<sup>11</sup> has organized annual exams for all the students of the community in Grade 3 (8 years old), Grade 6 (11 years old) and Grade 10 (15 years old; not assessed in 2016). In parallel with these examinations, four questionnaires were organized for the various stakeholders: one addressed to the parents, one addressed to the student (Grade 6 and Grade 10), one addressed to the school director, and one addressed to the teachers. The main aim of these questionnaires was to assess people's own feelings about the quality of the educational system, but also to evaluate people's involvement (such as the time parents devote to their child's education, or the weekly time children spend on homework). Surprisingly enough, these data have never been used in academic research up to date.

The first contribution of the present paper was to gather a set of disparate files and documents into a unique and harmonized database. Even if they are not panel data, as students cannot be tracked individually from one year to the next, these data do have a number of advantages. First, this is not a simple survey as they cover all pupils in the Madrid community (whether in private or public schools). Then, pupils have a common identifier on examinations and questionnaires, so that it is possible to combine quantitative data on academic performance with more qualitative data, describing the educational environment in some detail. In a way, the loss of information due to the fact that these are not panel data is compensated for by the richness and complementarity of the available data set.

This study focuses on three subjects: mathematics, literature and English

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<sup>11</sup> Consejería de Educación y Investigación de la Comunidad de Madrid.

(foreign language). As with many of the world's leading education surveys,<sup>12</sup> the final exam score in each subject is calculated on the basis of the *Item Response Theory* (IRT). That refers to a family of mathematical models that attempt to explain the relationship between a candidate's response to an item and that candidate's aptitude or skills. In this study, the *Partial Credit Model* (PCM) is implemented (see [Masters and Wright, 1997](#)). As with the Pisa results, the scoring is then transformed so that the mean is 500 and the standard deviation 100.

The database contains information for, approximatively, 615,000 students: 230,000 in Grade 3, 240,000 in Grade 6 and 145,000 in Grade 10. If we take into account students whose parents responded to the questionnaire, we obtain 321,544 students: 145,096 students in Grade 3, 123,811 students in Grade 6 and 52,637 students in Grade 10. An important question concerns the impact of parents' level of education on their child's academic performance. We create a variables with three 'homogenous' categories, based on the highest level of education observed among parents:<sup>13</sup> before Grade 11, Grade 12/Vocational Training/Short-Cycle Tertiary Education and Bachelor/Master/Doctorate. Respectively, they are coded from 0 to 2 and correspond, according to the *International Standard Classification of Education* (ISCED 2011), Levels 0 to 2, Levels 3 to 5 and Levels 6 to 8. The rest of the data is described in Tables 2.1 to 2.5, in Appendix.

We illustrate in Figure 2.1 the impact of the parents' highest level of education on child's mathematics scores, for Grades 3 and 10. We plot the cumulative distribution functions of the scores, conditional on the parents'

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<sup>12</sup> A few examples: PISA, TALIS or PIAAC, for the OECD; TIMSS or PIRLS for the International Association for the Evaluation of Educational Achievement (IEA); TOEFL and Cambridge Certification.

<sup>13</sup> We could also have chosen the father's highest level, or that of the mother. In this paper, we do not investigate whether the effects of parental schooling can be explained by assortative mating, or if the partial effects of parents can be differentiated. We consider *parents' education as a potential* from which children can benefit. See [Holmlund et al. \(2011\)](#), Page 3, for a detailed discussion on this issue.



(highest level of schooling) group. For each grade, we can see that the cumu-

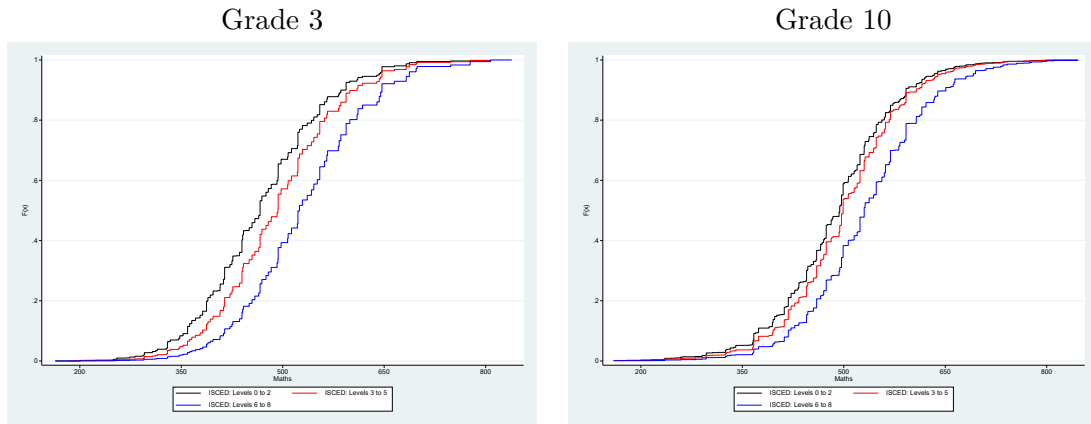


Figure 2.1: CDFs of mathematics scores according to parents' highest education

lative distribution functions are ordered in the sense of *first order stochastic dominance*: For any given score, the probability of having a score higher than it is all the greater the higher the parents' group. This pattern holds true for mathematics, but it also applies to all subjects and all grades in our data (see Figures 2.6 and 2.7 in Appendix). First-order dominance is generally considered to be a clear indication of *inequality of opportunity*, since academic performance depends on a dimension beyond the child's control (Lefranc *et al.*, 2009; Jaoul-Grammare and Magdalou, 2013). This result is in line with a robust trend already observed in the literature.

The second question looks at the evolution of parental influence on child's results, throughout schooling. In Figure 2.1, we see a convergence of the CDFs between Grades 3 and 10 in mathematics, suggesting that the dependence of results on parents' group decreases. However, such an observation must be treated with caution. First, the *tests are of a different nature* for each grade. Then, the fact that the results are standardized (average of 500) can be misleading for comparison purposes. Finally, external factors can significantly impact the results, that can only be analyzed by econometric estimates.

One possible bias in the comparison of the impact of parents' level of education on child's score, at different grades, may be linked to a *composition effect*. For instance, the convergence of the CDFs between Grades 3 and 10 may be a consequence of the fact that, in the group of children whose parents have the lowest level of education, only the most gifted children remain represented in Grade 10. As established in Table 2.5 in Appendix, we do not observe, for each year and each grade, any significant difference in the proportions that each group represents: The proportions are all close to those obtained at global level, i.e. 9.5%, 31.5%, and 59% for parents with ISCED levels, respectively, 0–2, 3–5, and 6–8. We can therefore consider that our data do not suffer from this compositional bias.

The equivalent of Figure 2.1 in literature and English is provided, respectively, in Figures 2.6 and 2.7 in Appendix. Whereas the convergence of CDFs is evident in mathematics and literature between Grades 3 and 10, this is not the case for English: The inequality of opportunity observed at Grade 3 seems to increase at Grade 10. This finding is confirmed by the econometric analysis presented in the following sections.

### 2.3. Impact of parent's level of education

In this section we regress students' score in the three subjects under consideration (three regressions), focusing on the impact of parents' highest level of education.<sup>14</sup> The score of student  $i$  is denoted  $y_{igts}$ , where  $g$  is the grade (Grade 3, Grade 6 or Grade 10),  $t$  the year (from 2016 to 2019) and  $s$  the school attended. As described earlier, parents' highest level of education is modeled by an ordered categorical variable with 3 possible values, hereafter referred as *parents' level*. We introduce independent dummy variables ( $p_j$  with  $j = 1, 2, 3$ ) that allow us to compare the impact of parents' levels two by two,

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<sup>14</sup>We stress that the data are not panel.

with the lowest group ( $j = 1$ ) as the reference value.

We also introduce two groups of control variables, one for the *student characteristics* (each denoted  $s_k$ ) and another for the *households characteristics* (each denoted  $h_k$ ).<sup>15</sup> For each subject, we make an overall estimate of the student's score for all academic years and all grades. Although the tests are common to all schools in the Community of Madrid over the whole period, results may vary in time (from one year to another), and in space (from one school to another, particularly between public and private schools). With the aim of controlling these dimensions, we introduce *two fixed effects*, one for the academic year ( $a_t$ ) and one for the identifier of the school  $s$  where the student  $i$  is registered ( $b_s$ ).<sup>16</sup> One obtains the following regression.

$$y_{igts} = \alpha_0 + \sum_{j=1,2} \alpha_j p_{ji} + \sum_k \beta_k s_{ki} + \sum_k \gamma_k h_{ki} + a_t + b_s + \epsilon_{igts}. \quad (2.3.1)$$

This first regression, for each subject, isolates the influence of parents' highest level of education on student's score. The results are shown in Table 2.6 for mathematics, Table 2.7 for literature and Table 2.8 for English. Whatever the regression specification (including or not the control variables), and for each subject, the results are the same and robust: moving from one parents' level to a higher one, significantly increases student's score. For instance, in mathematics, moving from parent Level 1 (ISCED 0 to 2) to parent Level 3 (ISCED 6 to 8) increases the score by 29.7 points on average when all control variables are included. The effect is larger in literature than in mathematics, and in English than in literature. We summarise these results in Figure 2.2 (estimates with all control variables, also plotting standard deviation), remembering that

<sup>15</sup> Student characteristics include country of birth, number of days a week spent on homework, and gender. Household characteristics include country of birth of both parent, the frequency of use of books/computers/internet at home, the number of books at home, the employment status of both parents, the frequency with which parents talk about school subjects/teach homework/help with homework/check homework with the child.

<sup>16</sup> At this stage, we do not introduce a fixed effect for the grade because the mean score, whatever the grade, is always normalised at 500 at the population level (and the standard deviation at 100). Even if there is a small variation in average scores between disciplines and grades in our samples, they remain very close to 500. Notice that the constants estimated in regressions (3.4.1) is close to this value (see results tables).

a variation of 10 points is equivalent to 10% of the normalised standard deviation at the population level. This result confirms a trend already widely observed in the literature, namely that the parents' level of education has a major influence on the child's academic performance, whatever the subject.

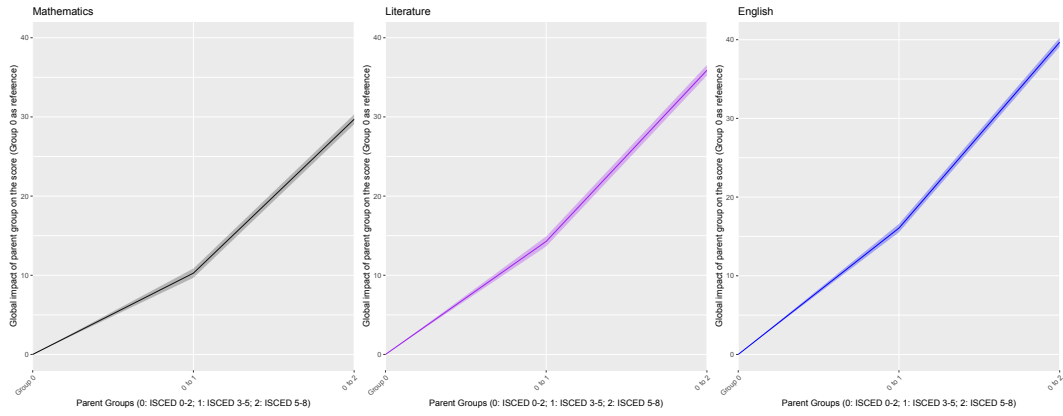


Figure 2.2: Global impact of parents' highest level of education on student's score

A more complex question (at the heart of this paper) concerns the evolution of this impact over time, throughout children's education. To this end, we supplement the previous regression with interaction components between parental highest education and grade level of the student. Precisely, we compare the grades two by two (3 vs. 6, 6 vs. 10 and 3 vs. 10), running a regression for each possible grades pair  $(a, b)$ , where  $a < b$ . In each of these regressions, we retain only the observations of students' scores for grades  $a$  and  $b$  (excluding the third grade). Remembering that  $g$  indicates the grade, we introduce a dummy variable  $I(a, b)$  which takes the value 0 if  $g = a$  (reference grade), and 1 if  $g = b$ . When we compare the grades  $a$  and  $b$ , we obtain the following expression, with  $g \in \{a, b\}$ .

$$y_{igts} = \alpha_0 + \sum_{j=1,2} \alpha_j p_{ji} + \eta I(a, b) + \sum_{j=1,2} \theta_j p_{ji} \times I(a, b) + \sum_k \beta_k s_{ki} + \sum_k \gamma_k h_{ki} + a_t + b_s + \epsilon_{igts}. \quad (2.3.2)$$

The  $\eta$  coefficient indicates the extra points obtained on average by the students in Grade  $b$ , compared with Grade  $a$ . As the average score is standardised at 500 for all grades, this coefficient is not very informative (values other than 0 are due to sample selection). We focus on coefficients  $\alpha_j$  and  $\theta_j$ , for  $j = 1, 2$ . By definition of  $p_{ji}$  and  $I(a, b)$ , the variable  $p_{ji} \times I(a, b)$  takes the value 1 if and only if student  $i$  is in grade  $b$ , with parents from level  $j$ . Since the parents' reference level is the lowest ( $j = 1$ ), and the same applies to the grade (the reference is  $a$ , with  $a < b$ ), the  $\alpha_j$  coefficient is interpreted as the extra points obtained by the student in Grade  $a$  when the parents are in level  $j$  (compared with 0), and  $\theta_j$  is interpreted as the marginal impact of parent's level  $j$ , when the student is in Grade  $b$  instead of Grade  $a$ .

For each subject, we obtain 9 regressions (3 regressions, depending on whether the student and household characteristics are included or not, for each of the 3 pairs of grades compared). The results are shown in Table 2.9 for mathematics, Table 2.10 for literature and Table 2.11 for English. As established in the regressions without interaction components, parents' highest level of education significantly increases student's score, in each discipline (coefficients  $\alpha_j$ ). If we focus on the regressions that take into account all the control variables (columns 3, 6 and 9), we can see that moving from parent Level 1 (ISCED 0 to 2) to Level 3 (ISCED 3 to 5) significantly increases the score, between 11 and 16 points in the three subjects. From parent Level 1 to 3 (ISCED 6 to 8), the score increases between 28 and 37 points. These last values are relatively high, in the range of a third of the normalised standard deviation at the population level (equal to 100).

We now examine the estimates of the interaction components ( $\theta_j$ ), again focussing on the regressions that take into account all the control variables (columns 3, 6 and 9). In mathematics (Table 2.9), there is no significant marginal impact of parents' level between Grades 3 and 6, but the impact is significant and negative between Grade 6 and 10 (and, consequently, also

between Grades 3 and 10). As a result, the impact of parents' highest level of education diminishes as student progresses through grades, from Grade 6 upwards. Between Grades 6 and 10, moving from parent Level 1 to 2 results in a 7.9 point decrease in the score gap, and moving from parent Level 1 to 3 results in a 13.6 point decrease in the score gap. A comparable pattern applies to literature (Table 2.10), with a small difference: between Grades 3 and 6, the marginal impact of moving from parent Level 1 to 3 is significantly positive (about 12.2 points). The same change in parent level, but between Grades 6 and 10, implies a gap reduction of 11.5 points. The effect is therefore a bell-shaped curve in literature. The situation is completely different in English (Table 2.11). Between Grades 3 and 6, and also between Grades 6 and 10, the impact of parents' level increases significantly. For instance, between Grades 3 and 6, the marginal impact of moving from parent Level 1 to 3 is around 9.5 points and, from Grade 6 to Grade 10, is about 9.9 additional points. Hence, influence of parents' level is continuously and significantly increasing in English.

We summarise the main results of the estimates with interaction components in Figure 2.3. We focus here on the evolution of the impact of parents' level on the student score, from Grade 6 to Grade 10 (estimates with all control variables).

#### 2.4. Impact of parental investment and child's effort

In this paper, we analyse the impact of parental environment on academic performance for their child through two channels: parent's level of education (thus, skills acquired before bringing up children), and parental investment (an effort made by parents during the upbringing of their child). In the previous section, we showed that the effect of parents' education tends to decrease between Grades 6 and 10 in mathematics and literature, but increases in English. This section focuses on the second aspect, i.e. the impact of parental

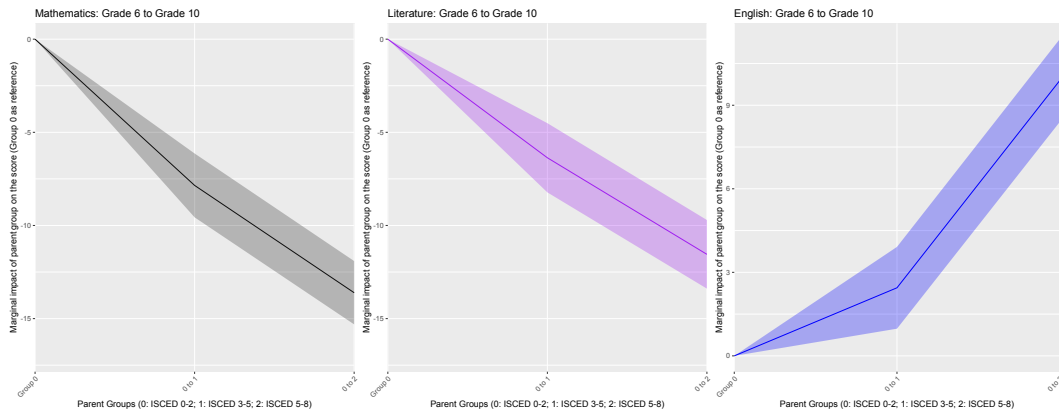


Figure 2.3: Marginal impact of parents' highest level of education from Grade 6 to Grade 10

investment, but also on the impact of efforts made by the child in her studies. We run regressions comparable to Equation (3.4.1), but one per subject and per grade. The results are presented in Table 2.12. We focus on two explanatory dimensions for, respectively, parental investment and child's effort: 'frequency parents talk to their child about school' and 'days per week devoted to homework' (both are introduced in the form of dummy variables).

Estimates are summarised in Figure 2.4. In terms of child's effort, a clear trend emerges, whatever the subject: in Grade 3, the more days per week devoted to homework, the lower the scores (compared with the lowest category, i.e. 'one day or less'). In Grade 6, an increase in the number of days dedicated to homework goes with an increase in results up to 4-5 days per week, then decreases thereafter. In Grade 10, scores increase with the number of days dedicated to homework. The negative impact of the number of days dedicated to homework in the first grade seems to indicate a reverse causality (which could be confirmed by further investigations), i.e. it is poor school results that implies more time devoted to homework (the volume of homework being lower than in the higher grades). As students progress in their studies, effort seems to have an increasing impact, culminating in a clear positive impact in Grade 10.

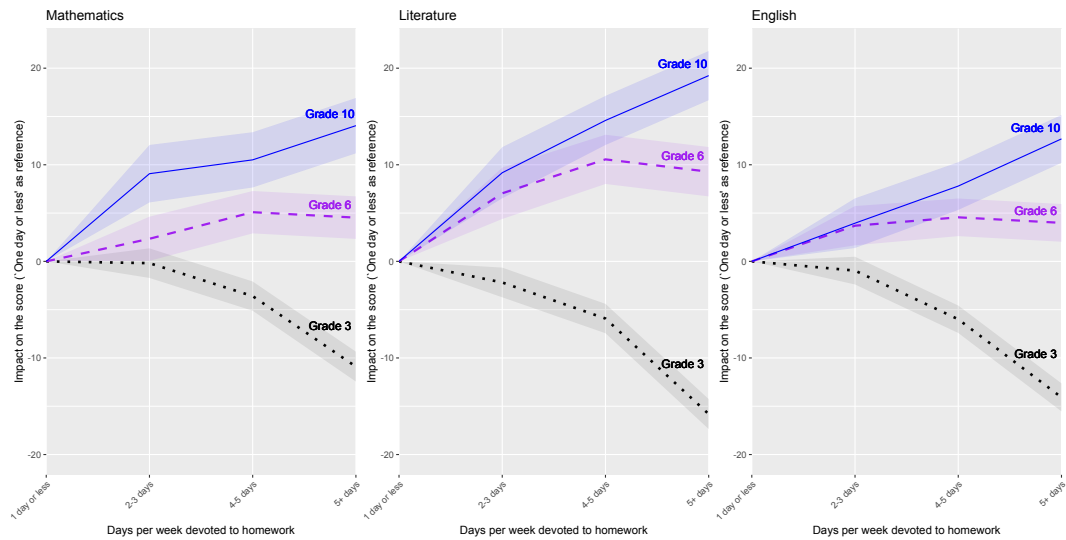


Figure 2.4: Impact of child's effort

Finally, if we focus on the highest effort category ('five days or more') in Grade 10, we can see that the greatest positive impact is for literature (+19.23 points), then mathematics (+14.05 points), and finally English (+12.68 points).

The number of days per week dedicated to homework cannot be considered as a purely effort variable for the child, as homework is supervised by parents (particularly in early childhood). However, children gain independence as they progress through the grades and, as time goes on, the more work they do, the better their results. This form of emancipation is weaker in English, compared with the other two subjects.

The impact of parental investment on child's achievement also seems to go hand in hand with lower emancipation in English. First of all, we observe in Table 2.12 that, whatever the subject or grade (with some few exceptions), if the frequency with which parents talk to their child about school increases, then student achievement improves. However, between Grades 3 and 10, if we focus on the highest category of investment ('every or almost every day'), the positive impact of parental investment decreases slightly in mathematics



and quite sharply in literature (by more than a third), while it increases in English. Moreover, if we compare the intensity of the impact between subjects, we obtain the following ranking : English < mathematics < literature in Grade 3, but literature < mathematics < English at Grade 10. Hence, the impact of parental investment is clearly increasing in English, as compared to the other subjects. These results are shown in Figure 2.5 (where standard deviations have not been shown for the sake of clarity).

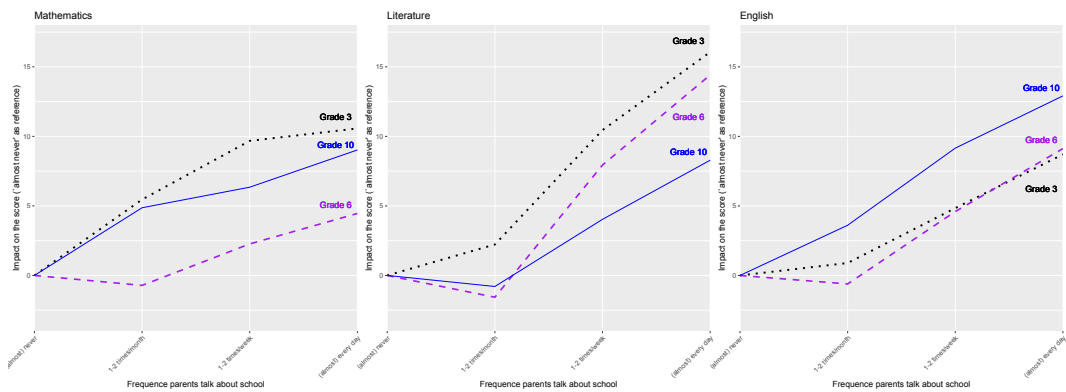


Figure 2.5: Impact of parental investment

Finally, if we look at all the explanatory variables in Grade 10, we see that in mathematics and literature, the impact of child's effort exceeds the impact of parental investment and is comparable to the impact of parents' level of education. This is not the case in English: the impact of the child's effort and that of the parents' investment are roughly comparable, while the impact of parents' level of education is much greater.

## 2.5. Discussion, related literature, and policy implications

*Matthew effect in education.* Few empirical studies have attempted to test the Matthew effect hypothesis in education, most of them applied to reading abilities and its impact on acquisition of literacy (and other related

skills). They all agree that the differences in reading abilities in the early education stages continue on until adulthood (Cunningham and Stanovich, 1997; Rigney, 2010), but the results are mixed on the existence of a Matthew effect: There is not a strong support for a pattern of widening or decreasing achievement differences (Pfof *et al.*, 2014). Some papers find that the effect is strongly increasing (Awaida and Beech, 1995; Howley, 2001), others that it is intermediate (Bast and Reitsma, 1998) and some that it is not even significant or related to social background (Shawitz *et al.*, 1995; Protopapas *et al.*, 2011).

While our study confirms a persistent impact of parental environment on child's academic performance (a fact widely accepted since the Coleman report, 1966), the results differ between subjects as regards the Matthew effect. From age 11 to 15, the effect of parent's level of education decreases in mathematics and literature, while it increases in English. At age of 15, spending '5 days or more' doing homework (compared with 'one day or less') increases child achievement, but more strongly in literature than in mathematics, and more strongly in mathematics than in English. Similarly, at the same age, the impact of 'the frequency with which parents talk to their child about school' is stronger in English, followed by mathematics and then by literature (although the order is reversed at age 8).

To sum up, these results therefore reflect a partial emancipation (from the influence of parental environment) in mathematics and literature, while social determinism increases in English. In the first two subjects, the results echo the work of cognitive psychology initiated by Jean Piaget, according to which the child is partly master of his or her own development: They have an intrinsic ability to learn, without this necessarily being transmitted by others, and their strategies and involvement play a role in their academic performance (Onatsu-Arvilomni and Nurmi, 2000). The notion of an age of consent (for responsible choice) can therefore make sense, including in education, and this age can be set between 12 and 16, as proposed by Hufe *et al.* (2017).

Conversely, our results confirm the social dimension of learning a foreign language, compared with other academic subjects. In that case, external factors appear to play a decisive role in the learning process (Vygotsky, 1978). In addition, the theory of Cunha and Heckman (2007) which describes a path-dependency in the formation of cognitive skills, seems to be confirmed. As Gardner (1968) and Dornyei (1998) point out, the acquisition of a new language involves a great deal of integrative motivation (in the sense that people are interested in learning a language because they want to communicate with the other language community), and parents play a crucial role in encouraging this integrative motivation (as opposed to instrumental motivation). According to Gardner (1968), parents play two roles in their child's success in learning a second language: an active role which consists of actively and consciously encouraging their child to learn the language, and a (more important) passive role, which consists of the attitudes that parents have towards the community whose language their child is learning.

***Policy implications.*** Our results, which need to be confirmed using other databases and complementary methodologies, have several implications for educational policies. The first concerns remediation programmes, aimed at improving the skills of children experiencing difficulties. The second concerns national selection processes in higher education ('Grandes Ecoles' in France, for instance), which include foreign language skills as a criterion for admission.

With regard to remedial programmes, the main recommendation resulting from the empirical estimates of Cunha and Heckman (2007) and Cunha *et al.* (2010) is to focus (adolescent) remediation strategies for disadvantaged children on the development of non-cognitive skills. Our results indicate that programmes focusing on cognitive skills can also be effective, particularly in mathematics. These results are in line with those of Bahr (2007, 2008), who assesses US postsecondary remediation programmes. He first observes that the degree of deficiency (depth) and the number of deficient basic skill areas

(breadth) are good predictors of successful math remediation: Those who require the least remediation are the most likely to remediate successfully. But he also observes that when remediation works (at a low rate, unfortunately) it works extremely well: ‘students who remediate successfully in mathematics exhibit attainment that is comparable to that of students who achieve college mathematics skill without the need for remediation’ (Bahr, 2008, Page 442).

The second implication in terms of public education policy concerns the weight of foreign languages in the selection process to access higher education, at different levels. We have found that parents’ education and involvement are essential factors in children’s success in learning a foreign language. What’s more, the child’s effort has (slightly) less impact on results than in subjects such as mathematics or literature. This is a strong sign of inequality of opportunity, and including foreign languages as an admission criterion reinforces this inequality. It therefore seems essential that educational systems give a high priority to foreign language teaching, particularly in non-English-speaking countries, from an early age, so as not to further penalise children from socially disadvantaged backgrounds.

## 2.6. Appendix

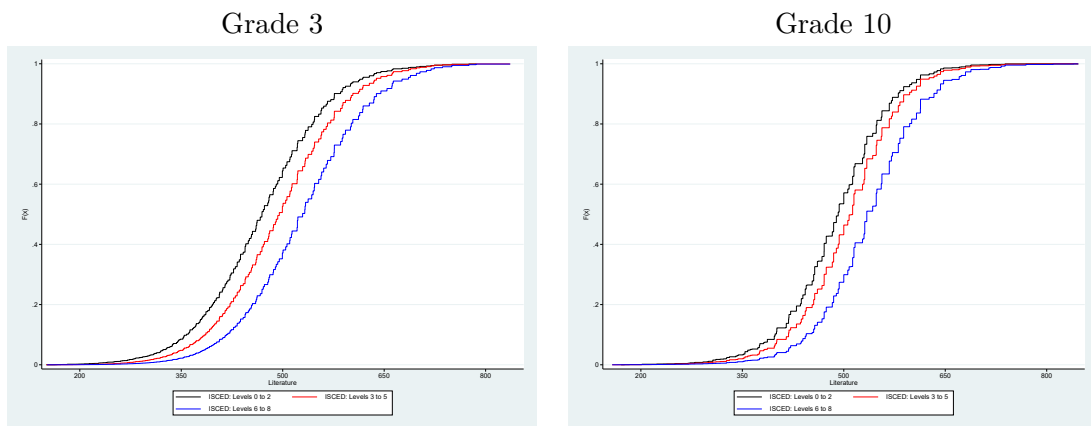


Figure 2.6: CDFs of literature scores according to parents' highest education

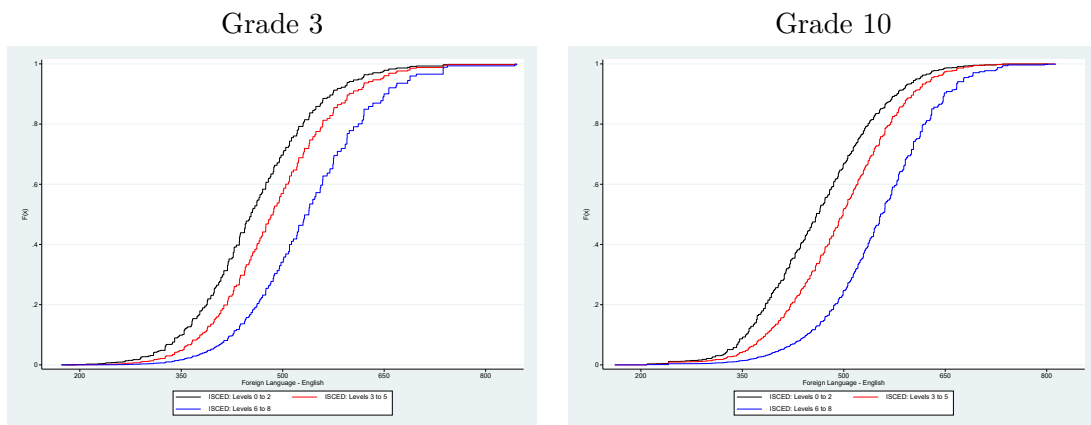


Figure 2.7: CDFs of English scores according to parents' highest education

Table 2.1: Variables Description

	Type	Values	Description
<b>Students marks</b>			
Mathematics	Num.	0 - 1034	Transformed Mathematics mark
Literature	Num.	0 - 1001	Transformed Literature mark
English (Foreign Language)	Num.	0 - 845	Transformed English mark
<b>Parents highest education</b>			
Parents highest education	Qual.	0 - 2	0 ISCED 0 to 2 1 ISCED 3 to 5 2 ISCED 6 to 8
<b>Child's characteristics</b>			
Child's country of birth	Qual.	1 - 2	1 Spain 2 Other
Days/week dedicated to homework	Qual.	1 - 4	1 One day or less 2 Two or 3 days 3 Four or 5 days 4 More than 5
Child's gender	Qual.	1 - 2	1 Female 2 Male
<b>Household's characteristics</b>			
Mother's country of birth	Qual.	1 - 2	1 Spain 2 Other
Father's country of birth	Qual.	1 - 2	1 Spain 2 Other
Freq. books used at home	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Freq. computer used at home	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Freq. internet used at home	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Nb of books at home	Qual.	1 - 5	1 From 0 to 10 2 From 11 to 50 3 From 51 to 100 4 From 101 to 200 5 More than 200
Mother's labour situation	Qual.	1 - 5	1 Full time employee

Table 2.1: Variables description (continued)

	Type	Values	Description
			2 Part time employee 3 Unemployed looking for a job 4 Retired 5 Don't have and don't look for a job
Father's labour situation	Qual.	1 - 5	1 Full time employee 2 Part time employee 3 Unemployed looking for a job 4 Retired 5 Don't have and don't look for a job
Freq. parents talk about school	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Freq. parents schedule homework	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Freq. parents help for homework	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Freq. parents check homework	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
<i>N</i>		327163	

Table 2.2: Summary Statistics

	mean	sd
<b>Students marks</b>		
Mathematics	517.4546	95.00513
Literature	505.935	101.8927
English Foreign Language	517.1402	93.7307
<b>Parents highest education</b>		
Parents highest education	1.494245	.6642053
<b>Child's characteristics</b>		
Child's country of birth	1.044064	.2052369
Days/week dedicated to homework	3.310194	.7581023
Child's gender	1.502942	.4999921
<b>Household's characteristics</b>		
Mother's country of birth	1.165642	.3717597
Father's country of birth	1.159382	.3660328
Freq. books used at home	3.375672	.837836
Freq. computer used at home	3.794766	.5249957
Freq. internet used at home	3.865501	.4511002
Nb of books at home	3.515174	1.203279
Mother's labour situation	1.651739	1.015354
Father's labour situation	1.303231	.7056803
Freq. parents talk about school with child	3.82281	.5012083
Freq. parents schedule homework with child	3.476625	.9059994
Freq. parents help for homework	2.99286	1.098742
Freq. parents check homework with child	3.440297	.9775864
<i>N</i>	327163	

Table 2.3: Maths, Literature and English means according to grade level

	(1) Gr.3	(2) Gr.6	(3) Gr.10
Maths	513.29	521.52	519.33
Literature	514.21	489.35	522.26
English	515.02	515.77	526.17
<i>N</i>	145096	123811	52637



Table 2.4: Maths, Literature and English means according to grade level, by academic year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	2016	2016	2017	2017	2017	2018	2018	2018	2019	2019	2019
	Gr.3	Gr.6	Gr.3	Gr.6	Gr.10	Gr.3	Gr.6	Gr.10	Gr.3	Gr.6	Gr.10
Maths	507.1	509.8	514.5	515.3	514.1	518.1	545.5	522.9	515.9	518.4	520.9
Lit.	510.5	436.3	513.3	514.8	518.7	517.6	524.1	526.5	517.0	516.6	521.1
English	509.2	510.0	515.3	516.1	522.2	520.1	520.1	530.7	517.7	520.5	525.1
<i>N</i>	47061	44249	32390	24578	18029	36535	31060	19594	29110	23924	15014

Table 2.5: Students distribution according to parent highest education, grade level and academic year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	2016	2016	2017	2017	2017	2018	2018	2018	2019	2019	2019
	Gr.3	Gr.6	Gr.3	Gr.6	Gr.10	Gr.3	Gr.6	Gr.10	Gr.3	Gr.6	Gr.10
ISCED 0 to 2	11.15%	10.90%	7.945%	9.520%	9.335%	8.845%	10.15%	8.574%	8.737%	9.296%	8.468%
ISCED 3 to 5	33.40%	35.43%	29.87%	32.93%	35.53%	28.87%	31.07%	32.08%	26.72%	28.57%	30.14%
ISCED 6 to 8	55.45%	53.67%	62.19%	57.55%	55.14%	62.28%	58.79%	59.35%	64.54%	62.13%	61.40%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
<i>N</i>	47081	44305	33077	24706	18425	36619	31036	19909	29769	24644	15470

Table 2.6: Parents highest education impact - Mathematics

	(1)	(2)	(3)
	Maths	Maths	Maths
<b>Parents highest education</b>			
ISCED 0 to 2	0 (.)	0 (.)	0 (.)
ISCED 3 to 5	15.81*** (0.479)	16.72*** (0.517)	10.27*** (0.589)
ISCED 6 to 8	41.40*** (0.491)	42.92*** (0.530)	29.70*** (0.625)
Constant	482.3*** (0.499)	486.6*** (1.150)	476.5*** (2.661)
Academic Year fixed-effect	Yes	Yes	Yes
School fixed-effet	Yes	Yes	Yes
Child's characteristics	No	Yes	Yes
Household's characteristics	No	No	Yes
Observations	415226	367492	316294
Adjusted $R^2$	0.160	0.172	0.204

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 2.7: Parents highest education impact - Literature

	(1)	(2)	(3)
	Literature	Literature	Literature
<b>Parents highest education</b>			
ISCED 0 to 2	0 (.)	0 (.)	0 (.)
ISCED 3 to 5	19.25*** (0.515)	20.27*** (0.556)	14.28*** (0.634)
ISCED 6 to 8	46.42*** (0.527)	48.65*** (0.569)	35.89*** (0.673)
Constant	478.3*** (0.536)	504.4*** (1.237)	488.8*** (2.865)
Academic Year fixed-effect	Yes	Yes	Yes
School fixed-effet	Yes	Yes	Yes
Child's characteristics	No	Yes	Yes
Household's characteristics	No	No	Yes
Observations	414805	367757	316529
Adjusted $R^2$	0.146	0.175	0.197

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 2.8: Parents highest education impact - English

	(1)	(2)	(3)
	English	English	English
<b>Parents highest education</b>			
ISCED 0 to 2	0 (.)	0 (.)	0 (.)
ISCED 3 to 5	21.81*** (0.437)	21.75*** (0.471)	16.06*** (0.535)
ISCED 6 to 8	52.55*** (0.448)	52.34*** (0.483)	39.68*** (0.568)
Constant	473.7*** (0.455)	492.3*** (1.048)	468.3*** (2.418)
Academic Year fixed-effect	Yes	Yes	Yes
School fixed-effet	Yes	Yes	Yes
Child's characteristics	No	Yes	Yes
Household's characteristics	No	No	Yes
Observations	413466	365774	314863
Adjusted $R^2$	0.293	0.303	0.329

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 2.9: Parents highest education's (registered as "Level 1, 2 and 3") impact according to grade level (compared two-by-two) - Panel A: Maths

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Math	Math	Math	Math	Math	Math	Math	Math	Math
	Gr.3/6	Gr.3/6	Gr.3/6	Gr.6/10	Gr.6/10	Gr.6/10	Gr.3/10	Gr.3/10	Gr.3/10
<b>Parents highest education</b>									
Level 1	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
Level 2	18.84***	19.05***	12.05***	18.40***	17.86***	11.03***	18.97***	19.00***	12.33***
	(0.757)	(0.762)	(0.864)	(0.819)	(0.816)	(0.921)	(0.769)	(0.765)	(0.877)
Level 3	46.16***	46.16***	30.22***	47.02***	46.62***	31.28***	45.24***	45.39***	30.08***
	(0.745)	(0.750)	(0.874)	(0.833)	(0.833)	(0.966)	(0.777)	(0.776)	(0.917)
<b>Grade 3 vs Grade 6</b>									
<i>I(3, 6)</i>	9.017***	10.49***	-2.856***						
	(0.932)	(0.940)	(1.081)						
<b>Interactions</b>									
<i>Level 1 * I(3, 6)</i>	0	0	0						
	(.)	(.)	(.)						
<i>Level 2 * I(3, 6)</i>	-0.759	-1.029	-1.161						
	(1.083)	(1.090)	(1.219)						
<i>Level 3 * I(3, 6)</i>	-0.0122	0.0649	0.626						
	(1.021)	(1.027)	(1.155)						
<b>Grade 6 vs Grade 10</b>									

Table 2.9: Parents highest education's (registered as "Level 1, 2 and 3") impact according to grade level (compared two-by-two) - Panel A: Maths (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Math	Math	Math	Math	Math	Math	Math	Math	Math
	Gr.3/6	Gr.3/6	Gr.3/6	Gr.6/10	Gr.6/10	Gr.6/10	Gr.3/10	Gr.3/10	Gr.3/10
<i>I</i> (6, 10)				6.615***	13.98***	-8.327***			
				(1.205)	(1.506)	(1.696)			
<b>Interactions</b>									
<i>Level 1 * I</i> (6, 10)				0	0	0			
				(.)	(.)	(.)			
<i>Level 2 * I</i> (6, 10)				-9.866***	-11.76***	-7.850***			
				(1.229)	(1.545)	(1.714)			
<i>Level 3 * I</i> (6, 10)				-19.15***	-20.84***	-13.61***			
				(1.220)	(1.529)	(1.700)			
<b>Grade 3 vs Grade 10</b>									
<i>I</i> (3, 10)							9.617***	17.89***	-12.96***
							(1.163)	(1.463)	(1.707)
<b>Interactions</b>									
<i>Level 1 * I</i> (3, 10)							0	0	0
							(.)	(.)	(.)
<i>Level 2 * I</i> (3, 10)							-10.50***	-12.24***	-8.859***
							(1.187)	(1.500)	(1.684)
<i>Level 3 * I</i> (3, 10)							-16.23***	-16.64***	-9.076***

Table 2.9: Parents highest education's (registered as "Level 1, 2 and 3") impact according to grade level (compared two-by-two) - Panel A: Maths (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Math	Math	Math	Math	Math	Math	Math	Math	Math
	Gr.3/6	Gr.3/6	Gr.3/6	Gr.6/10	Gr.6/10	Gr.6/10	Gr.3/10	Gr.3/10	Gr.3/10
Constant	475.5*** (0.740)	483.6*** (1.329)	485.8*** (3.166)	474.7*** (0.822)	469.3*** (1.784)	464.1*** (4.107)	474.8*** (0.769)	482.1*** (1.410)	480.3*** (3.225)
Academic Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child's characteristics	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Household's characteristic	No	No	Yes	No	No	Yes	No	No	Yes
Observations	310508	306732	264386	248339	202678	173619	271605	225574	194583
Adjusted $R^2$	0.178	0.186	0.222	0.155	0.167	0.206	0.180	0.200	0.225

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Parental highest schooling: Level.1 = ISCED 0 to 2; Level.2 = ISCED 3 to 5; Level.3 = ISCED 6 to 8

$I(a, b)$  is a dummy variable which takes the value 0 if  $g = a$  (reference grade), and 1 if  $g = b$



Table 2.10: Parents highest education's (registered as "Level 1, 2 and 3") impact according to grade level (compared two-by-two) - Panel B: Literature

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.
	Gr.3/6	Gr.3/6	Gr.3/6	Gr.6/10	Gr.6/10	Gr.6/10	Gr.3/10	Gr.3/10	Gr.3/10
<b>Parents highest education</b>									
Level 1	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
Level 2	19.91***	20.39***	13.30***	21.82***	22.05***	14.96***	21.19***	21.90***	15.32***
	(0.845)	(0.840)	(0.950)	(0.877)	(0.884)	(0.993)	(0.751)	(0.745)	(0.850)
Level 3	44.50***	45.18***	28.44***	52.57***	53.50***	36.83***	46.60***	48.01***	32.75***
	(0.832)	(0.826)	(0.960)	(0.892)	(0.902)	(1.042)	(0.758)	(0.754)	(0.888)
<b>Grade 3 vs Grade 6</b>									
<i>I</i> (3, 6)	-30.56***	-29.72***	-42.57***						
	(1.040)	(1.035)	(1.188)						
<b>Interactions</b>									
<i>Level 1 * I</i> (3, 6)	0	0	0						
	(.)	(.)	(.)						
<i>Level 2 * I</i> (3, 6)	1.955	2.237*	2.442*						
	(1.210)	(1.201)	(1.339)						
<i>Level 3 * I</i> (3, 6)	10.85***	11.26***	12.21***						
	(1.140)	(1.133)	(1.269)						
<b>Grade 6 vs Grade 10</b>									

Table 2.10: Parents highest education's (registered as "Level 1, 2 and 3") impact according to grade level (compared two-by-two) - Panel B: Literature (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.
	Gr.3/6	Gr.3/6	Gr.3/6	Gr.6/10	Gr.6/10	Gr.6/10	Gr.3/10	Gr.3/10	Gr.3/10
<i>I</i> (6, 10)				15.05***	21.71***	3.264*			
				(1.297)	(1.637)	(1.837)			
<b>Interactions</b>									
<i>Level 1</i> * <i>I</i> (6, 10)				0	0	0			
				(.)	(.)	(.)			
<i>Level 2</i> * <i>I</i> (6, 10)				-5.898***	-7.829***	-6.367***			
				(1.324)	(1.680)	(1.858)			
<i>Level 3</i> * <i>I</i> (6, 10)				-15.16***	-17.01***	-11.55***			
				(1.314)	(1.662)	(1.842)			
<b>Grade 3 vs Grade 10</b>									
<i>I</i> (3, 10)							9.118***	16.65***	-8.665***
							(1.140)	(1.428)	(1.661)
<b>Interactions</b>									
<i>Level 1</i> * <i>I</i> (3, 10)							0	0	0
							(.)	(.)	(.)
<i>Level 2</i> * <i>I</i> (3, 10)							-5.154***	-7.210***	-6.144***
							(1.165)	(1.466)	(1.639)
<i>Level 3</i> * <i>I</i> (3, 10)							-7.959***	-9.132***	-3.856**

Table 2.10: Parents highest education's (registered as "Level 1, 2 and 3") impact according to grade level (compared two-by-two) - Panel B: Literature (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.	Lit.
	Gr.3/6	Gr.3/6	Gr.3/6	Gr.6/10	Gr.6/10	Gr.6/10	Gr.3/10	Gr.3/10	Gr.3/10
Constant	491.3*** (0.826)	518.2*** (1.467)	508.6*** (3.479)	395.9*** (0.879)	409.4*** (1.939)	390.1*** (4.434)	(1.152) 475.5*** (0.750)	(1.449) 499.9*** (1.373)	(1.630) 488.1*** (3.129)
Academic Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child's characteristics	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Household's characteristic	No	No	Yes	No	No	Yes	No	No	Yes
Observations	311019	307233	264811	247527	202556	173528	271064	225725	194719
Adjusted $R^2$	0.162	0.192	0.224	0.209	0.249	0.282	0.152	0.176	0.205

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Parental highest schooling: Level.1 = ISCED 0 to 2; Level.2 = ISCED 3 to 5; Level.3 = ISCED 6 to 8

$I(a, b)$  is a dummy variable which takes the value 0 if  $g = a$  (reference grade), and 1 if  $g = b$

Table 2.11: Parents highest education's (registered as "Level 1, 2 and 3") impact according to grade level (compared two-by-two) - Panel C: English

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Engl	Engl	Engl	Engl	Engl	Engl	Engl	Engl	Engl
	Gr.3/6	Gr.3/6	Gr.3/6	Gr.6/10	Gr.6/10	Gr.6/10	Gr.3/10	Gr.3/10	Gr.3/10
<b>Parents highest education</b>									
Level 1	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
Level 2	18.59***	19.22***	13.35***	22.10***	22.29***	15.87***	19.19***	19.93***	14.05***
	(0.698)	(0.700)	(0.794)	(0.727)	(0.719)	(0.806)	(0.711)	(0.708)	(0.806)
Level 3	46.57***	47.07***	33.11***	51.79***	52.93***	37.69***	45.51***	47.29***	33.20***
	(0.687)	(0.689)	(0.803)	(0.739)	(0.734)	(0.846)	(0.718)	(0.717)	(0.843)
<b>Grade 3 vs Grade 6</b>									
<i>I</i> (3, 6)	-3.799***	-3.022***	-13.54***						
	(0.859)	(0.862)	(0.993)						
<b>Interactions</b>									
<i>Level 1 * I</i> (3, 6)	0	0	0						
	(.)	(.)	(.)						
<i>Level 2 * I</i> (3, 6)	4.857***	4.882***	5.017***						
	(0.998)	(1.000)	(1.119)						
<i>Level 3 * I</i> (3, 6)	8.692***	9.089***	9.549***						
	(0.940)	(0.943)	(1.060)						
<b>Grade 6 vs Grade 10</b>									

Table 2.11: Parents highest education's (registered as "Level 1, 2 and 3") impact according to grade level (compared two-by-two) - Panel C: English (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Engl	Engl	Engl	Engl	Engl	Engl	Engl	Engl	Engl
	Gr.3/6	Gr.3/6	Gr.3/6	Gr.6/10	Gr.6/10	Gr.6/10	Gr.3/10	Gr.3/10	Gr.3/10
<i>I</i> (6, 10)				-2.601**	3.110**	-10.94***			
				(1.069)	(1.326)	(1.484)			
<b>Interactions</b>									
<i>Level 1 * I</i> (6, 10)				0	0	0			
				(.)	(.)	(.)			
<i>Level 2 * I</i> (6, 10)				1.979*	1.604	2.445			
				(1.090)	(1.359)	(1.499)			
<i>Level 3 * I</i> (6, 10)				7.618***	6.814***	9.885***			
				(1.083)	(1.346)	(1.488)			
<b>Grade 3 vs Grade 10</b>									
<i>I</i> (3, 10)							-11.74***	-5.893***	-28.24***
							(1.072)	(1.348)	(1.565)
<b>Interactions</b>									
<i>Level 1 * I</i> (3, 10)							0	0	0
							(.)	(.)	(.)
<i>Level 2 * I</i> (3, 10)							4.794***	4.653***	5.232***
							(1.094)	(1.382)	(1.543)
<i>Level 3 * I</i> (3, 10)							16.01***	16.55***	19.72***

Table 2.11: Parents highest education's (registered as "Level 1, 2 and 3") impact according to grade level (compared two-by-two) - Panel C: English (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Engl	Engl	Engl	Engl	Engl	Engl	Engl	Engl	Engl
	Gr.3/6	Gr.3/6	Gr.3/6	Gr.6/10	Gr.6/10	Gr.6/10	Gr.3/10	Gr.3/10	Gr.3/10
Constant	477.8*** (0.682)	498.6*** (1.222)	483.3*** (2.908)	474.3*** (0.729)	483.2*** (1.572)	457.9*** (3.599)	478.4*** (0.712)	497.2*** (1.304)	478.7*** (2.961)
Academic Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child's characteristics	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Household's characteristic	No	No	Yes	No	No	Yes	No	No	Yes
Observations	308884	305117	263032	247798	202173	173209	270250	224258	193485
Adjusted $R^2$	0.301	0.312	0.337	0.315	0.328	0.360	0.302	0.314	0.337

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Parental highest schooling: Level.1 = ISCED 0 to 2; Level.2 = ISCED 3 to 5; Level.3 = ISCED 6 to 8

$I(a, b)$  is a dummy variable which takes the value 0 if  $g = a$  (reference grade), and 1 if  $g = b$

Table 2.12: Parental investment and child effort

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Math	Math	Math	Lit.	Lit.	Lit.	Engl	Engl	Engl
	Gr.3	Gr.6	Gr.10	Gr.3	Gr.6	Gr.10	Gr.3	Gr.6	Gr.10
<b>Parents highest education</b>									
ISCED 0 to 2	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
ISCED 3 to 5	12.04***	10.99***	3.304**	15.27***	14.68***	7.688***	14.71***	16.40***	16.46***
	(0.861)	(0.909)	(1.496)	(0.864)	(1.054)	(1.325)	(0.806)	(0.806)	(1.290)
ISCED 6 to 8	30.01***	30.84***	17.90***	32.99***	35.96***	24.54***	35.62***	39.08***	42.99***
	(0.914)	(0.972)	(1.584)	(0.917)	(1.128)	(1.403)	(0.855)	(0.862)	(1.366)
<b>Days/week dedicated to homework</b>									
One day or less	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
2 or 3 days	-0.185	2.338	9.076***	-2.184	7.045***	9.176***	-0.957	3.693*	3.954
	(1.533)	(2.288)	(2.978)	(1.538)	(2.658)	(2.648)	(1.437)	(2.030)	(2.572)
4 or 5 days	-3.599**	5.090**	10.51***	-5.920***	10.56***	14.59***	-5.995***	4.559**	7.796***
	(1.516)	(2.194)	(2.863)	(1.521)	(2.548)	(2.545)	(1.421)	(1.947)	(2.473)
More than 5	-10.90***	4.527**	14.05***	-15.81***	9.282***	19.23***	-14.08***	3.986**	12.68***
	(1.548)	(2.203)	(2.866)	(1.553)	(2.558)	(2.548)	(1.451)	(1.955)	(2.476)
<b>Freq. parents talk about school</b>									
Never or almost never	0	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
1 or 2 times/month	5.461	-0.716	4.868*	2.225	-1.567	-0.793	0.894	-0.611	3.610

Table 2.12: Parental investment and child effort (continued)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Math	Math	Math	Lit.	Lit.	Lit.	Engl	Engl	Engl
	Gr.3	Gr.6	Gr.10	Gr.3	Gr.6	Gr.10	Gr.3	Gr.6	Gr.10
	(4.141)	(3.151)	(2.705)	(4.152)	(3.661)	(2.394)	(3.862)	(2.798)	(2.339)
1 or 2 times/week	9.676***	2.266	6.345***	10.45***	7.938***	4.034**	4.841	4.593*	9.155***
	(3.545)	(2.650)	(2.303)	(3.553)	(3.077)	(2.038)	(3.299)	(2.353)	(1.992)
Every or almost every days	10.57***	4.455*	9.023***	16.06***	14.41***	8.285***	8.704***	9.119***	12.91***
	(3.485)	(2.585)	(2.228)	(3.492)	(3.001)	(1.970)	(3.243)	(2.295)	(1.927)
Constant	482.3***	473.2***	470.8***	491.0***	472.2***	463.2***	483.7***	463.5***	441.5***
	(4.572)	(4.881)	(9.367)	(4.582)	(5.657)	(8.268)	(4.265)	(4.331)	(8.148)
Academic Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child's characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household's characteristic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	142675	121711	51908	143001	121810	51718	141654	121378	51831
Adjusted $R^2$	0.262	0.235	0.202	0.230	0.301	0.200	0.361	0.378	0.343

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$



## Chapter 3

### **Does birth date impact academic performance and grade retention probability on the long-run?**

If being part of the youngest of the group has a well-known negative impact on school achievement in early grade levels, it remains unclear whether this impact persists over time or disappears. Empirical studies differ according to countries, due to scholar system's particularities. In this paper we show that relative age effect is high in Grade 3 in Madrid Community (Spain) in mathematics, literature, and English (second language) among all social backgrounds. This effect declines sharply as children grow and even disappears in mathematics in Grade 10. We also show that grade retention is high among children born in Q4 in Grade 3 compared to those born in Q1 (+123%). But this strong disequilibrium evolves to more balanced ratios in Grade 10 (+43% more likely to have repeated in Grade 10 if born in Q4 compared to Q1). Contrary to other countries like Canada, England, USA or Japan, the Madrilenian scholar system is not facing the challenge of the persistence of relative age effect over time.

### 3.1. Introduction

In all countries, many answers to future challenges like growth, adaptation to technical changes, innovation, democracy, rest on the population's education. At an individual level, good education is a necessary condition to achieve more freedom, wether economical or ideologically. For those reasons, studies aiming at ensuring large and equal chances to perform well at school are of interest. In this paper, we analyse one aspect of equality in education: the impact of birth date on school achievement.

If being part of the youngest of the group has a well-known negative impact on school achievement in early grade levels ([Strøm, 2004](#); [Sprietsma, 2010](#)), it remains unclear whether this impact persists over time ([Smith, 2009](#); [Gutiérrez-Domènech and Adsera, 2012](#)) or disappears ([Kinard and Reinherz, 1986](#); [Dobkin and Ferreira, 2010](#)).

This phenomenon in which older children in a school cohort take advantage of their physical and mental maturity is called the relative age effect<sup>1</sup>. Because of this effect and with a view to limiting unfair inequality, in the last two decades, an increasing literature emerges about what can be the appropriated age at school entry. Some papers recommend postponing compulsory education starting age ([Fredriksson and Öckert, 2014](#)) when others found no impact of age at school entry on school attainment (see [Fertig and Kluge, 2005](#); [Sakic \*et al.\*, 2013](#), for Germany and Croatia respectively).

In the United-States, where entrance rules are not strict and subject to the influence of parents, an increasing part of children differs their school entry date by one year (redshirting), mainly to evade the relative age effect and, doing so, to optimize school attainment and to reduce grade retention probability ([Datar, 2006](#)).

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<sup>1</sup> A terminology widely used in economy, but which comes from the developmental psychology literature.

Nevertheless, redshirting is not neutral and has negative consequences from an equality of opportunity point of view on one hand and from a human capital perspective on the other hand. Indeed, as [Elder and Lubotsky \(2009\)](#) demonstrate, the positive relationship between kindergarten entrance age and school achievement reflects skill accumulation prior to kindergarten. They also found that relative age effect is especially pronounced among children from upper-income families, a group likely to have accumulated the most skills to school entry due to greater level of investment by their parents prior to kindergarten. Once school starts, this positive relationship declines sharply in subsequent years, proving that school tends to decrease the high level of differences in abilities observed at school entry according to socio-economic background. From an equality of opportunity perspective, it is crucial that compulsory school entry does not tend to be delayed because of the relative age effect.

From a human capital point of view, starting school early is also a cornerstone. As demonstrated by [Cunha \*et al.\* \(2010\)](#), it is easier to redress endowment deficits that determine cognition in the first stage of a child's life cycle than in the second stage and that is why the optimal policy consists in investing relatively more in disadvantaged children compared to the advantaged in the early years. [Elder and Lubotsky \(2009\)](#) also find that, if redshirting decreases grade retention probability and improves academic performances for a given grade level, it decreases the academic abilities reached by a child at a given age (as the child is attending a lower grade as he should have if he had entered school at the strict predicted age). For those two reasons, redshirting has a negative impact on human capital accumulation.

If postponing school entry is not a satisfying answer to the relative age effect, one may question the causes of such an effect to be able to thwart it satisfactorily. A convincing theory is the one developed by [Allen and Barnsley \(1993\)](#). According to this theory, differences in early age abilities are due to

differences in maturity and, as abilities are difficult to observe and impossible to separate from maturity at younger age, any selection that is made before the end of the maturity effect<sup>2</sup> contains errors: having doted but immature children sent to lower stream and less able but more mature children sent to top stream. As this theory makes the nonastrology assumption<sup>3</sup>, if the relative age effect is still observed over a number of periods, it implies that initial selection errors have not been eradicated. They make the hypothesis that the persistence of selection errors in training systems is an increasing function of the size of the quality difference in training between streams. They oppose the training effect to the ability effect. If the former is the strongest, all initial selection errors will persist. If the latter dominates, all initial selection errors will be corrected. They take the example of Canadian hockey where the relative age effect is observed in adults when the differences in maturity have disappeared to illustrate a case where early streaming and highly differential training lead to the persistence of initial selection errors in adulthood. So the answer to relative age effect is avoiding early streaming and early training differential.

In accordance with the theory, empirical studies are not all aligned as the persistence of the relative age effect depends on the selection rules and training differential of each educational systems. [Bedard and Dhuey \(2006\)](#), analysing American and Canadian academic data (TIMNNS 1995 and 1999) to evaluate the effect of age at school entry on educational outcomes, find that youngest students perform poorer, are less likely to enrol in pre-university academic track courses and high-end academic universities. In line with the theory of [Allen and Barnsley \(1993\)](#), they demonstrate that early relative maturity effects propagate into adulthood through the structure of education

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<sup>2</sup> The differences in maturity disappear with age for proportional reason. This effect is also known as the absolute age effect ([Kawaguchi 2011](#)): initial gap vanishes as children age because the fraction of age difference to absolute age disappears as children grow.

<sup>3</sup> Ability is unrelated to month of birth.

systems. [Kawaguchi \(2011\)](#), using Japanese data, also finds that older children do better than younger ones in primary school and that this better academic performance translates into higher annual earnings among males in adulthood. [Smith \(2009\)](#), for Canada, finds that older students still have a sizable skill advantage in Grade 10 (15 years old) across numeracy, reading and writing tests which suggests a certain degree of permanence to age related skill differences that may spill over and affect adult outcomes. [Ponzo and Scoppa \(2014\)](#) for Italy, [Gutiérrez-Domènech and Adsera \(2012\)](#) for Catalonia (Spain), [Crawford et al. \(2010\)](#) for England, also find that the advantage of older students does not dissipate as they grow older and even persists into higher education decisions (England), with age 19/20 participation declining monotonically with month of birth. On the contrary, [Fertig and Kluge \(2005\)](#) for Germany, [Sakic et al. \(2013\)](#) for Croatia, and [Fredriksson and Öckert \(2014\)](#) for Sweden, find no effect of age at school entry on grade retention or degree attainment (Germany, Croatia) and on net earnings over the entire life cycle (Sweden).

With this paper, I want to contribute to the debate focusing on two aspects of school achievement in Madrid Community (Spain): academic performance and grade retention probability at three different grade levels. Academic performance can be seen as a picture of the student's level at a precise moment in time but based on previous skills and knowledge accumulation. On the contrary, grade retention probability is more like a stock, something that can evolve with grade level, but which is also inherited from previous academic years: a child who has repeated a grade at 8 years old, will still appear in the repeaters at 15 years old. For this reason, in a dynamic analysis, repeaters must be carefully studied. The ratios evolution (dynamic vision) matters as much as the ratios themselves.

In the following second section, I present my contribution to the literature and preliminary results based on the theory of the Equality of Opportunity (EOp). Then I explain the database and the main descriptive statistics. In a

third section I present the linear regressions that enable us to study the link between academic performance and quarter of birth, focusing in the end on the impact of parental highest schooling. The fourth section shows the logistic regressions that present the probability of repeating a grade for those born at the end of the year compared to those born in the first quarter. Finally, I discuss the results and their implication for educational policies.

### 3.2. Contribution and preliminary results

In Spain, using data from PISA 2009 and a static point of view, [Pedraja-Chaparro \*et al.\* \(2015\)](#), already find that students born in the last months of the year are between 70% and 80% more likely to repeat a grade than children born in the first month.

With a dynamic approach and focusing both on grade retention and academic performance, I contribute to the literature in three ways. *First*, I demonstrate that quarter of birth impacts academic performance in Grade 3 (8 years old), 6 (11 years old) and 10 (15 years old) but decreases sharply between each grade level. *Second*, I show that in mathematics, this impact has disappeared in Grade 10. *Third*, I find that grade retention probability is much higher (+123%) for the youngest compared to the oldest in early grade (certainly due to maturity deficit) but, by Grade 10, readjustment occurs. The probability of having repeated a grade by Grade 10 for the youngest is ‘only’ 43% higher than the oldest. Given the initial disequilibrium, this evolution of the probabilities is meaningful: proving that, if in early grades children may repeat a grade mainly for maturity reason, when they age, they repeat a grade for other reasons (like shortage of abilities or shortage of investment which are no longer linked to maturity and quarter of birth). A close look at grade repetition probabilities’ evolution according to parents highest schooling confirms this idea: in Grade 6, children from highly educated or low educated parents born in the last quarter, are between 115% and 146% (respectively) more likely

to have repeated a grade than children born in the first quarter. In Grade 10, those percentages evolve to 46% and 28% respectively, showing a clear re-balancing among quarter of birth comparing to Grade 3 mainly for children of less educated parents, a group likely to receive less parental investment and, consequently, more likely to face abilities shortages. On the contrary, children from highly educated parents are less likely to face a lack of parental investment and, for this reason, less likely to repeat a grade as they age, limiting the balancing effect among quarter of birth noticed in higher grade.

Following the EOp theory, I first took a general look at all the database and checked the first order stochastic dominance between the cumulative distribution functions (CDFs) of academic results in mathematics, literature, and English (second language) based on the quarter of birth of the student. The quarter of birth being a circumstance according to the EOp theory: something the student cannot be held responsible for.

In Figure 3.1, it is clear that the curves do not cross and that the most disadvantaged profile is the one of student born in the last quarter for each subject. So, equality of opportunity is broken for the circumstance: birth date, at a global level. When I look at what happens at each grade level (Grade 3, Grade 6 and Grade 10), I obtained more balanced results that can be seen in Figures 3.2 to 3.4 in Appendix.

In Grade 3 (Figure 3.2) the curves do not cross, neither do they in Grade 6 (Figure 3.3) but they seem closer to each other. In Grade 10 (Figure 3.4) they cross, and they merge at various points making clear conclusion impossible in terms of EOp. Comparing the graphs' evolution give us the intuition that the impact of birth date on school achievement exists but may decline with age.

Focusing on grade retention repartition by birth quarter and grade level leads to the same intuition (see Table 3.1). Indeed, in Grade 3, 35% of the repeaters are born in the last quarter but they are only 28.55% in Grade 10. If students born at the end of the year are still overrepresented among the

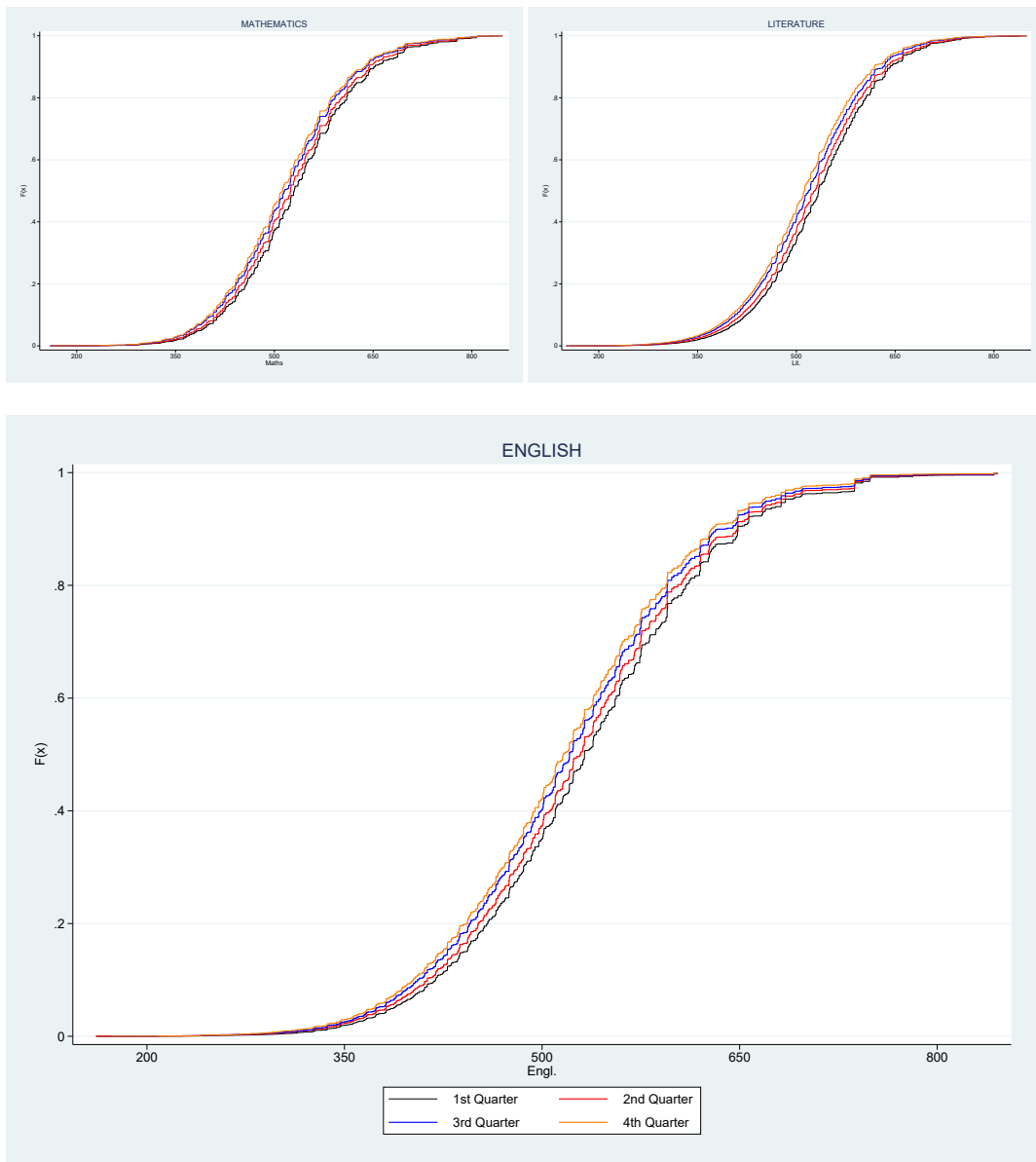


Figure 3.1: CDFs of students' scores according to birth quarter for each subject



repeaters in Grade 10, they represent a lower part of them compared to Grade 3 or Grade 6. Given the fact that repetition is partly ‘inherited’ from previous grade level, those figures show that the negative impact of being the youngest of the group on grade retention declines with age.

Table 3.1: Repeaters’ split according to grade level and quarter of birth

	(1)	(2)	(3)
	Gr.3	Gr.6	Gr.10
1 <sup>st</sup> Quarter	16.40%	18.39%	20.53%
2 <sup>nd</sup> Quarter	21.63%	22.00%	24.34%
3 <sup>rd</sup> Quarter	26.97%	26.91%	26.58%
4 <sup>th</sup> Quarter	35.00%	32.70%	28.55%
Total	100%	100%	100%
<i>N</i>	3671	5073	6628

### 3.3. Data and descriptive statistics

The strength and contribution of this paper remains essentially in the uniqueness and richness of its data base. As in PISA, scores are standardised and comparable for all students. Alongside the quantitative information, the database is composed of several qualitative data coming from two questionnaires: one addressed to the parents and one addressed to the students.

I created the database by re-coding and merging data from more than 33 excel files providing from the Ministry of Education and Research of Madrid Community<sup>4</sup>. The Ministry organized, for 3 consecutive years (2017, 2018 and 2019), global exams for all the students of the community in Grade 3 (8 years old), Grade 6 (11 years old) and Grade 10 (15 years old). Several disciplines were tested but I took on the three ones that were shared by the three grade levels: mathematics, literature (Spanish) and English (foreign language). As

<sup>4</sup> Consejería de Educación y Investigación de la Comunidad de Madrid

for many leading international surveys in the education field<sup>5</sup>, the Item Response Theory<sup>6</sup> (IRT) was implemented to compute the final score obtained by each student in each discipline. Logistic models with one parameter<sup>7</sup>(the item difficulty) were used in this case: the Rasch model for dichotomous items and the Partial Credit model for polytomous items<sup>8</sup>. Like in Pisa, scores are transformed so that the mean is 500 and the standard deviation 100.

In the regressions, I used the quarter of birth as the independent categorical variable and the academic year and the school indicator as fixed effects. As shown in table 3.7 in the Appendix, I also created two control groups: *student's characteristics* and *households characteristics*. The details of the summary statistics for all the variables used in this paper are presented in table 3.8 in Appendix.

The database is composed of about 560.000 students: 181.000 students in Grade 3, 202.000 students in Grade 6 and 177.000 students in Grade 10. As shown in Table 3.2, when I take on students whose qualitative questionnaires, birth date and grade repetition were completed, I end up with 224.409 students: 209.037 students who never repeat and 15.372 students who repeated at least once. 98.199 students are in Grade 3, 80.164 students are in Grade 6 and 46.046 students are in Grade 10.

<sup>5</sup> PISA, TALIS o PIAAC for the OECD, TIMSS o PIRLS for the IEA or the TOEFL and Cambridge certification

<sup>6</sup> IRT refers to a family of mathematical models that attempt to explain the relationship between a candidate's answer to an item and this candidate's aptitude or skills. All the models count with an item's difficulty parameter ( $b_j$ ) and a candidate parameter ( $\theta$ ).

<sup>7</sup> They are simple IRT models where the difficulty of the item is the only parameter. According to those models, the trait of a candidate (the underlying variable) depends only on her aptitude and the item difficulty.

<sup>8</sup> Rasch model:  $P_j(\theta) = \frac{1}{1 + e^{-(\theta - b_j)}}$  where  $P_j(\theta)$  is the probability of scoring 1 at item  $j$ ,  $\theta$  is the candidate's ability and  $b_j$  is item  $j$ 's difficulty parameter defined as the location on the measurement variable at which a score of 1 on item  $j$  is as likely as a score of 0. Partial Credit model:  $P_{jx}(\theta) = \frac{1}{1 + e^{-(\theta - b_{jx})}}$ ,  $x=1,2,\dots,m$ , where  $P_{jx}(\theta)$  is the probability of scoring  $x$  at item  $j$ ,  $\theta$  is the candidate's ability and  $b_{jx}$  is an item parameter governing the probability of scoring  $x$  rather than  $x - 1$  on item  $j$ .

Table 3.2: Students divided into repeaters and non-repeaters

	(1) Gr.3	(2) Gr.6	(3) Gr.10	(4) Total
No	94528	75091	39418	209037
Yes	3671	5073	6628	15372
<i>N</i>	98199	80164	46046	224409

As I study the impact of birth date on school achievement and grade retention probability, I must ensure that there is no selection bias or parental calculation: having more students born in the first quarter compared to those born in the last one.

In Table 3.3 we see that the split between the different birth quarters is almost perfectly balanced among students (excluding repeaters) for each grade level of each academic year: being approximately 25% each. It is clear that parents do not make calculation to have their children born at the beginning of the year.

Table 3.3: Students split according to quarter of birth, grade level and school year

	(1) 2017 Gr.3	(2) 2017 Gr.6	(3) 2017 Gr.10	(4) 2018 Gr.3	(5) 2018 Gr.6	(6) 2018 Gr.10	(7) 2019 Gr.3	(8) 2019 Gr.6	(9) 2019 Gr.10
1 <sup>st</sup> Q.	24.03%	24.95%	24.31%	24.61%	25.18%	24.05%	24.44%	24.09%	24.57%
2 <sup>nd</sup> Q.	26.98%	26.63%	26.25%	26.17%	25.92%	26.92%	25.73%	26.47%	26.01%
3 <sup>rd</sup> Q.	25.51%	24.54%	24.74%	25.03%	24.94%	24.43%	25.09%	24.83%	24.97%
4 <sup>th</sup> Q.	23.48%	23.88%	24.71%	24.18%	23.95%	24.61%	24.74%	24.61%	24.45%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%
<i>N</i>	31691	23050	15442	34269	28876	14111	28568	23165	9865

Table 3.9 in Appendix shows the average score by subject, grade level and birth quarter. In Grade 3 and Grade 6, students born in Q1 have higher scores than those born in Q2, who themselves have higher scores than those born in

Q3, who themselves have higher scores than those born in Q4. And this is true for all the three subjects studied. In Grade 10, the effect of birth date is not as clear: scores are more alike and, in mathematics and in English (foreign language), students born in Q4 have slightly higher scores than those born in Q3.

The intuition behind all those descriptive statistics is that birth date impacts both academic performance and grade retention probability from Grade 3 to Grade 10 but that this impact declines with time without completely disappearing in Grade 10.

**3.4. Impact of birth date on academic performance: linear regression by grade level and subject**

I first studied the impact of birth date on academic performance controlling for school attended, academic year, *students' and households' characteristics*.

I did simple linear regressions by grade level and by discipline using as explained variables the student's scores in mathematics, literature, and English (foreign language). I denote  $y_{igts}$  the score of student  $i$  in grade  $g$  for academic year  $t$  and attending school  $s$ . The independent variable is the quarter of birth, modeled by an ordered categorical variable with 4 possible values. I introduce independent dummy variables ( $q_j$  with  $j = 1, 2, 3, 4$ ) that allow me to compare the impact of quarter of birth two by two, with the lowest group ( $j = 1$ ) as the reference value. As detailed in section 3.3, I also add two control groups: one for the *student characteristics* (each denoted  $s_k$ ) and another for the *households characteristics* (each denoted  $h_k$ ).<sup>9</sup> Finally, I use the academic year ( $a_t$ ) and the school attended by student  $i$  ( $b_s$ ) as fixed effects to control

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<sup>9</sup> Student characteristics include country of birth, number of days a week spent on homework, and gender. Household characteristics include country of birth of both parent, the frequency of use of books/computers/internet at home, the number of books at home, the employment status of both parents, the frequency with which parents talk about school subjects/teach homework/help with homework/check homework with the child.

for the results' variation over time (from one year to another) and in space (from one school to another).

Formally, I first estimate the following regression equation:

$$y_{igts} = \alpha_0 + \sum_{j=1,2,3,4} \alpha_j q_{ji} + \sum_k \beta_k s_{ki} + \sum_k \gamma_k h_{ki} + a_t + b_s + \epsilon_{igts}. \quad (3.4.1)$$

Table 3.4: Academic performance according to quarter of birth by subject and grade level - Excluding Repeaters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Math	Math	Math	Lit	Lit	Lit	Engl	Engl	Engl
	Gr.3	Gr.6	Gr.10	Gr.3	Gr.6	Gr.10	Gr.3	Gr.6	Gr.10
<b>Child birth quarter</b>									
2 <sup>nd</sup> Quarter	-8.379*** (0.750)	-4.943*** (0.846)	-2.323* (1.213)	-8.823*** (0.751)	-6.269*** (0.845)	-1.768* (1.043)	-6.499*** (0.712)	-5.320*** (0.775)	-2.239** (1.010)
3 <sup>rd</sup> Quarter	-18.13*** (0.759)	-10.22*** (0.860)	-1.812 (1.233)	-18.88*** (0.760)	-13.01*** (0.859)	-3.343*** (1.060)	-14.74*** (0.721)	-9.631*** (0.788)	-1.998* (1.028)
4 <sup>th</sup> Quarter	-24.60*** (0.769)	-13.25*** (0.866)	-1.153 (1.234)	-28.30*** (0.770)	-18.42*** (0.866)	-4.467*** (1.061)	-21.87*** (0.730)	-12.32*** (0.795)	-3.850*** (1.028)
Constant	496.3*** (5.905)	502.0*** (6.720)	480.6*** (12.69)	512.2*** (5.892)	508.6*** (6.709)	476.8*** (10.81)	503.7*** (5.580)	498.9*** (6.157)	469.5*** (10.73)
Academic Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child's characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household's characteristic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	92325	73829	38436	92548	73703	38406	91999	73533	38400
Adjusted $R^2$	0.312	0.263	0.204	0.282	0.218	0.173	0.364	0.352	0.309

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Table 3.4 shows the coefficients of the linear regressions. We can see that students born in Q4 have significantly worse academic performance compared to those born in Q1 in all subjects at each grade level. But this effect declines with time until becoming non-significant in mathematics in Grade 10. We can notice that in English and in literature the negative impact of being born in Q4 is still significant but strongly reduced. It weakens from -28 to -4 points between Grade 3 and Grade 10 in literature and from -22 to -4 points between Grade 3 and Grade 10 in English.

If we look at those same academic performances according to parents' highest education (Table 3.10, Table 3.11 and Table 3.12 in Appendix), we find that, in Grade 10, in literature and in English, being born in Q4 remains negatively significant and explains part of the lower results for youngest children from highly educated parents (-5.12 and -3.45 respectively compared to children born in the first quarter) but not for youngest children from low educated parents. In mathematics, in Grade 10, being born in the last quarter is no longer significant, independently of parental schooling.

**3.5. Impact of birth date on retention probability: logistic regression by grade level**

I then studied the impact of birth date on the probability of grade retention controlling for academic year, *students' and households' characteristics*.

To do so, I did logistic regressions by grade level using as explained variable a dummy called 'Repeater' which is equal to 1 if the student has repeated at least once, 0 otherwise. The independent categorical variable is the quarter of birth. I used the academic year as fixed effects and the same control groups as the linear regressions (*student's characteristics* and *households characteristics*).

Table 3.5 shows that students born in Q4 have a probability of having repeated a grade higher than those born in Q1 of 123% in Grade 3. This

Table 3.5: Odds ratio: repeating year according to quarter of birth by grade level

	(1) Grade 3	(2) Grade 6	(3) Grade 10
<b>Child birth quarter</b>			
2 <sup>nd</sup> Quarter	1.230*** (0.0696)	1.152*** (0.0555)	1.137*** (0.0481)
3 <sup>rd</sup> Quarter	1.592*** (0.0865)	1.494*** (0.0693)	1.294*** (0.0541)
4 <sup>th</sup> Quarter	2.234*** (0.117)	1.894*** (0.0852)	1.432*** (0.0592)
Constant	0.158*** (0.039)	0.823 (0.162)	1.154 (0.315)
Academic Year Fixed-Effect	Yes	Yes	Yes
Child's characteristics	Yes	Yes	Yes
Household's characteristic	Yes	Yes	Yes
Observations	98199	80164	46046

Exponentiated coefficients; Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

percentage is of 89% in Grade 6 and 43% in Grade 10. We see that the impact of birth date on grade retention probability is high and significant from Grade 3 to Grade 10 but declines sharply with time, showing that there is a balancing effect as children grow. This result suggests that, if children seem to repeat a grade in early age for maturity reason (Corman, 2003), as they grow, shortage in abilities due to other factors (as lack of investment from children or parents) are at play.

This intuition is confirmed when we look at grade retention probabilities' evolution by parents' highest education (Table 3.6). Indeed, the balancing in Grade 10 among children from different quarters of birth is particularly important for students from low educated parents (from +146% to +28% probability of having repeated a grade if born in Q4 compared to born in Q1) and smallest for students from highly educated parents (from +115% to +46%). If all students may face a lack of maturity in early ages, independently of their social



background, as they grow, maturity is no longer a cause for grade retention and shortage in abilities due to lack of investment<sup>10</sup> predominates. Children from less educated parents are more likely to lack parental investment and that is why the balancing is more important among them. On the contrary, children from well-educated parents are more likely to receive parental investment (either directly by financing private schools or private lessons or indirectly by showing interest in their children's academic performances or by stimulating their curiosity, taste for reading or schooling) and then, less likely to repeat a grade for lack of abilities in later grade. Therefore, the over-representation of children born in the last quarter in the repeaters, inherited from lower grades, is less likely to be absorbed in later grades in this favoured social category.

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<sup>10</sup>In line with theories on the educational production function (Cunha and Heckman, Elder and Lubotsky, Hanushek) where parental investments are part of the explanation of differences in achievement between children.

Table 3.6: Odds ratio: repeating year according to quarter of birth and parents' highest education (registered as "Level 1, 2 and 3") by grade level

	(1) Gr.3 Level 1	(2) Gr.3 Level 2	(3) Gr.3 Level 3	(4) Gr.6 Level 1	(5) Gr.6 Level 2	(6) Gr.6 Level 3	(7) Gr.10 Level 1	(8) Gr.10 Level 2	(9) Gr.10 Level 3
<b>Child birth quarter</b>									
2 <sup>nd</sup> Quarter	1.355*** (0.151)	1.104 (0.0994)	1.310*** (0.126)	1.204** (0.105)	1.123 (0.0809)	1.148 (0.112)	1.154 (0.113)	1.172*** (0.0715)	1.083 (0.0804)
3 <sup>rd</sup> Quarter	2.030*** (0.215)	1.526*** (0.130)	1.361*** (0.130)	1.470*** (0.126)	1.472*** (0.102)	1.536*** (0.142)	1.235** (0.121)	1.339*** (0.0809)	1.255*** (0.0910)
4 <sup>th</sup> Quarter	2.463*** (0.258)	2.122*** (0.173)	2.150*** (0.191)	1.736*** (0.146)	1.869*** (0.126)	2.057*** (0.181)	1.284** (0.125)	1.466*** (0.0881)	1.463*** (0.103)
Constant	0.265*** (0.093)	0.019*** (0.013)	0.035*** (0.019)	1.250 (0.357)	0.401*** (0.139)	0.103*** (0.055)	1.320 (0.623)	0.827 (0.351)	0.216* (0.128)
Academic Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child's characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household's characteristic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8270	27958	61971	7760	24745	47659	4080	15267	26699

Exponentiated coefficients; Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Parents highest education: Level 1 = ISCED 0 to 2; Level 2 = ISCED 3 to 5; Level 3 = ISCED 6 to 8

### 3.6. Conclusion and policy implication

This paper shows that relative age effect is high in Grade 3 in Madrid Community (Spain) in mathematics, literature, and English (second language) among all social backgrounds, but it declines sharply as children grow and even disappears in mathematics in Grade 10. In literature and in English, being part of the youngest of the class still has a negative and significant effect in Grade 10, but much smaller compared to Grade 3 (from -28 to -4 points in literature and from -22 to -4 points in English). The trend is a strong decreasing of the effect over time, proving that Madrid Community scholar system is not maintaining initial maturity differences as children grow. Following Allen and Barnsley's theory, this is the proof that Madrid scholar system avoid early streaming and early differential training among children.

Grade retention is high among children born in Q4 in Grade 3 compared to those born in Q1 (+123%). Yet, the strong disequilibrium observed in Grade 3 evolves to more balanced ratios in Grade 10 (+43% more likely to have repeated in Grade 10 if born in Q4 compared to Q1). Maturity is clearly at play in explaining grade retention in Grade 3. But the strong re-balancing by Grade 10 is the proof that, as children grow, maturity is no more the cause for grade retention. Students' lack of abilities, leading to grade retention in higher grade, seems more linked to students' social background. So, for grade retention also, the impact of quarter of birth decreases over time.

We can conclude that Madrilenian scholar system does not perpetuate initial academic differences due to maturity discrepancies. Even if relative age effect does not disappear entirely by Grade 10, it decreases sharply from Grade 3 to Grade 10 and even disappears in mathematics. Grade retention re-balancing between Grade 3 and Grade 10 according to quarter of birth leads to the same conclusion. Contrary to Canada ([Smith, 2009](#)), England ([Cobley et al., 2009](#); [Crawford et al., 2010](#)), Japan ([Kawaguchi, 2011](#)) or the United-States ([Bedard and Dhuey, 2006](#)), Madrilenian scholar system is not facing the challenge of

the persistence of relative age effect over time.

## 3.7. Appendix

Table 3.7: Variables' description

	Type	Values	Description
<b>Students marks</b>			
Mathematics	Num.	0 - 1034	Transformed Mathematics mark
Literature	Num.	0 - 1001	Transformed Literature mark
English Foreign Language	Num.	0 - 845	Transformed English mark
<b>Quarter of birth</b>			
Quarter of birth	Qual.	1 - 4	1 1 <sup>st</sup> Quarter 2 2 <sup>nd</sup> Quarter 3 3 <sup>rd</sup> Quarter 4 4 <sup>th</sup> Quarter
<b>Repeaters</b>			
Repeaters	Qual.	0 - 1	0 Have never repeated 1 Have repeated at least once
<b>Parents highest education</b>			
Parents highest education	Qual.	0 - 2	0 ISCED 0 to 2 1 ISCED 3 to 5 2 ISCED 6 to 8
<b>Child's characteristics</b>			
Child's country of birth	Qual.	1 - 2	1 Spain 2 Other
Days/week dedicated to homework	Qual.	1 - 4	1 One day or less 2 Two or 3 days 3 Four or 5 days 4 More than 5
Child's gender	Qual.	1 - 2	1 Female 2 Male
<b>Household's characteristics</b>			
Mother's country of birth	Qual.	1 - 2	1 Spain 2 Other
Father's country of birth	Qual.	1 - 2	1 Spain 2 Other
Freq. books used at home	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Freq. computer used at home	Qual.	1 - 4	1 Never or almost never

Table 3.7: Variables description (continued)

	Type	Values	Description
			2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Freq. internet used at home	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Nb of books at home	Qual.	1 - 5	1 From 0 to 10 2 From 11 to 50 3 From 51 to 100 4 From 101 to 200 5 More than 200
Mother's labour situation	Qual.	1 - 5	1 Full time employee 2 Part time employee 3 Unemployed looking for a job 4 Retired 5 Don't have and don't look for a job
Father's labour situation	Qual.	1 - 5	1 Full time employee 2 Part time employee 3 Unemployed looking for a job 4 Retired 5 Don't have and don't look for a job
Freq. parents talk about school	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Freq. parents schedule homework	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Freq. parents help for homework	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
Freq. parents check homework	Qual.	1 - 4	1 Never or almost never 2 One or 2 times/month 3 One or 2 times/week 4 Every or almost every days
<i>N</i>		268054	

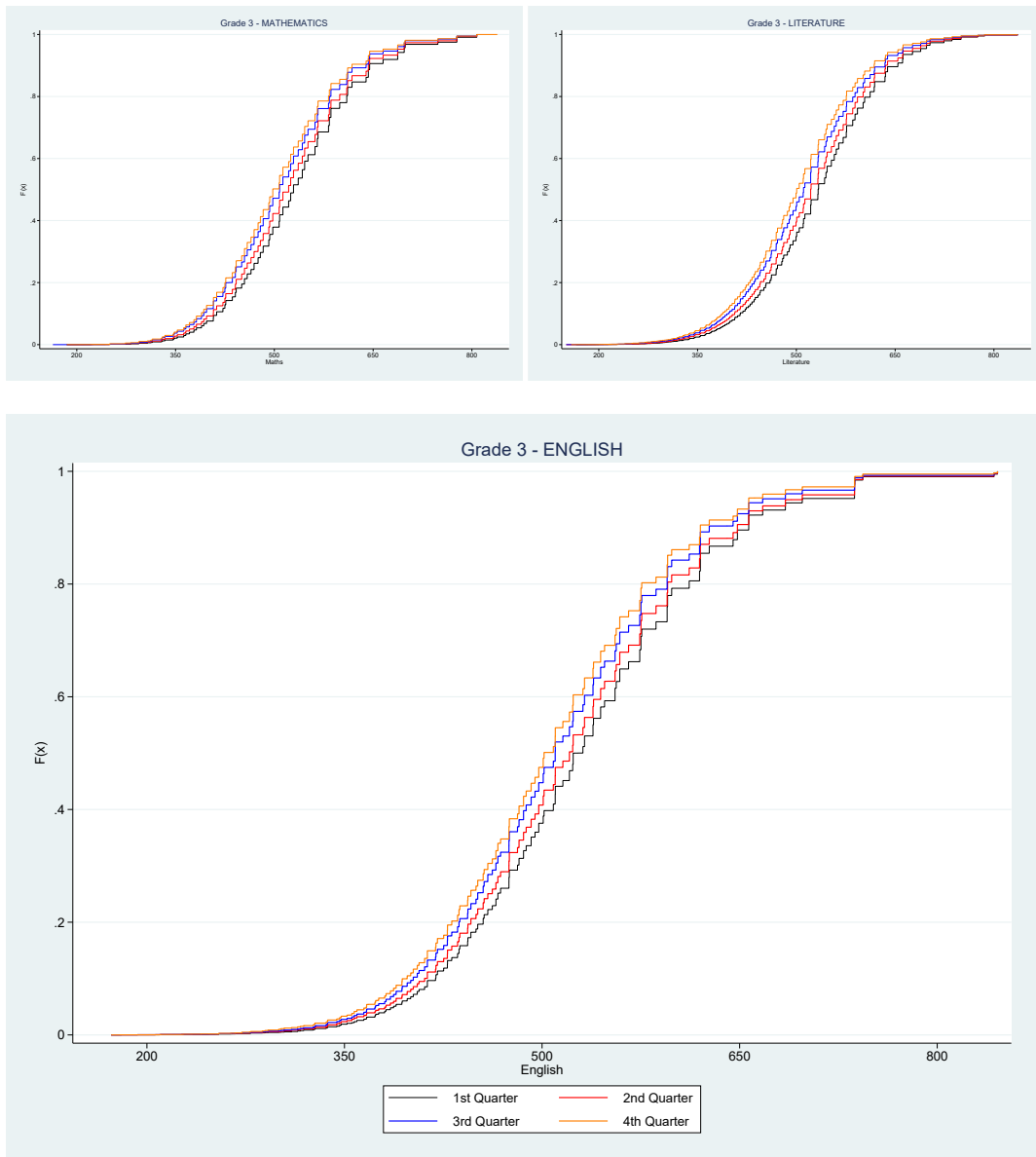


Figure 3.2: CDFs of students' scores in Grade 3 according to birth quarter for each subject

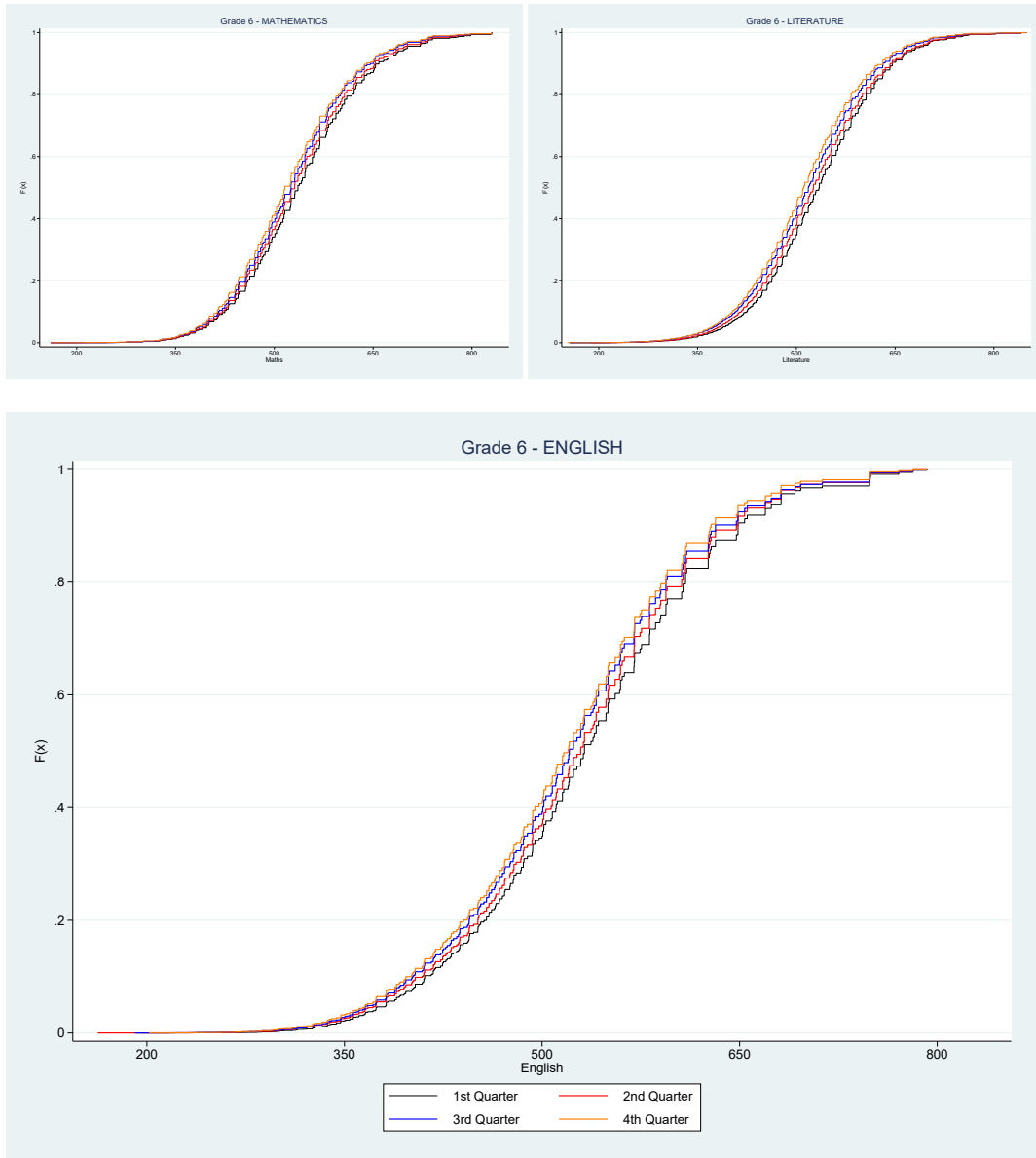


Figure 3.3: CDFs of students' scores in Grade 6 according to birth quarter for each subject



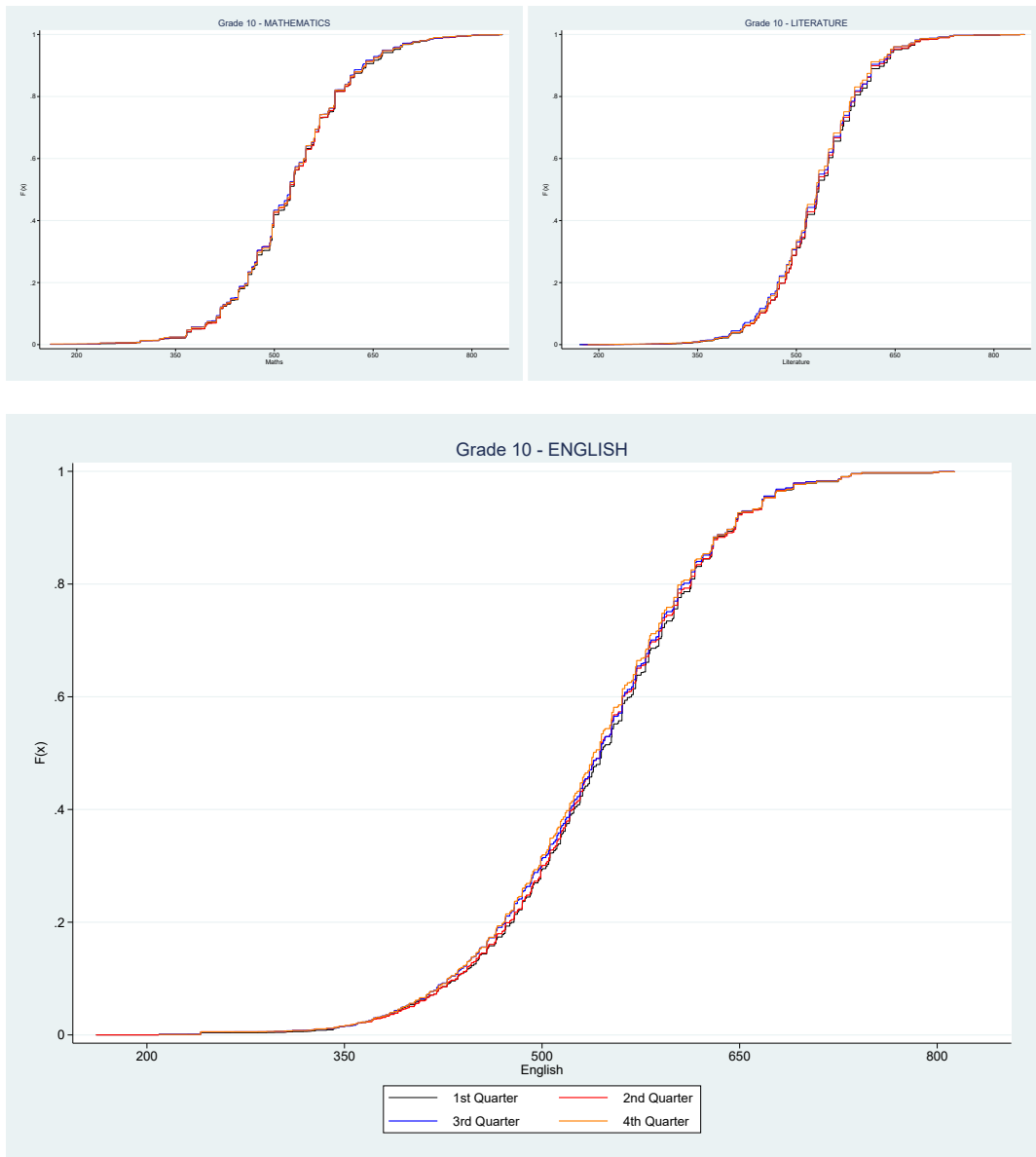


Figure 3.4: CDFs of students' scores in Grade 10 according to birth quarter for each subject

Table 3.8: Summary Statistics

	mean	sd
<b>Students marks</b>		
Mathematics	519.5886	95.85943
Literature	505.2685	104.1959
English Foreign Language	518.6788	93.88768
<b>Quarter of birth</b>		
Quarter of birth	2.50395	1.107423
<b>Repeaters</b>		
Repeaters	.0687846	.253088
<b>Parents highest education</b>		
Parents highest education	1.503257	.6599287
<b>Child's characteristics</b>		
Child's country of birth	1.045394	.2081668
<i>llc</i> Days/week dedicated to homework	3.294974	.7627006
Child's gender	1.503014	.4999918
<b>Household's characteristics</b>		
Mother's country of birth	1.157823	.3645753
Father's country of birth	1.151331	.3583723
Freq. books used at home	3.362636	.8447286
Freq. computer used at home	3.802032	.5128015
Freq. internet used at home	3.874667	.4310152
Nb of books at home	3.527166	1.196783
Mother's labour situation	1.660968	1.044567
Father's labour situation	1.252942	.673269
Freq. parents talk about school with child	3.818667	.5056303
Freq. parents schedule homework with child	3.44422	.9275225
Freq. parents help for homework	2.926414	1.108953
Freq. parents check homework with child	3.398256	1.003374
<i>N</i>	268054	

Table 3.9: Means of the scores by subject according to grade level and quarter of birth

	(1) Gr.3 Q1	(2) Gr.3 Q2	(3) Gr.3 Q3	(4) Gr.3 Q4	(5) Gr.6 Q1	(6) Gr.6 Q2	(7) Gr.6 Q3	(8) Gr.6 Q4	(9) Gr.10 Q1	(10) Gr.10 Q2	(11) Gr.10 Q3	(12) Gr.10 Q4
Maths	533.9	523.8	512.1	505.9	541.7	535.3	529.2	524.4	528.1	526.3	524.5	525.5
Lit.	534.8	524.3	512.7	503.5	535.1	528.1	519.8	513.5	534.7	533.1	529.3	528.6
Engl.	533.9	523.8	512.1	505.9	541.7	535.3	529.2	524.4	523.4	518.4	518.3	519.9
<i>N</i>	22614	24439	23354	22342	18448	19561	18400	17932	9404	10205	9552	9550

Table 3.10: Scores in mathematics by grade level and parents' highest education (registered as "Level 1, 2 and 3") - Excluding Repeaters

	(1) Gr.3 Level 1	(2) Gr.3 Level 2	(3) Gr.3 Level 3	(4) Gr.6 Level 1	(5) Gr.6 Level 2	(6) Gr.6 Level 3	(7) Gr.10 Level 1	(8) Gr.10 Level 2	(9) Gr.10 Level 3
<b>Child birth quarter</b>									
2 <sup>nd</sup> Quarter	-8.043*** (2.925)	-8.928*** (1.410)	-8.203*** (0.947)	-5.845* (3.034)	-3.494** (1.487)	-5.804*** (1.117)	-2.867 (5.248)	-1.020 (2.161)	-2.977* (1.570)
3 <sup>rd</sup> Quarter	-16.42*** (2.934)	-18.37*** (1.425)	-18.12*** (0.961)	-10.43*** (3.096)	-6.124*** (1.513)	-12.13*** (1.136)	-2.374 (5.392)	-4.347** (2.195)	-0.852 (1.599)
4 <sup>th</sup> Quarter	-20.69*** (3.008)	-25.01*** (1.462)	-24.70*** (0.967)	-15.19*** (3.110)	-10.98*** (1.532)	-14.24*** (1.142)	-8.560 (5.324)	-3.301 (2.218)	-0.253 (1.592)
Constant	508.8*** (15.77)	493.2*** (11.72)	523.3*** (8.979)	515.7*** (14.68)	482.2*** (11.30)	514.4*** (12.09)	457.6*** (31.71)	454.4*** (19.95)	505.9*** (20.60)
Academic Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child's characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household's characteristic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6872	25795	59658	5889	22101	45839	2494	11624	24318
Adjusted $R^2$	0.287	0.275	0.275	0.260	0.234	0.222	0.201	0.166	0.182

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ 

Parents highest education: Level 1 = ISCED 0 to 2; Level 2 = ISCED 3 to 5; Level 3 = ISCED 6 to 8

Table 3.11: Scores in literature by grade level and parents' highest education (registered as "Level 1, 2 and 3")  
- Excluding Repeaters

	(1) Gr.3 Level 1	(2) Gr.3 Level 2	(3) Gr.3 Level 3	(4) Gr.6 Level 1	(5) Gr.6 Level 2	(6) Gr.6 Level 3	(7) Gr.10 Level 1	(8) Gr.10 Level 2	(9) Gr.10 Level 3
<b>Child birth quarter</b>									
2 <sup>nd</sup> Quarter	-7.097** (3.059)	-8.371*** (1.442)	-9.098*** (0.936)	-4.307 (3.175)	-4.495*** (1.560)	-7.682*** (1.088)	-9.162* (4.848)	-1.153 (1.952)	-1.901 (1.308)
3 <sup>rd</sup> Quarter	-19.12*** (3.071)	-17.51*** (1.458)	-18.96*** (0.949)	-18.82*** (3.237)	-10.12*** (1.589)	-13.88*** (1.106)	-7.314 (4.942)	-3.922** (1.984)	-2.968** (1.331)
4 <sup>th</sup> Quarter	-23.83*** (3.148)	-28.21*** (1.496)	-28.58*** (0.955)	-18.15*** (3.251)	-15.83*** (1.609)	-19.61*** (1.112)	-5.458 (4.900)	-4.119** (2.006)	-5.112*** (1.325)
Constant	503.6*** (16.33)	514.8*** (11.95)	545.7*** (8.860)	518.6*** (15.32)	511.5*** (11.85)	528.0*** (11.89)	472.7*** (29.26)	469.0*** (18.01)	499.3*** (16.81)
Academic Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child's characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household's characteristic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6892	25870	59786	5895	22057	45751	2492	11616	24298
Adjusted $R^2$	0.237	0.236	0.257	0.184	0.179	0.189	0.141	0.148	0.149

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

Parents highest education: Level 1 = ISCED 0 to 2; Level 2 = ISCED 3 to 5; Level 3 = ISCED 6 to 8

Table 3.12: Scores in English by grade level and parents' highest education (registered as "Level 1, 2 and 3") - Excluding Repeaters

	(1) Gr.3 Level 1	(2) Gr.3 Level 2	(3) Gr.3 Level 3	(4) Gr.6 Level 1	(5) Gr.6 Level 2	(6) Gr.6 Level 3	(7) Gr.10 Level 1	(8) Gr.10 Level 2	(9) Gr.10 Level 3
<b>Child birth quarter</b>									
2 <sup>nd</sup> Quarter	-5.696** (2.753)	-6.901*** (1.326)	-6.508*** (0.904)	-3.820 (2.960)	-5.371*** (1.427)	-5.976*** (0.995)	-6.311 (4.759)	-1.125 (1.898)	-1.937 (1.265)
3 <sup>rd</sup> Quarter	-16.33*** (2.764)	-13.54*** (1.341)	-15.22*** (0.918)	-11.69*** (3.025)	-7.990*** (1.453)	-10.08*** (1.011)	-7.533 (4.893)	-2.151 (1.930)	-1.516 (1.290)
4 <sup>th</sup> Quarter	-17.93*** (2.836)	-21.87*** (1.374)	-22.51*** (0.923)	-8.071*** (3.034)	-10.67*** (1.471)	-13.68*** (1.017)	-9.074* (4.835)	-4.032** (1.951)	-3.451*** (1.283)
Constant	514.3*** (14.71)	494.8*** (10.96)	528.6*** (8.540)	494.3*** (14.27)	507.5*** (10.86)	536.6*** (10.78)	456.3*** (28.86)	455.1*** (17.89)	508.8*** (16.92)
Academic Year Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
School Fixed-Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Child's characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household's characteristic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6868	25744	59387	5855	22013	45665	2502	11644	24254
Adjusted $R^2$	0.362	0.322	0.308	0.347	0.319	0.273	0.235	0.213	0.244

Standard errors in parentheses

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ 

Parents highest education: Level 1 = ISCED 0 to 2; Level 2 = ISCED 3 to 5; Level 3 = ISCED 6 to 8

## General Conclusion

Through a web experiment on a representative sample of the French population, the first chapter tests the acceptance rate of various types of transfers: From the most widely used by academics and institutions, the Pigou-Dalton transfer to the most demanding uniform on the right and on the left transfer, by way of uniform on the right or on the left transfers. A first striking result is the low acceptance rate of the Pigou-Dalton transfer. Only 40% of the respondents (representative of the French society) find it reduces inequality. Uniform transfers are significantly more approved, with greater acceptance of uniform transfers on the left (60%), proving that society may be more sensitive to poverty. That is confirmed by our estimation of the extended Gini social welfare function where we find that the median level of inequality aversion obtained ( $\eta = 3.13$ ) is well above that of the Gini coefficient ( $\eta = 2$ ). This implies a more convex weighting function  $f$ , which puts more weight on the left-hand tail of the income distribution. It would be interesting to test the evolution of inequalities in Europe, and particularly in France, over the last decades, using an inequality aversion parameter close to 3, and see whether the trend is the same.

In a second chapter we study the impact of parental environment (parents' highest education and parental investment) on student's achievement and how this link evolves with age in the Madrilenian Community. In this chapter we adopt a long-term approach, enlightened by the theory of Equality of Opportunity (EOp), and focusing on intergenerational transfers. Parental environment

is considered a circumstance for the student, something she cannot be responsible for, which should not play a role in her academic performance. Yet we find that the impact is positively significant and that, in English (foreign language), it increases with age. For this subject, a Matthew effect exists. In mathematics and in literature, the impact of parental environment decreases with age and even becomes non-significant in mathematics in Grade 10. Those results are interesting and shed light on the social discrimination that can be intensified depending on the weight put on the different subjects at the time of selecting students.

Finally, the third chapter, in line with the second one, analyses the link between student's academic performance, student's grade retention probability and her date of birth (another circumstance). Here the theory predicts that if selection comes at an age when maturity discrepancies are still at play and if training is highly differentiated (providing better trainings to previously identified better performers), then selection errors will persist and relation between date of birth and performance will still be observed in adulthood. Otherwise, no link should be observed, as the student age, between date of birth and academic performance. As expected, according to the scholar system characteristics of each country, different results are observed in the empirical studies. In our case, we focus on the Madrilenian Community's students and find encouraging results in terms of EOp. Indeed, we find that the impact of date of birth on academic performance decreases with age, and even disappears in mathematics in Grade 10 and that grade retention probability becomes more balanced with age. The Madrilenian scholar system is not facing the issue of relative age effect's persistence over time.



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