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Are those attending preparatory classes more sensitive to wages than those attending university?

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Thomas NOEL

Délégation générale à l'emploi
et à la formation professionnelle (DGEFP)

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Thomas Noel[*]

Abstract

This paper examines how students decide whether to enrol in university or attend preparatory classes after leaving high school. It is to my knowledge the first paper to investigate whether students attending preparatory classes are more sensitive to expected wages than those attending university. To tackle this question, I first provide a theoretical framework that incorporates both monetary and non-monetary elements in the value function of agents. Then, by structurally estimating the dynamic model, I find that students are sensitive to expected wages when deciding to enrol in higher education. Furthermore, my results suggest that the probability of finding a job upon graduation from business or engineering school significantly increases the likelihood of students entering higher education rather than the likelihood to enter the labour market directly after high school. Nevertheless, the choice between attending preparatory classes or university remains largely driven by intrinsic student preferences. Simulations show that changing the probability of passing the competitive exam to attend a business or engineering school changes the college decision of students and can lead to unanticipated overcrowding in university-based master's programs. This type of simulation is of particular interest as there is a considerable heterogeneity in the annual cost to the government of a student attending preparatory classes or a student attending university.

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[*] Délégation générale à l'emploi et à la formation professionnelle (DGEFP).

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Introduction

The diversity of options available in French higher education, exemplified by French-specific preparatory classes (*classes préparatoires)* make the analysis of the students' choice of type of college very interesting. Preparatory classes are intensive and offer high quality teaching to students, while university offers more specific courses and students tend to receive less guidance. But the recent development of new university tracks, in France, makes the study even more compelling, as universities are now able to compete with preparatory classes to attract the best students by proposing a wider range of subjects. In addition, university graduates with a bachelor's degree can now take exams to enter top business and engineering schools. Previously, these competitive exams were mainly for students from preparatory schools. However, there are now two types of competitive exams: one for university students and one for preparatory school students. Despite this change, a higher proportion of students in business and engineering schools still come from preparatory schools, as these schools are specifically designed to prepare students for these exams[1]. While the positive effects of additional years of schooling and in particular of higher education on labour market outcomes have been largely studied in the literature (Becker, 1994; Card, 1999; Oreopoulos, 2006; Petronijevic, 2013), a growing body of literature examines the determinants of educational attainment. Both monetary and non-monetary factors have been shown to play an important role in school choice, raising the question of how students choose the length of their education and how they choose the school they attend. More concretely, it is important to understand the variables that underlie students' decision-making. From the student's perspective, the choice of institution of higher education can be crucial because it leads to a specialization that will guide their professional career. Although scholars have attempted to answer these questions for the college major choice (Arcidiacono, 2004; Beffy *et al.*, 2012; Wiswall & Zafar, 2015; Patnaik *et al*., 2022)[2], little is known regarding the choice of the type of college.

This present thesis sheds light on the variables that influence the choice of educational institutions that students in France attend immediately after completing secondary school. Following the 'baccalauréat', over 90% of students pursue further studies. As illustrated in the appendix (cf. figure A1), students are faced with many options and educational paths, which vary both by the status of the school but also by their lengths and their price[3]. While the majority of students choose to enrol in universities (over 60%), a significant proportion opt for private institutions such as business schools or engineering schools, accounting for 7.6% and 6.2% of students, respectively. The second most popular choice is two years of education in 'lycées', which offer both preparatory classes and BTS (vocational training) programs. In this paper, I restrict my analysis on the differences between two types of schools: preparatory classes and universities. These schools are different in some respects but do not present a selection at the entrance[4]. This distinction is also appealing because, after completing preparatory classes or obtaining a bachelor's degree, students can continue their education in the same type of schools (e.g. business or engineering schools), while this is not the case for vocational education, for example.

This study aims at proposing a theoretical model to understand the choice of type of school made by students, inspired by the literature on the college major choice, and adding the specific features of the French higher education system. To the best of my knowledge, this is the first study to analyse students' decisions regarding the type of college, rather than their choice of major, specifically focusing on the differences between preparatory classes and university paths. The decision to enrol in university or to attend a preparatory class can affect both educational pathways and lifetime labour market outcomes. The data show a great deal of heterogeneity in labour market outcomes based on the highest degree obtained and the type of school attended after high school. There appears to be a wage premium for those who attend preparatory classes, as these students tend to earn higher wages on average. This latter point is mostly driven by differences in quality within the school attended in the second period, since students in top schools mostly come from preparatory classes and may be better students than those enrolling in university (this may be due to pure selection effects, but I do not intend to establish causality between wages and the path students take). Investigating why students with similar characteristics choose different pathways is therefore relevant. I believe that this paper contributes to the large literature on determinants of school choices after high school. I present

[1] Source: summary of the IPP report '*Quelle démocratisation des grandes écoles depuis le milieu des années 2000 ?*'
[2] See the literature review section for more details.
[3] The length of studies varies, between 2 years and 5 years excluding PhD, also greatly depending the type of institution chosen.
[4] Actually, preparatory classes select at entry, but this selection remains limited because there is a great heterogeneity in the quality of preparatory classes and thus almost every student can access this type of school.

a comprehensive and adaptable theoretical model for analysing student decisions, which can be applied to various contexts. This paper is also one of the first to examine, both theoretically and empirically, the effect of the probability of graduation and of the probability to pass the competitive exam on the college decision of students. Finally, it highlights the determinants of students' choices, documenting that both monetary and non-monetary factors are crucial in the final decision, aligning with recent literature.

To address the above questions, I first build a dynamic model of post-high school choice. A $T + L$ periods game is considered:

- **Period 1:** students face three options: enrol in university, attend a preparatory course, or enter the labour market directly after high school.
- **Period 2:** depending on their initial choice and exam results from period 1, they can either attend specialized schools (business or engineering schools) or continue in university to pursue a master's degree[5].
- **Period 3:** all individuals enter the labour market for 40 years.

Students are assumed to form rational expectations and base their decisions on both monetary and non-monetary factors, considering these elements both during their time in school and upon entering the labour market. The theoretical model is designed to be flexible and allows both to capture the switching between schools and to endogenize the length of study, as students have the possibility to leave school at any period. Second, I provide a structural estimation of this model using maximum likelihood. I first estimate the expected present discounted value of students' lifetime earnings for all highest degrees using a Heckman equation with the *Enquête Emploi* (2016) database, which allows me to get a more representative estimate of expected wages. I then use data from the *Enquête Génération* 2013 survey conducted by Céreq (a French centre for research and studies on qualifications) for the structural estimation. Although the data do not allow for a full reconstruction of individuals' educational trajectories, they do provide information on students' initial choices in their first year and the highest degree attained. Another key challenge in the structural estimation is to account for the various sources of unobserved heterogeneity. Specifically, both the ability to succeed in competitive exams and the intrinsic preferences of the students are assumed to be unknown.

The results of the structural estimation suggest that both expected wages and intrinsic preferences play significant roles in students' decisions regarding the college decision of students. The expected wages of graduating from business or engineering schools significantly increase the likelihood that a student takes a preparatory class in period 1 but decrease the chance that a student attends university (even for the path university in period 1 and business or engineering school in period 2). Moreover, increasing the probability of finding a job after graduating from a business or engineering school increases the likelihood of students enrolling in higher education compared to the option of entering the labour market immediately after high school. The probabilities of graduating and of passing the competitive examination when attending both university or preparatory classes in period 1 are influenced significantly by the educational background of the students (e.g. high school results), but these variables do not have a significant effect on the final choice. Nevertheless, there is no evidence of significant differences by high school track (e.g. vocational or general tracks). In conclusion, this paper provides valuable insights for policy recommendations through direct simulations that analyse the effects of changes in determinants on students' final educational choices. My evidence points to the conclusion that increasing the probability of passing the competitive exam when attending university in period 1 increases the share of students choosing the university track in period 1 and specialized schools in period 2 at the detriment of preparatory classes. Furthermore, increasing the probability of passing the competitive examination by taking preparatory classes increases the proportion of students enrolling in preparatory classes at the expense of the track bachelor + specialized schools and of the track bachelor at university. Lastly, if the same number of seats in specialized schools is allocated to both university and preparatory classes, the proportion of students choosing the preparatory class option falls sharply, while the proportion of students following the university path increases (especially for the path university + specialized schools). I also proposed a simple cost-benefit analysis of such a policy for the government (without considering general equilibrium effects), motivated by the significant differences in cost to the government of preparatory class students compared to university students.

[5] Throughout this paper, the term 'specialized schools' or *Grandes Écoles* will be used to refer to business and engineering schools.

The paper is structured as follows: section 1 reviews the literature; section 2 presents the characteristics of preparatory classes and university in France; then section 3 proposes a theoretical model of the nature of the college decision. Sections 4 and 5 describe the data and present the empirical strategy and the estimation of the model, Section 6 provides a simulation analysis.

1. Literature review

1.1. Mixed evidence on importance of expected earnings

The model proposed in this present paper is largely inspired by the extensive literature focusing on the students' major choice in the US. While scholars have given particular attention to the return to schooling, traditional models (Becker, 1994; Ben-Porath, 1967; Spence, 1973) are not suitable to explain students' major choice after high school. Willis and Rosen (1979) were among the first to tackle this question. They allow the demand for higher education to depend on expected future earnings. Assuming that students form rational expectations, the authors show that the expected stream of post-education earnings is a strong determinant of college attendance. Following this research, the influential paper of Berger (1988) provides a theoretical framework for modelling the choice of college major. His study highlights the relationship between predicted future earnings for five broad fields of study and college students' choice of major using a life-cycle approach and rational expectations. The main finding is that students are likely to choose majors with higher future earnings rather than majors with higher initial earnings at the time of choice. However, this model does not take into account the uncertainty of graduation in a major. Later on, Montmarquette *et al.* (2002) have attempted to address this limitation by introducing the probability of graduating into their model (the probability is assumed to be individual and major specific). Their results show that the choice of college major depends crucially on the expected earnings in a particular major but, they do not control for selection in the major. Previous work by Altonji (1993) also provides a framework for modelling students' choice of major under uncertainty about the probability of graduating and found similar results regarding the importance of expected earnings. Although, his model is based on a restricted choice of majors (only two majors) he introduces the possibility of dropping out of college or switching major at the end of each period because students receive new information about their tastes. But, in this model, the probability of graduating in a major, which depends on the stock of knowledge and on the ability of the student, does not evolve over time.

Previous studies have demonstrated that expected earnings play a crucial role in students' choice of major. However, more recent research indicates that while the income elasticity of major choice is significant, it remains low. This suggests that expected earnings are not the only relevant determinant of major choice. Beffy *et al.* (2012) estimate, from French data, the impact of expected labour market income on the choice of the post-secondary field of study. They propose a semi-structural model of choices and try to disentangle between the simultaneous effects of, on the one hand, preferences and abilities, and on the other hand, expected returns, on the choice of major. Unlike previous papers, they introduce uncertainty in the length of post-secondary studies (i.e. students do not know the length of their study when they choose a major). They also assume, as in Altonji (1993), that both future earnings and the highest level of education attained are uncertain to students. The model is three stages: first students choose their major, then they choose the length of their studies and finally they enter the labour market. The results indicate that the choice of major is mainly driven by the consumption value of schooling rather than the investment value of schooling, i.e. ability and preferences matter more than expected earnings in the choice of major. In the same vein, Wiswall and Zafar (2015) use a survey and experimental design to study the determinants of college major choice among students at New York University (NYU). The survey data allow the authors to compare the change in the subjective probability of completing a major when respondents are given more information about expected earnings and major characteristics. By estimating a structural life-cycle model, they measure the impact of all these variables on the decision to major. Their results document that on average students have biased beliefs about population earnings but students update their beliefs when accurate information is given. Their evidence also demonstrates that while beliefs about future earnings are a significant determinant in the choice of a field of study, the elasticity of major choice in response to changes in future earnings remain modest (between 0.03 and 0.97). On the other hand, the dominant variable in college major decisions is the residual unobserved taste, echoing the results of Beffy *et al.* (2012) and Arcidiacono (2004). Using the same database, Patnaik *et al*. (2022) show similar evidence when accounting for heterogeneity in risk aversion and time preference.

Another strand of the literature focusing on college choice emphasizes this ambiguity about the importance of non-pecuniary elements in students' final choices. Long (2004) uses a conditional logit model to examine the changing role of university cost, quality and distance in post-secondary decisions. She found supportive evidence that tuition fees play a role in both enrolment decisions and where students enrol. Additionally, she discovered that tuition fees and distance have a smaller impact on the final decision of students than in the past. On the other hand, according to her results, the quality of the university has become more important over the period. Similarly, Skinner (2019) found that the monetary cost of attending college has a decreasing influence on student choice. School quality does play a role in student decisions, as students are more likely to choose a college with a higher median SAT score compared to their SAT score. Drewes and Michael (2006), who studied students' college choices in Ontario, provide further evidence that distance and scholarships are important factors in individuals' choices, assuming a uniform college price. In addition, they find that higher levels of educational expenditure increase the likelihood that a college will be selected by applicants.

1.2. Non-pecuniary characteristics matter

As noted above, recent literature on student choice of major emphasizes the importance of non-pecuniary characteristics in students' decisions. In this setting, the non-pecuniary elements are twofold: within college (e.g. interest in coursework) and post-college elements (e.g. job amenities and family domains). Arcidiacono et al. (2016) elicits additional beliefs on occupation-specific probabilities conditional on pursuing a major as well as expected earnings for each of those major-occupation pairs. They found a large role of non-pecuniary factors in major and occupation choices. Furthermore, as mentioned previously, Wiswall and Zafar (2015) pointed out that unobserved taste is the primary driver of student choice, echoing previous work by Zafar (2013). The results of the latter illustrate that enjoyment and interest in courses, parental approval, and enjoyment of work are influential variables in the choice of a major. However, there is a large gender difference, with non-pecuniary elements accounting for half of men's choice while explaining over three quarters of women's choice. Papers by Wiswall and Zafar (2015) and Patnaik *et al.* (2022) found similar results, suggesting that men are more responsive to changes in expected earnings than women and less sensitive to non-monetary components. In their paper Wiswall and Zafar (2015) using the sample of NYU students focus on the relationship between major choice and expectations about marriage and labour supply. They provide evidence that both men and women anticipate that the college major decision will have a substantial effect on spousal quality, marriage timing and the number of children. Omitting these variables would lead to an upward bias of the importance of earnings in major choice. Finally, D'Haultfoeuille and Maurel (2013) estimated an extended Roy model applied to schooling decisions in France (two elements are added to the standard Roy model: non-pecuniary outcomes and uncertainty in potential earnings). According to their findings, non-pecuniary elements are a major driver of schooling decisions. For example, they conclude that the rate of higher education attendance in France would drop from 83.1 percent to 72 percent if there were no non-pecuniary factors.

Although expected earnings and non-pecuniary outcomes are decisive to understand how students choose their majors, they cannot explain entirely this decision.

First, it has been well documented that gender-specific preferences exist and have a significant effect on the choice of major. Zafar (2013) notes that differences in preferences for majors are much more important than differences in the distribution of major-specific skills in explaining the gender gap in college major choices. Similarly, Gemici and Wiswall (2014), using rational expectations and a dynamic model of human capital investments, found evidence that men are more responsive than women to the increase in skills rental rates of science compared to humanities. More importantly, they claim that the most significant gender difference in college major choices is driven by tastes rather than skills. Women favour humanities more than men because they have a stronger preference for this field, not because they have lower ability. Then Patnaik *et al.* (2022) emphasizes the role of risk aversion in college decision. According to their findings, omitting risk aversion leads to overestimating the earnings elasticity of college major choice. Although Wiswall and Zafar (2015) provided similar evidence, the key innovation of Patnaik *et al.*'s paper is that the authors elicit individual risk aversion (while Wiswall and Zafar assumed constant risk aversion for all individuals) and individual discount factors. Their conclusions suggest that when one allows for heterogeneity in both time preference and risk aversion, a 10% change in earnings increases the probability of majoring in a particular field by less than 1%, whereas omitting individual-specific measures leads to an increase in the probability of majoring in that field by more than 3.5% (for all majors). Nevertheless, it is noteworthy that individual risk preferences seem to matter more than heterogeneity in time preference.

Lastly, using a structural approach, Raposo and Alves (2007), focusing on the choice of college rather than the choice of major, show that individual factors (e.g. intrinsic motivation) have the greatest influence on the student's final decision. Surprisingly, the influence of others has a significant but negative impact on individuals' choice of college. There is, however, still a great deal of diversity between majors. Similarly, Chapman (2015) emphasizes the importance of both student characteristics and external influences in the final choice. He defines external influences as significant others, university characteristics and the institution's efforts to communicate with prospective students. His findings suggest that the choice of university is primarily influenced by the individual's background and current characteristics and that external influences have a lesser, but not negligible, influence on the decision.

1.3. Information and update beliefs

In the context of schooling decisions, it is particularly relevant to focus on perceived ability in the choice of college major. Sophisticated models often incorporate the ability to revise initial beliefs as more information is revealed. In a seminal paper, Arcidiacono (2004) not only models the choice of major but also examines the selection of college and the interconnectedness between these decisions. In particular, it is one of the first papers to introduce dynamics into the choice of college major, incorporating the learning process of students about their own ability and controlling for selection. Selection based on ability can manifest in two ways: high-ability individuals may perceive college as a less costly investment, and the returns to college may vary across individuals based on their abilities. He proposes a 3-period model in which the timing is as follows: in period 1, students choose a major and college or decide to enter the labour market; in period 2, after learning about their abilities and updating their beliefs, students decide whether to change college or major or enter the labour market; in period 3, everyone enters the labour market. His results highlight that ability is a crucial variable in the decision to change or drop out of college, and that most ability sorting is driven by preferences for majors and jobs rather than by differences in monetary returns. Moreover, the earnings differential premium persists across majors even after controlling for selection. The most striking finding is that ability learning due to new information (e.g. grades) has a significant effect on students' college decisions, suggesting that students are sensitive to accurate information when making their choices. Later on, Arcidiacono et al. (2015) builds on the previous work of Arcidiacono (2004) examines how students update their ability beliefs when they receive new information by allowing for imperfect information about schooling ability and labour market productivity. The paper allows for correlated learning through college grades and wages, where individuals may leave or re-enter college based on new information about their ability and productivity. Surprisingly, the results indicate that college grades reveal little about future labour market productivity.

In the same vein, Fricke *et al*. (2018), using a natural experiment in which they ask students at the University of St Gallen who have not yet chosen their major to write a research paper in three different fields (economics, business or law) that are randomly assigned to the students, also prove that information about the field of the major is crucial for the students' choice. Interestingly, the results show that exposure to economics or law increases the likelihood of majoring in that field (an increase of 2.7 percentage points). Aydede (2020) documented the importance of information asymmetry in children's attraction to their parents' field of study reflected by assortative tendencies in child – parent matches. In order to control for other characteristics that are unobserved by the researcher but aggregated in field of study attraction, he uses an intergenerational transmission framework which is a process that outlines the transfer of individual characteristics, (e.g. abilities, preferences, and outcomes), from parents to their children. The results underline that, after controlling for ability sorting and unobserved differences between tracks, children's choice of field of study shows significant assortative preferences. He also exhibits that the assortative tendency is highest between fathers and sons compared to all other pairs.

Finally, another strand of the literature emphasizes that students tend to have misguided expectations about the probability of graduating and about future labour market outcomes, and that they are sensitive to accurate information. Stinebrickner and Stinebrickner (2013) focus on initial beliefs of students about whether they will graduate and, if they do graduate, their major at graduation. By comparing beliefs about outcomes at the time of entry with realized outcomes, they find that there is a great deal of uncertainty at the time of entry. In particular, their main insight is that the science major is an outlier, implying that students tend to overestimate the likelihood of graduating in science compared to other majors. They estimate that 45% of the dropouts that occur in the first two years of college can be attributed to what students learn about their academic performance, but this type of learning becomes less important as a determinant of dropouts over time. In addition, conversely to previous works, Conlon (2021) found that students tend to underestimate mean salaries by majors. Yet, when information regarding earnings information about a given field is provided to students, there is significant evidence that they are more likely to major in that field. Hoxby & Avery (2013), Hoxby & Turner (2015) provide poor students with high SAT scores with information about their chances of admission to different types of institutions and the financial aid they could expect to receive. Students who received this information were significantly more likely to apply to and attend private institutions than the control group, although overall initial college attendance rates remained unchanged. Similarly, Arcidiacono *et al*. (2012) collect similar data from male undergraduate students at Duke University and similarly find that expected earnings and ability are important factors in the choice of major. Their simulations show that a non-negligible proportion of students would change their major if they had accurate perceptions of their ability. Overall, this literature suggests that information frictions are salient in the student choice process.

2. Background on preparatory classes and universities in France

This section describes the characteristics of both preparatory classes and universities in France and examines the reasons why students might prefer preparatory classes to universities. The development of new courses and opportunities at universities in recent years makes the topic even more compelling since business and engineering schools now offer university students the opportunity to take competitive exams to enter their schools[6]. There are thus two possible ways to enter the country's top business and engineering schools: either after having attended preparatory classes or after having obtained a degree at university. Indeed, in the early 2000s, business and engineering schools started to offer places to students with a university degree. Although at the beginning of 2010 the share of university students in these specialized schools was modest (which is reflected in the data by the fact that only a few students graduate from a specialized school after having completed a bachelor's degree at university), it is now slightly growing, with around 15% of graduates from business and engineering schools having followed a Bachelor in university instead of a preparatory class.[7] Secondly, the development of new types of university tracks such as dual degrees, both selective and of high quality, also questions the premium placed on the quality of preparatory classes, considered to be very difficult but offering a thorough and high-quality education. Thirdly, there is a large difference in the annual cost to the state of a preparatory class student compared to a university student. The average cost to the state of a preparatory class student is 15,700 euros per year, while the average annual cost of a university student is around 10,000 euros. Yet, while somewhat different, these two types of schools have some shared attributes. On the one hand, both options are free of charge and, on the other hand, there is almost no selection at the entrance[8], which makes it possible to avoid the problem of selection after high school (this selection issue being present in other types of colleges such that vocational training and post high school specialized schools).

At this stage, a further description of the main features of these two options may be instructive. Preparatory classes are two- or three-year courses covering a broad range of subjects (such as mathematics, economics, physics, sociology, etc.). These classes are highly intensive, and they are specifically designed to prepare students for competitive exams. They are known for forming the majority of students who enter the top French business or engineering schools. However, taking a preparatory class does not necessarily lead to further study in business or engineering schools; a non-negligible proportion of students continue their studies in university after taking a preparatory class (63% in my sample). On the other hand, university is more specialized as students need to choose one or two majors in the first year. Students are also more autonomous, and class size is significantly higher. The courses are nevertheless generally less intensive, but one should also bear in mind that after getting a bachelor's degree from university, students may decide to take an

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[6] In most cases, schools propose two separate competitive exams: one for preparatory classes students and one for university students. One can also see that I only focus on specialized schools that require a competitive exam at least two years after high school, so I do not include post-high school business or engineering schools.

[7] More information on: https://medias.vie-publique.fr/data_storage_s3/rapport/pdf/278177.pdf

[8] As mentioned in the introduction, selection in preparatory classes remains limited. While it is true that the best preparatory classes rigorously select their students, the wide variation in the quality of preparatory classes makes them accessible to almost all students.

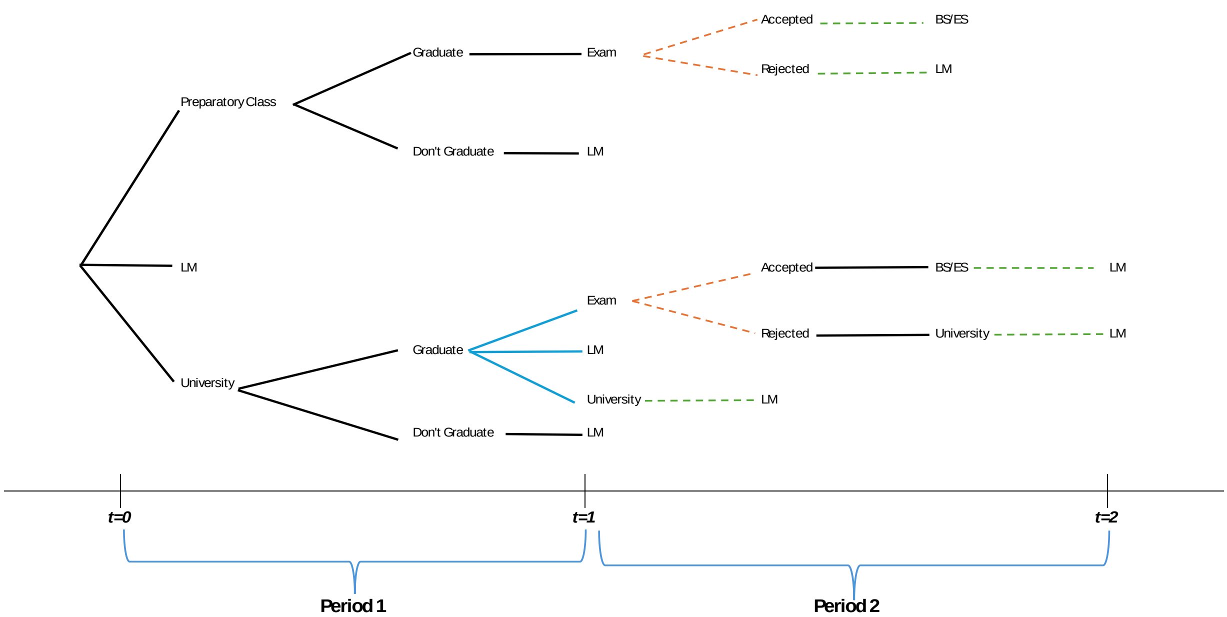
entrance exam for business or engineering schools. One last point worth mentioning is that after completing a bachelor's degree at a university or finishing a preparatory class, students have the option to pursue a master's degree, either at a university or in specialized schools (pending acceptance). It's important to note that business and engineering schools are not free, and tuition fees can be quite expensive, whereas university education is typically free in France. However, the length of study of these two options is similar. In addition, it is generally accepted that specialized schools have larger alumni networks, allowing students to find labour market opportunities more easily[9].

3. Model

This section describes the theoretical framework used in the analysis. I consider a $T = 40 + L$ periods game, which can be decomposed into $0 \leq L \leq 2$ periods of schooling and 40 periods of labour market. In other words, it is assumed that students can study at most for 2 periods ($L \in \{0; 1; 2\}$). The game is presented in figure 1.

At time 0, students choose the type of school they want to attend. They choose between three options: entering a preparatory class, enrolling at university or entering the labour market. If the latter option is chosen, the individuals work for 40 years and study for 0 years (i.e. $T = 40$ and $L = 0$). It is assumed that the labour market is an absorbing state; that is after entering the labour force, a student cannot resume her studies. Then, depending on their results and preferences, they decide at time 1 whether they want to pursue higher education. Depending on the choice made at time 0, the situation of a student at the end of the first period is different. A student who chooses and successfully completes a preparatory class in period 1 will take a competitive exam between period 1 and period 2 and, depending on the result, will continue her studies in business or engineering school or at university[10]. More precisely, it is assumed that if the student passes the exam, she[11] will continue in specialized schools and if she is rejected, she will pursue in university (rejected may simply mean that the student does not get the school she wanted). I also assume that students do not enter the labour market directly after successfully completing the first period of the preparatory class (i.e. having the preparatory class as their highest diploma), as this phenomenon is very rare in the data.

Figure 1 • Timeline of the game



[9] Find more information on: https://www.cge.asso.fr/wp-content/uploads/2020/06/2020-06-16-Rapport-2020.pdf.
[10] At this stage, it is worth mentioning that the length of the period may be different. Indeed, in reality, a preparatory class is two or three years while a university bachelor is three years but here both represent one period. On the other hand, after a preparatory course, students continue their higher education for three years, while university students study for only two years (master's degree). Overall, both successful preparatory school and university students study for five years.
[11] Note to the reader: in this paper, the pronoun 'she' is used as a neutral form.

On the other hand, if a student opts for university in period 1 and successfully completes this period, she has the choice of entering the labour market, pursuing a master's degree at university or taking a competitive exam to enrol in specialized schools. The latter option works in the same way as for the preparatory classes, i.e. if a student passes the exam, she continues in specialized schools, otherwise she continues in university. It is also assumed that the probability of graduating in the second period, that is to complete a master's degree, is one (for both specialized schools and university). In other words, no one fails the second period. In addition, if a student does not graduate in the first period, she necessarily enters the labour force in the second period (I do not allow for the possibility of reorientation), and the expected utility she receives is exactly the same as if she entered the labour market at the beginning of period 1 with a delay of one period (it starts at $t = 1$ instead of $t = 0$). Thus, if a student successfully completes the first part of the university track, she has, at time 1 (i.e. between period 1 and period 2), a choice to make, between taking the exam, pursuing a master's degree without taking the exam or entering the labour market, whereas when completing the first period in preparatory class leads not to such choice as all these students should take the exam. The model also allows, at the end of the first period, students also have the opportunity to switch from one type of school to another. The path set can be written as follows:

$$X = \{\text{Out,University Bachelor + Out,University + University Master,University Bachelor + BSES,}$$
$$\text{Preparatory Class + University Master,Preparatory Class + BSES,Preparatory Class + Out}\}$$
$$\mathrm{X} = \{O, U_1/O, U_1/U_2, U_1/B, CP/U_2, CP/B, CP/O\}$$

where Out stands for entering the labour market just after high school. In the remainder of the paper, one should bear in mind that I will only consider the general path CP (i.e. taking a preparatory class) as this track includes all possible paths after a preparatory class. Indeed, since for students who attend a preparatory class in period 1, there is no real choice at the end of period 1 between a master's in university or a master's in specialized schools (due to the assumption that the school attended in period 2 depends on the results of the competitive exam and because the path CP/O corresponds only to students who do not successfully complete the first period), all the possible track will be encompassed in the value function CP. In other words, the path CP is a combination of all possible labour market outcomes after a preparatory class in period 1.

3.1. Value functions

To represent the decision process of the student, I define value functions for each option. First, p_k denotes the probability of completing school k

($k \in$ {Undergraduate university,Master university, Specialized schools,Preparatory class,Outside Option}) and γ_k is the probability of passing the exam conditional on attending school k in period 1. Then, $\mathcal{V}_{\mathrm{LM},k',j}$ stands for the labour market expected utility of entering the labour market in period j after obtaining a degree in school k' (corresponding to the highest degree obtained, $k' \in$ {Undergraduate university,Master university,Specialized schools,Outside Option}, α_k represents the intrinsic preference of student for school k in period 1 and β is the discount factor. Based on the assumptions made above, one has α_{U_2} and α_B normalized to zero, $\alpha_O = p_O = 0$, $p_{U_2} = p_B = 1$ (no one fails the second period), and $\gamma_{U_2} = \gamma_O = 0$ since masters students and students entering the labour force just after high school cannot take the entrance exam. One should also keep in mind that the subscripts k and k' are slightly different as k' refers to the highest diploma obtained and k refers to all types of institutions that a student can join either in the first or in the second period.

Let's first consider the case where the student chooses to complete both bachelor's and master's degrees at the university without taking the competitive exam (i.e. the path U_1/U_2). The value function evaluated at time 0 is given by[12]:

$$\mathcal{V}_{U_1/U_2} = \beta\alpha_{U_1} + \beta^3 p_{U_1}\mathcal{V}_{\{\mathrm{LM},U_2,2\}} + \beta^2(1 - p_{U_1})\mathcal{V}_{\{\mathrm{LM},O,1\}}$$

[12] For the sake of simplicity, individual subscripts have been dropped, but individual heterogeneity is present for every variable.

First, this equation suggests that the student enrolled in the university receives a utility α_{U_1} that is not related to labour market outcomes. Then, if the student completes the first period (with probability p_{U_1}), she will receive the labour market outcome associated with a master's degree $\mathcal{V}_{\{\mathrm{LM},U_2,2\}}$. On the contrary, if she does not complete the first period, she will enter the labour market in period 2 and receive the labour market outcome associated with the outside option $\mathcal{V}_{\{\mathrm{LM},O,1\}}$. Second, since the decision is made at time 0, the utility in the first period must be discounted and the utility for the labour market flows must be discounted twice or three times discounted. Because the probability of graduating in period 2 is assumed to be 1, only the probability of completing period 1 is relevant. To reduce the dimensionality of the unobserved heterogeneity, the intrinsic utility of university attendance in period 2 is not part of the value function (it amounts to the hypothesis $\alpha_{U_2} = 0$). Lastly, one should keep in mind that it is the highest diploma obtained that matters for the labour market outcome and not the path followed by the students[13].

I now turn to the case where the student takes the competitive exam after university in period 1 (path U1/B). A cost C of taking the exam is included here to distinguish between the case where the student enrols in a master's degree at university without taking the exam to enter specialized schools and the case where the student enrols in a master's degree at university because she is rejected from the competitive exam. The latter captures potential psychological or monetary costs of taking the exam, which may be due to the additional effort required to pass the exam compared to the effort required to complete a bachelor's degree at university (e.g. extra classes taken). If there were no costs associated with taking the exam, all students who completed the first period would take the exam, but this is unrealistic from an empirical perspective. The value function of this path is:

$$\mathcal{V}_{U_1/B} = \beta\alpha_{U_1} + p_{U_1}\left[\gamma_{U_1}\left[\beta^3\mathcal{V}_{\{\mathrm{LM},B,2\}} - \beta^2 C\right] + (1-\gamma_{U_1})\left[\beta^3\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \beta^2 C\right]\right] + \beta^2(1-p_{U_1})\mathcal{V}_{\{\mathrm{LM},O,1\}}$$

To pursue in specialized schools, the student must graduate period 1 and must pass the competitive examination. If both conditions are met, then she will expect to receive the labour market outcomes associated with business or engineering schools. If she does not pass the exam, she will continue at university and receive: $\mathcal{V}_{\{\mathrm{LM},U_2,2\}}$. If she does not complete the first period, she cannot take the exam and thus enters the labour market at the end of the first period. One can also notice that the cost to take the exam is supported in period 2.

Finally, the value function for a student who only study for one period in university and then enters the labour market is given by:

$$\mathcal{V}_{U_1/O} = \beta\alpha_{U_1} + \beta^2 p_{U_1}\mathcal{V}_{\{\mathrm{LM},U_1,1\}} + \beta^2(1-p_{U_1})\mathcal{V}_{\{\mathrm{LM},O,1\}}$$

I then move on to examine the situation of preparatory class. If a student is enrolled in a preparatory class in period 1, she will always take a competitive exam between the two periods. If she passes the exam, she will be admitted to a specialized school, otherwise she will go to the university to study for a master's degree. The value function can be written as following:

$$\mathcal{V}_{CP} = \beta\alpha_{CP} + \beta^3 p_{CP}\left[\gamma_{CP}\mathcal{V}_{\{\mathrm{LM},B,2\}} + (1-\gamma_{CP})\mathcal{V}_{\{\mathrm{LM},U_2,2\}}\right] + \beta^2(1-p_{CP})\mathcal{V}_{\{\mathrm{LM},O,1\}}$$

The expression reads the same as for the U_1/B path but note that I do not include the cost of taking the exam in this last value function. This is simply because students know that if they choose to enrol in preparatory classes, they will have to take an exam at the end of the first period, so this cost is implicitly incorporated in α_{CP}.[14]

[13] This assumption is constrained by the data. In fact, to estimate the Heckman equation, I used the *Enquête Emploi* database, which does not provide complete information on students' pathways through secondary education, but only information on the highest diploma obtained.

[14] This statement relies on the credible assumption that every student who completes a preparatory class will take a competitive exam.

3.2. Labour market utility

The last step before writing the complete value function explicitly, is to derive the expected utility of an individual entering the labour force, which amounts to clearly expressing $\mathcal{V}_{\{\mathrm{LM},k',j\}}$ in the previous expressions. The expected utility in the labour market depends on both monetary and non-monetary elements that may influence the choice of the individual in period 0. Let's denote by $\lambda_{k'}$ the probability to find a job after graduating from school k'. This probability is assumed to be a constant hazard rate, and so is constant over time. I also assume that when a person finds a job, she remains employed until retirement. I denote by w_t the wage the individual earned in period t. Two cases need to be distinguished: the situation where the individual finds a job during her active life and the situation where she does not find a job. In its general form, the discounted expected labour market utility of a student graduating from college k evaluated when she is in high school (evaluated at period 0) is given as follows:

$$\mathcal{V}_{LM,k',L} = \sum_{l=0}^{40} (1-\lambda_{k'})^l \lambda_{k'}^{\mathbf{1}(l<40)} \left[\mathbf{1}_{(l>0)} b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \, \mathbf{E}[w_t | k'] \right]$$

where b stands for the unemployment benefits. The term outside the square brackets captures the time needed to find a job. The first term in brackets is the unemployment benefit for the time the individual is looking for a job. The second term in brackets is the labour market outcome once the individual has found a job. I make explicit the fact that the labour market outcome depends on the time spent in higher education and on the highest degree obtained (i.e. the type of school also matters). For instance, depending on the type of school from which students graduated, the probability of finding a job may differ due to more or less developed alumni networks: business schools having in general stronger alumni networks compared to universities. One can see that, if an individual never finds a job, the labour market outcome is given by (it simply corresponds to the previous case but assuming that $l = 40$):

$$(1-\lambda_{k'})^{40} b \sum_{t=1}^{40} \beta^t$$

Finally, the situation $L = 0$ is also interesting as it corresponds to the value function of the outside option. It can be written as following:

$$\mathcal{V}_{LM,O} = \sum_{l=0}^{40} (1-\lambda_O)^l \lambda_O^{\mathbf{1}(l<40)} \left[\mathbf{1}_{(l>0)} b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \, \mathbf{E}[w_t | O] \right] \quad (1)$$

3.3. Complete value functions

Then, the complete value function for each path should be derived. In the core text, I only focus on the value function of the path CP as it requires an additional step, that is the competitive exam. The remaining paths are provided in the appendix A.1. The last step is to express the form of the probabilities: p_k and γ_k. Both probabilities are unknown at time 0 but to reduce the dimensionality of the unobserved heterogeneity it is assumed that the probability of graduating in school k is only a function of the observable characteristics. Thus, it can be written as follows: $p_{ik} = \theta_{X_k} X_{ik}$[15]. On the contrary, the probability of passing the exam is unknown and depends on the grades obtained in period 1, which are also unknown in period 0, and unobservable to the econometrician. More precisely, I denote N_k the grades obtained in period 1 by the student, which are unknown at time 0. I assume that N_k depend on observable characteristics plus a shock (representing ability), unobserved, so the grades can be expressed in a linear way as follows:[16]

$$N_{ik} = \theta_{Z_k} Z_{ik} + \epsilon_{ik}$$

[15] Since p_{ik} does not include any unobserved heterogeneity, one can leave the general form of p_{ik} in the value functions.
[16] The grade function of observables of preparatory classes and universities are different.

To pass the exam as students should get a grade higher than a threshold $\widehat{N_k}$ (assumed to be known). In other words, if $N_{ik} \geq \widehat{N_k}$ a student pursues in specialized schools. Therefore, at time 0, a student will expect to pass the exam if and only if $N_k \geq \widehat{N_k}$. Assuming ϵ_{ik} to be normally distributed, thus $\epsilon_{ik} \sim N\left(0, \sigma^2_{\epsilon_k}\right)$, one has:

$$\gamma_{ik} = \Pr\left[N_{ik} \geq \widehat{N_k}\right] = \Pr\left[\theta_{Z_k} Z_{ik} + \epsilon_{ik} \geq \widehat{N_k}\right] = 1 - \Phi\left(\frac{\widehat{N}_k - \theta_{Z_k} Z_{ik}}{\sqrt{\sigma^2_{\epsilon_{ik}}}}\right).$$

The value function of path CP can therefore be rewritten as follows:

$$\begin{aligned}
\mathcal{V}_{CP} &= \beta\alpha_{CP} + \beta^3 \times p_{CP} \times \left[1 - \Phi\left(\frac{\widehat{N_{CP}} - \theta_{Z_{CP}} Z_{CP}}{\sqrt{\sigma^2_{\epsilon_{CP}}}}\right)\right] [\sum_{l=0}^{40} (1-\lambda_B)^l \, \lambda_B^{\mathbf{1}(l<40)} \left[b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \, \mathbf{E}[w_t|B]\right] \\
&\quad + \Phi\left(\frac{\widehat{N}_C P - \theta_{Z_{CP}} Z_{CP}}{\sqrt{\sigma^2_{\epsilon_{CP}}}}\right) [\sum_{l=0}^{40} \left(1-\lambda_{U_2}\right)^l \, \lambda_{U_2}^{\mathbf{1}(l<40)} \left[b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \, \mathbf{E}[w_t|U_2]\right]] \\
&\quad + \beta^2 \times (1 - p_{CP}) \times \left[\sum_{l=0}^{40} (1-\lambda_O)^l \, \lambda_O^{\mathbf{1}(l<40)} \left[b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \, \mathbf{E}[w_t|O]\right]\right]
\end{aligned}$$

4. Data and descriptive statistics

4.1. Data

To conduct the empirical analysis, I rely on two databases. The main database used comes from a survey conducted by the *Centre d'études et de recherches sur les qualifications* (Céreq) entitled *Enquête Génération* 2013. This survey is a longitudinal study conducted in France to analyse the career paths of young people leaving the education system. Its primary objective is to investigate the transitions between education and employment, and to explore the diverse career trajectories of individuals over time. The survey covers graduates from secondary schools in France and covers a wide range of levels and fields. Individuals are interviewed three years after leaving the education system, so the focus is on the 2013 cohort, and the interview took place in 2016[17]. This survey provides very detailed and complete information on both the educational pathways and the occupational integration of the respondents: it collects information about the level of education achieved, the type of diploma obtained, the duration of the job search, etc. More specifically, it makes it possible to reconstruct the entire career of young people during their first three years of active life and to analyse them in terms of their educational background and the degrees they have obtained. Besides the characteristics of the school career and the diplomas obtained, the data includes criteria such as gender, social origin, national origin, place of residence, geographical mobility, marital status and social networks. Nevertheless, this data does not allow me to fully recover the educational path of the students. Indeed, only information regarding the choice right after high school and the highest diploma is provided, therefore it is impossible to know with certainty the higher educational path of the students. In order to reconstruct the student's path, I consider the choice immediately after high school and the highest diploma obtained. For example, if a student indicates that she is enrolled in university just after high school and her highest diploma is a master's in business school or in engineering school, she is assigned to the path: university + specialized schools. In total, the data provide information on more than 17,653 individuals, but I restrict my analysis to students enrolling either in preparatory classes or in university as well as individuals who enter the labour market directly after high school, i.e. after high school. The final sample is composed of 5,836 observations, including 50% of women[18]. The average age at the time of the survey is about 24 years, more than 83% of the respondents are employed and less than 11% are unemployed.

[17] Respondents answer question by telephone or via Internet (depending on the year).
[18] This drop in the number of observations is mainly due to the fact that most students opt for short higher education path after high school.

I have also used a second database: the *Enquête emploi* 2016, a survey conducted by the *Institut national de la statistique et des études économiques* (INSEE). This survey is the reference source for the measurement of the concepts of activity, unemployment, employment and inactivity in France in accordance with the definitions of the International Labor Office. It also contains a large amount of information on the characteristics of individuals (gender, age, degree, experience, etc.), employment conditions (occupation, type of contract, working hours, duration of employment, underemployment, etc.), and non-employment situations (job search methods, studies, retirement, etc.). The purpose of using this database is to compute the discounted expected wages of students over a longer period. The *Enquête Génération* database provides information on individuals' wages only 3 years after their graduation, representing entry-level salaries. In contrast, the *Enquête Emploi* allows for a more comprehensive estimate of the expected wages that students can anticipate receiving.

4.2. Descriptive statistics

Descriptive statistics, displayed in table 1, suggest gender differences in post-secondary education choices. Women are more likely to enrol in university immediately after high school and less likely than men to enter the labour force without a higher education degree. Specifically, about 38% of individuals who decided to join the labour force directly after high school are women. Furthermore, less than 40% of respondents who chose preparatory classes in period 1 and specialized schools in period 2 are women. Only 43% of those graduating from specialized schools after obtaining a bachelor's degree from a university are women, indicating that women are also less likely to graduate from specialized schools. This disparity can potentially explain wages gap since the fourth column of this table also highlights the great heterogeneity of average wages three years after higher education depending on the type of institution chosen. The top panel shows that attending a preparatory class in period 1 results in an average salary 33% higher than enrolling in university. However, this result should be qualified, as the middle panel indicates that this difference is primarily due to students who only obtained a bachelor's degree at university. The wage gap between students who earn a master's degree from a university and those who earn a degree from specialized schools narrows to less than 15.5%. Moreover, for the same higher degree (a master's), students who attended a preparatory class seem to earn higher salaries than those who enrolled directly in university, with a difference of about 21.5%, according to the bottom panel. This last point may be driven by the heterogeneity in school quality, as the proportion of students from preparatory classes in the top French specialized schools is higher than that of students coming from universities[19]. One can also observe that pursuing higher education results in higher wages compared to entering the labour market without any higher education. Moreover, students who attend a preparatory class have a higher probability of finding a job than those who attend university. Even for the same degree, students who have taken a preparatory class have a higher probability of securing employment than those who have not, reinforcing the hypothesis of a preparatory class premium. Additionally, the probability of graduating is slightly higher for students in preparatory classes than for those in university. While these results may seem surprising, it is important to note that the probability of graduating from a preparatory class does not necessarily mean that a student will pass the competitive exam; it simply indicates that the student completes the two or three years of preparatory coursework.

I also present some descriptive statistics on the choice of students and their probabilities of success according to their educational background. Table A1 indicates that students who followed a general path in high school are much more likely to take a preparatory class than students who followed either a vocational or a technical track. In my sample, about 95% of the students in the preparatory class followed the general track in high school. Although these patterns are also at stake for university, the difference is even more striking for preparatory classes. Additionally, students with a general academic background are more likely to graduate and pass the exam than students with a technical or vocational background. For example, the probability of completing the first period in university for students with a general background is more than 80% while it is 35% for students with a technical background and only 6% for students with a vocational background. In addition, having obtained 'high honours' or 'very high honours' in the baccalaureate also increases the likelihood of attending a preparatory class and of attending a business or engineering school after a preparatory class. Students with 'high honours' and 'very high honours' are also more likely to graduate and to pass both the university and preparatory school competitive exams. Then, since previous literature has shown that controlling for field of study (i.e. major) is important, I present brief descriptive statistics on the choice of

[19] However, in my earnings estimation I cannot account for this since the *Enquête Emploi* does not allow me to recover the track by which people got their masters.

major. In the data, the most favoured field of study is the natural sciences, followed by the social sciences. There is a great deal of disparity in the choice of field of study by gender, as the field of study 'health and social work' is dominated by women. On the other hand, males are more likely to choose industrial engineering and science after upper secondary education (cf. top graph in figure A2). Finally, bottom graph of figure A2 shows the average wage by major based on the *Enquête Génération* database. At first glance, it appears that students majoring in science, industrial engineering, and finance and business have the highest average wages, while students majoring in health and social sciences or arts and languages have the lowest average wages.

Table 1 • Descriptive statistics

	Frequency	Share of women	Wages	Probability of finding a job	Probability of graduating	Probability of passing the exam
1st classification						
Outside	1 778	0,39	1328 (410.63)	0,7	-	-
University	4 044	0,59	1679 (652.68)	0,79	0,61	0,29
Preparatory classes	1 521	0,51	2,241 (736.48)	0,9	0,78	0,03
2nd classification						
3 years University	647	0,65	1450 (471.13)	0,81	-	-
5 years University	2 448	0,53	2079 (714.48)	0,85	-	-
BS/ES	548	0,4	2402 (670.38)	0,92	-	-
3rd classification						
CP+BS/ES	447	0,39	2418 (676.86)	0,93	-	-
Univ + BS/ES	101	0,43	2322 (636.34)	0,88	-	-
CP+Univ	738	0,49	2363 (689.20)	0,91	-	-
Univ+Univ	1 710	0,55	1944 (686.33)	0,83	-	-

Note: all the statistics computed are mean and the numbers in parentheses represent the standard deviation.
Source: Céreq, *Enquête Génération* 2013 surveyed at year 3.

5. Empirical strategy

This section describes the empirical strategy followed in this paper. More specifically, it reviews and explains how the parameters have been estimated and presents the results of the structural estimation. According to my theoretical model, the decision of students to go to college depends on the following elements: the intrinsic preferences of students, the probability of graduating, the probability of passing the exam, the probability of finding a job, and the expected labour market flows (i.e. expected wages). The first step is therefore to estimate these values for all different options for each individual (i.e. each individual has potentially different expected wage for each path through the system). Once this is done, one can proceed to the structural estimation of the model.

5.1. Estimation of the model components

First, using the *Enquête Emploi* database, I estimate the expected wages with a Heckman equation. The use of this database is justified to obtain more reliable and more representative estimates of the expected wages by highest diploma. The selection equation is the following:

$$E_i \times \mathbf{1}_{\boldsymbol{D_i=k}} = \alpha_{0,k} + \alpha_{1,k}\text{Father Occupation}_{\text{i}} + \alpha_{2,k}\text{Mother Occupation}_{\text{i}} + \alpha_{3,k}\text{Age}_{\text{i}} + \alpha_{4,k}\text{Age}_{\text{i}}^2 + \alpha_{7,k}\text{Seniority}_i + \alpha_{9,k}\text{Nationality}_i + \alpha_{9,k}\text{Region}_i + \nu_{i,k}$$

where E_i stands for whether individuals are employed and D_i is the highest diploma obtained by individual i. The selection equation is assumed to depend on the occupations of the parents at graduation as these variables may affect the probability of finding a job and the type of degree undertaken (e.g. family networks) but do not directly affect wages. The Heckman model can be formulated as following:

$$ln(w_{ik}) = \beta_0 + \beta_{1,k} \times \text{Age}_i + \beta_{2,k} \times \text{Age}_i^2 + \beta_{5,k} \times \text{Seniority}_i + \beta_{7,k}\text{Nationality}_i + \beta_{X,k}X_i + (\rho\sigma_u)_k\lambda(\alpha T) + u_{i,k}$$
$$such\ that: E_i \times 1_{D_i=k} = 1 \quad (2)$$

where X_i encompasses the field of major, the region of living and socio-professional categories. T is a matrix included the covariates of the selection equation, $\lambda(\alpha T)$ stands for the inverse Mills ratio evaluated at αT, σ_u represents the standard deviation of the unobserved determinants of wages and ρ is the correlation between the unobserved determinants of propensity to work and unobserved determinants of wages offered. This regression is conducted on four subsamples: one for each higher diploma, i.e. no higher education degree, university bachelor, university master and degree from specialized schools. In other words, I predict the outside option expected wage based on the coefficients obtained when running equation 2 on the sub-sample of students having chosen to enter the labour market immediately after high school. I implicitly assume that agents are myopic, i.e. that they base their observations on what they observe and do not include in their prediction possible future changes in the labour market that may affect wages (e.g. a change in the labour market environment that may increase the expected wages of students graduating from specialized schools). Results, displayed in table A2, are in line with the traditional findings. Indeed, the wages increase with age and with seniority in a non-linear way. Women earn lower monthly wages than men. These patterns hold for all higher educational degrees. French individuals graduating from specialized schools and those graduating with a bachelor's degree from a university tend to have significantly higher wages compared to non-French individuals with the same higher diploma. However, the results show that the occupation of the parents does not seem to have a significant effect on the probability of finding a job.

Then, to estimate the probability of finding a job by highest diploma, I conduct a Heckman selection model on the *Enquête Emploi* database, where the outcome equation is a dummy indicating whether individuals are employed or not, regressed on a set of covariates including the occupation of the parents (as for the selection equation of the Heckman equation for wages), and the selection equation regresses the highest diploma obtained on the track in high school of individuals and on the nationality of their parents[20]. For instance, for an individual obtaining her highest diploma from specialized schools, the Heckman model for the probability to find a job can be written as follows:

[20] The variable is a dummy indicating whether the mother (or father) was born in France. I believe that nationality has an influence on parents' knowledge of the different options available after secondary school and thus on the likelihood of choosing each path.

$E_{ik} = \alpha_0 + \alpha_1\text{Father Occupation}_i + \alpha_2\text{Mother Occupation}_i + \alpha_{3,k}\text{Age}_i + \alpha_{4,k}\text{Age}_i^2 + \alpha_{7,k}\text{Seniority}_i + \alpha_{9,k}\text{Nationality}_i + \alpha_{9,k}Region_i + \rho\sigma_v\lambda(\gamma V) + v_{i,k}$ (3)

such that $D_{ik} = 1$

where D_{ik} is a dummy indicating whether student choose path k or not:

$D_{ik} = \alpha_{0,k} + \alpha_{1,k}\text{Track in High school}_i + \alpha_{2,k}\text{Nationality of the mother}_i + \alpha_{3,\text{k}}\text{Nationality of the father}_i + \varepsilon_{\text{ik}}.$

V is a matrix that includes the covariates of the selection equation, $\lambda(\gamma V)$ is the inverse Mills ratio evaluated at γV, σ_v is the standard deviation of the unobserved determinants of the probability of finding a job, and ρ is the correlation between the unobserved determinants of the propensity to work and the unobserved determinants of college choice.

The next step is to perform the structural estimation[21]. Five equations are estimated simultaneously: the probability of graduation and the probability of passing the exam for both university and preparatory class and the choice equation. The choice equation will be presented in the next subsection. The probability of graduation from university (respectively preparatory class) is regressed on the subsample composed of individuals attending university (resp. preparatory class) in period 1. To construct these probabilities, which are not directly observed in the data, I create a dummy for each probability of success (either graduation or passing the competitive exam) that indicates whether the student succeeds (i.e. completes the first period or passes the exam). A student is assumed to graduate the first period at university if she attends university in period 1 and if her highest diploma corresponds at least to a bachelor’s degree. A student is assumed to complete the first period in preparatory class if she attends preparatory class after high school and if her highest diploma is a master’s degree (either at university or in specialized schools). Then, a student is assumed to pass the exam if she attends either preparatory class or university in period 1 and if she graduates from business or engineering school in the second period[22]. Several points are worth noting for the estimation of these probabilities. First, as mentioned previously, the probability of graduating is assumed to only be a function of observables, while the probabilities of passing the exam depend on both observables and an unobserved component (i.e. ability). Besides the desire to keep the model tractable and the dimensionality of the estimates manageable, this point can be motivated by the fact that even if ability affects both the probability of graduating and the probability of passing the exam, the effect is likely to be stronger on the probability of passing the exam. Therefore, I assume that only the probability of passing the exam depends on the student’s unobserved ability. It should be noted, however, that this is only the unobserved part of ability that affects the probability of passing the exam and not the probability of graduating, because the observed part of ability is included in all the equations for the probability of success, as I control for high school honours. Second, in order to recover the effect of the different probabilities on the path decision of students, I propose a unique probit model for each probability. In other words, to be able to identify the causal impact of each probability in the final choice (i.e. to satisfy the exclusion restriction condition), I include a different set of covariates in each equation. In each equation: I include the gender, the track in high school and the results in baccalaureate as it has been shown that results in high school and majors have significant effect on the probability of success in higher education[23]. For the probability of graduating, the exclusion restriction variable is the place of residence in the last year of high school, as students in large cities are more likely to attend higher education in the same city and then have a higher probability of graduating because they don’t have to look for a new place to live and adapt to a new city, for example. The exclusion restriction for the probability of passing the exam when attending university is whether students receive a scholarship during higher education. The probability of graduating from a preparatory class is identified thanks to a variable indicating whether students come from a low-income neighbourhood. Finally, the length of studies of parents is used to identify the probability of passing the exam when attending preparatory class. As an example, the expression for the probability of passing the exam from preparatory class can be written as follows:

[21] Appendix A.6. explains how probabilities to get Baccalaureate Honors in high school have been computed.
[22] For the sake of simplicity and due to missing information in the data, I assume that every student takes the exam (even after university in the first period) in order to calculate the probability of passing the exam, which I admit does not fully fit the theoretical framework.
[23] You can find more information here: https://www.enseignementsup-recherche.gouv.fr/sites/default/files/2022-01/-rapport-igesr-2022-004-16280.pdf, and here: https://www.cairn.info/revue-regards-croises-sur-l-economie-2015-1-page-51.htm.

$$\begin{aligned}\gamma_{i,CP} &= \alpha_{0,CP} + \alpha_{1,CP} \times \text{Sex}_i + \alpha_{2,CP} \times \text{Baccalaureate Honours}_i + \alpha_{3,CP} \times \text{Track in High School}_i \\ &\quad + \alpha_{4,CP} \times \text{Majors in Higher Education}_i + \alpha_{Z,CP} \times Z_i + \epsilon_{i,CP}\end{aligned}$$

where Z_i stands for the length of studies of the parents.

5.2. Structural model

This section specifies the form of the unobserved heterogeneity, and it derives the likelihood function, which are the final steps for the structural estimation.

5.2.1. Unobserved heterogeneity

The unobserved heterogeneity in this framework comes from two sources. As mentioned above, the probability of passing the exam is unknown, but the intrinsic preferences for a particular school in period 1 of a student (α_k) is also unknown to the econometrician. Overall, four terms are unobserved: α_{U_1}, α_{CP}, ϵ_{U_1},ϵ_{CP}, all assumed to be normally distributed. I allow the ability in college k to be correlated with the intrinsic preference of the student for college k. In line with the literature on major choice, it is not inconsistent for students with a higher ability for a college to have a higher preference for that college. In this case, the intrinsic preferences for the preparatory class and for the university are also correlated, because these preferences can be seen as partly complementary: an increase in the preference for the preparatory class leads to a relative decrease in the preference for the university. The same is true for ability in different types of school. The covariance expressions of these four terms are thus given by:

- $\text{Cov}(\alpha_k, \alpha_j) = \sigma_{\alpha_k,\alpha_j} \forall k \neq j$
- $\text{Cov}(\epsilon_k, \epsilon_j) = \sigma_{\epsilon_k,\epsilon_j} \forall k \neq j$
- $\text{Cov}(\alpha_k, \epsilon_j) = 0 \forall k \neq j$
- $\text{Cov}(\alpha_k, \alpha_k) = \text{Var}(\alpha_k) = \sigma^2_{\alpha_k}$
- $\text{Cov}(\epsilon_k, \epsilon_k) = \text{Var}(\epsilon_k) = \sigma^2_{\epsilon_k}$
- $\text{Cov}(\alpha_k, \epsilon_k) = \sigma^2_{\alpha_k,\epsilon_k}$

The covariance matrix can then be expresses as follows:

$$\Sigma = \begin{bmatrix} \sigma^2_{\alpha_{CP}} & \sigma_{\alpha_{CP},\epsilon_{CP}} & \sigma_{\alpha_{CP},\alpha_{U_1}} & 0 \\ \sigma_{\epsilon_{CP},\alpha_{CP}} & \sigma^2_{\epsilon_{CP}} & 0 & \sigma_{\epsilon_{CP},\epsilon_{U_1}} \\ \sigma_{\alpha_{CP},\alpha_{U_1}} & 0 & \sigma^2_{\alpha_{U_1}} & \sigma_{\alpha_{U_1},\epsilon_{U_1}} \\ 0 & \sigma_{\epsilon_{CP},\epsilon_{U_1}} & \sigma_{\epsilon_{U_1},\alpha_{U_1}} & \sigma^2_{\epsilon_{U_1}} \end{bmatrix}$$

Finally, the distribution of unobserved heterogeneity is given by:

$$\begin{bmatrix} \alpha_{CP} \\ \epsilon_{CP} \\ \alpha_{U_1} \\ \epsilon_{U_1} \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \sigma^2_{\alpha_{CP}} & \sigma_{\alpha_{CP},\epsilon_{CP}} & \sigma_{\alpha_{CP},\alpha_{U_1}} & 0 \\ \sigma_{\epsilon_{CP},\alpha_{CP}} & \sigma^2_{\epsilon_{CP}} & 0 & \sigma_{\epsilon_{CP},\epsilon_{U_1}} \\ \sigma_{\alpha_{CP},\alpha_{U_1}} & 0 & \sigma^2_{\alpha_{U_1}} & \sigma_{\alpha_{U_1},\epsilon_{U_1}} \\ 0 & \sigma_{\epsilon_{CP},\epsilon_{U_1}} & \sigma_{\epsilon_{U_1},\alpha_{U_1}} & \sigma^2_{\epsilon_{U_1}} \end{bmatrix} \right)$$

5.2.2. Likelihood function

The final step is to build the likelihood function of the model. One needs therefore to clearly write the contribution of each path to the likelihood function. Intuitively, a path contributes to the likelihood function if it defeats all the other paths (i.e. provide a higher expected discounted lifetime utility). For instance, the contribution of path CP is:[24]

[24] The contribution of the other paths to the likelihood-function are provided in appendix A.3.

$$\Pr[(\text{Choice} = CP)] = \Pr\left[[\mathcal{V}_{CP} \geq \mathcal{V}_O] \cap [\mathcal{V}_{CP} \geq \mathcal{V}_{U_1/B}] \cap [\mathcal{V}_{CP} \geq \mathcal{V}_{U_1/O}] \cap [\mathcal{V}_{CP} \geq \mathcal{V}_{U_1/U_2}]\right]$$

The probability that the path CP will be chosen can be rewritten in the following way:

$$\begin{aligned}\Pr[\text{Choice}_i = CP] &= \Pr[[\beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + p_{CP}[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}]\,(1-\theta_{Z_{CP}}Z_{CP}) \\ &\geq -\beta\alpha_{CP} + p_{CP}\epsilon_{CP}\beta^3[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}]] \cap [(p_{CP} - p_{U_1})[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] \\ &+ \beta^3[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\left[p_{CP}\theta_{Z_{CP}}Z_{CP} - p_{U_1}\theta_{Z_{U_1}}Z_{U_1}\right] + p_{U_1}C \\ &\geq \beta(\alpha_{U_1} - \alpha_{CP}) \\ &+ (p_{U_1}\epsilon_{U_1} - p_{CP}\epsilon_{CP})\beta^3[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]] \cap [(p_{CP} - p_{U_1})[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] \\ &- p_{CP}\theta_{Z_{CP}}Z_{CP}\beta^3[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}] \\ &\geq \beta(\alpha_{U_1} - \alpha_{CP}) + p_{CP}\epsilon_{CP}\beta^3[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}]] \cap [p_{CP}\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - p_{U_1}\beta^2\mathcal{V}_{\{\text{LM},U_1,1\}} \\ &- (p_{CP} - p_{U_1})\beta^2\mathcal{V}_{\{\text{LM},O,1\}} - p_{CP}\theta_{Z_{CP}}Z_{CP}\beta^3[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}] \\ &\geq \beta(\alpha_{U_1} - \alpha_{CP}) + p_{CP}\epsilon_{CP}\beta^3[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}]]]\end{aligned}$$

Then, I use the following notations:

- $\nu_{1''} = -\beta\alpha_{CP} + \beta^3 p_{CP}\epsilon_{CP}[V_{LM,U_2,2} - V_{LM,B,2}]$
- $\nu_2'' = (p_{CP} - p_{U_1})[\beta^3 V_{LM,U_2,2} - \beta^2 V_{LM,O,1}] + \beta^3[V_{LM,B,2} - V_{LM,U_2,2}]\left[p_{CP}\theta_{Z_{CP}}Z_{CP} - p_{U_1}\theta_{Z_{U_1}}Z_{U_1}\right] + p_{U_1}C$
- $\nu_3'' = \beta(\alpha_{CP} - \alpha_{U_1}) + \beta^3 p_{CP}\varepsilon_{CP}[V_{LM,U_2,2} - V_{LM,B,2}]$
- $\nu_4'' = \beta(\alpha_{U_1} - \alpha_{CP}) + \beta^3 p_{CP}\varepsilon_{CP}[V_{LM,U_2,2} - V_{LM,B,2}]$

One can notice that ν_i ∀ i ∈ {1;4} is normally distributed as it is a linear combination of normal distributions. The function h is therefore a mutlivariate normal distribution. In maths terms, it is:[25]

$$\begin{bmatrix}\nu_1'' \\ \nu_2'' \\ \nu_3'' \\ \nu_4''\end{bmatrix} \sim N(0, \Sigma'')$$

Finally, the contribution of path CP to the likelihood can be rewritten as follows:

$$\int_{-\infty}^{A_3}\int_{-\infty}^{B_3}\int_{-\infty}^{C_3}\int_{-\infty}^{D_3} h(\nu_1'', \nu_2'', \nu_3'', \nu_4'')\, d\nu_1'' d\nu_2'' d\nu_3'' d\nu_4''$$

where:

$$\begin{aligned}A_3 &= \beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + p_{CP}[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] \\ B_3 &= (p_{CP} - p_{U_1})[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] + \beta^3[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\left[p_{CP}\theta_{Z_{CP}}Z_{CP} - p_{U_1}\theta_{Z_{U_1}}Z_{U_1}\right] + p_{U_1}C \\ C_3 &= (p_{CP} - p_{U_1})[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] - p_{CP}\theta_{Z_{CP}}Z_{CP}\beta^3[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}] \\ D_3 &= p_{CP}\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - p_{U_1}\beta^2\mathcal{V}_{\{\text{LM},U_1,1\}} - (p_{CP} - p_{U_1})\beta^2\mathcal{V}_{\{\text{LM},O,1\}} - p_{CP}\theta_{Z_{CP}}Z_{CP}\beta^3[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}]\end{aligned}$$

Using the same procedure, one can derive the contribution of each path (see appendix A.4. for the computations and the upper bounds of the integral) and can write the likelihood function.

[25] The details of the computations, and in particular the expression of the matrix $\Sigma^{"}$, are given in appendix A.2.

$$L = \prod_{i=1}^{n} \prod_{x \in X} \Pr\left[\text{Choice}_i = x\right]^{\text{Choice}_i = x}$$
$$= \prod_{i=1}^{n} \Pr\left[\text{Choice}_i = U_1/O\right]^{\text{Choice}_i = U_1/O} \times \Pr[\text{Choice}_i = O]^{\text{Choice}_i = O} \times \Pr[\text{Choice}_i = CP]^{\text{Choice}_i = CP}$$
$$\times \Pr[\text{Choice}_i = U_1/B]^{\text{Choice}_i = U_1/B} \times \Pr[\text{Choice}_i = U_1/U_2]^{\text{Choice}_i = U_1/U_2}$$

where n represents the number of observations. The likelihood function can be finally written as follows:

$$L = \prod_{i=1}^{n} \left[\int_{-\infty}^{A_1}\int_{-\infty}^{B_1}\int_{-\infty}^{C_1} f(\nu_1,\nu_2,\nu_3)\, d\nu_1 d\nu_2 d\nu_3\right]^{Choice_i = U_1/O} \times$$
$$\left[\int_{-\infty}^{A_2}\int_{-\infty}^{B_2}\int_{-\infty}^{C_2}\int_{-\infty}^{D_2} g(\nu_1',\nu_2',\nu_3',\nu_4')\, d\nu_1' d\nu_2' d\nu_3' d\nu_4'\right]^{Choice_i = O} \times$$
$$\left[\int_{-\infty}^{A_3}\int_{-\infty}^{B_3}\int_{-\infty}^{C_3}\int_{-\infty}^{D_3} h(\nu_1'',\nu_2'',\nu_3'',\nu_4'')\, d\nu_1'' d\nu_2'' d\nu_3'' d\nu_4''\right]^{Choice_i = CP} \times$$
$$\left[\int_{-\infty}^{A_4}\int_{-\infty}^{B_4}\int_{-\infty}^{C_4}\int_{-\infty}^{D_4} m(\nu_1''',\nu_2''',\nu_3''',\nu_4''')\, d\nu_1''' d\nu_2''' d\nu_3''' d\nu_4'''\right]^{Choice_i = U_1/B} \times$$
$$\left[\int_{-\infty}^{0}\int_{-\infty}^{A_5}\int_{-\infty}^{B_5} n(\nu_1^*,\nu_2^*,\nu_3^*)\, d\nu_1^* d\nu_2^* d\nu_3^*\right]^{Choice_i = U_1/U_2} \quad (4)$$

5.3. Estimation and results

Once the covariates of interest are estimated, the next step is to perform the structural estimation of the model. Table 2 presents the results of the full structural estimation, including both the probabilities of finding a job and the expected wages, as well as the components of the probabilities of success equations.

The results suggest that, other things being equal, being a woman reduces the probability of passing the competitive exam to enter specialized schools, both after a university bachelor's degree and after a preparatory class. Women also seem to be less likely to complete a university degree. In addition, having followed a professional or technological track (vocational courses) reduces the probability of success in higher education compared to having followed a general track. Then, obtaining very high honours in the French baccalaureate increases the likelihood of success in the university track, both in terms of graduating and gaining entry to specialized schools. However, it has no significant effect on the probability of success in preparatory classes. Coming from a low-income neighbourhood negatively affects the probability of graduating from university, though this effect is not significant. Conversely, receiving a scholarship increases the probability of graduating from university but has no significant effect on the probability of passing the competitive exams for specialized schools. Next, one might expect the probability of graduating from university to be influenced by the size of the city in which one attended high school. The reasoning is that larger cities may offer better opportunities to stay in the same city for university, thus increasing the probability of graduating. However, evidence suggests that the size of the city in which one attended high school has a positive but insignificant effect on the probability of completing the first period of university. Finally, the level of education of the parents affects the probability of passing the exam in the preparatory class, but the effect is marginal.

For the choice equation (cf. equation 4), the results must be interpreted as a comparison with the baseline option, which is the outside option. First, it can be seen that higher expected wages after obtaining a bachelor's degree at university increases the probability of choosing the bachelor's degree track at university, although this effect remains insignificant at the 10% level. In contrast, higher expected wages after graduating from a specialized school significantly reduces the probability of enrolling in university immediately after high school. Moreover, the decision to pursue a bachelor's degree at university is not influenced by expected wages after a master's degree at university. In the same line, the probability of finding a job after a specialized school significantly reduces the probability of following the bachelor's degree track at university. The expected probabilities of finding a job in other tracks do not have a significant effect on the decision to follow the bachelor's degree track. The results then emphasize that higher expected wages after a bachelor's degree significantly increases the likelihood of pursuing a master's degree, while surprisingly, expected wages after a master's degree decrease the likelihood of pursuing a master's degree in the university track (the effect is not significant). These surprising results could be explained by the fact that students may perceive it as difficult to obtain a master's degree from a university and therefore place more value on the 'back up' option of not obtaining a master's degree. The expected probabilities of finding a job after all higher education paths, although the coefficients are positive, do not have a significant impact on the decision. Next, column 7 of table 2 suggests that higher expected wages after specialized schools and higher expected wages after master's in university increase the probability of choosing the bachelor's in university and master's in specialized schools tracks. Although the coefficients are not significant, we can see that the sign of the estimates is quite consistent with what we might expect. Indeed, for this track, students have two higher diplomas possible: either a master in university if they did not pass the competitive exam, or a master's in business schools, and students positively value both expected wages when deciding to enrol in this track. Finally, students attending preparatory classes in the first period are sensitive to high expected wages after specialized schools. More precisely, higher expected wages and a higher probability of finding a job after a master's degree in specialized schools significantly increase the probability of attending a preparatory class. Conversely, the expected wages of the outside option and of the university bachelor's path decrease the probability of attending a preparatory class (results significant at the 5% level). In summary, students in preparatory classes are more sensitive to expected wages than students in the university track. In addition, students value the expected wages of the highest diploma more than the expected probability of finding a job when deciding which track to enrol in. While overall, students do not seem to base their decision on the probability of finding a job after higher education, the probability of finding a job after graduating from specialized schools significantly influences the decision to attend a preparatory class. This is consistent with the hypothesis that specialized schools have well-developed alumni networks, which may facilitate job placement. Students appear to consider expected wages when choosing an institution. Nevertheless, expected wages do not fully explain students' choices, which are also driven by their intrinsic preferences.

5.3.1. Gender differences

As noted in the literature review, there are some gender differences in the way students make their educational decisions. Traditional evidence suggests that men are more sensitive to expected wages than women. Conversely, women tend to prioritize their own preferences for a major or type of college when making their high school decisions. I investigate this potential gender gap by running the same structural estimation as before, but on two different subsamples: one for men and one for women. Tables A3 and A4 report the results for the two subsamples[26]. According to the results, women are not at all sensitive to expected wages and, more generally, do not seem to base their choice on expected labour market outcomes. All estimates of expected wages are indeed insignificant at the 10% level. On the other hand, there is evidence that men are more sensitive to expected wages when deciding which educational path to take after leaving high school. Indeed, the probability of men attending a preparatory class increases significantly as the expected wage of a specialized school graduate increases. However, men also do not respond to the expected probability of finding a job regardless of the highest degree obtained. Overall, women seem to base their decisions more on intrinsic preferences than men, and men are slightly more responsive to expected labour market outcomes than women. Nonetheless, the difference remains quite small and the college decision for both men and women remain largely driven by the residuals (e.g. the consumption value of schooling).

[26] For ease of reading, only the expected wage and expected probability of finding a job coefficients are reported, but the same structural estimation was run as for my baseline (i.e. the 5 equations were run simultaneously).

Table 2 ● Results of the structural estimation

	Probability Exam		Probability Graduating		Final Choice			
					University			Preparatory class
	University	Preparatory class	University	Preparatory class	Univ. 3 years	Univ. 5 years	Univ. +BSES	
Gender: women	-0.80***	-0.28*	-0.17*	-553,47	0.83*	0,71	1,65	-9.87***
	(0.22)	(0.16)	(0.09)	-	(0.062)	(0.14)	(1.01)	(2.28)
Track in high school: professional	0.60**	-1.03**	0.03	366.38***	-0,83	-1,05	-	-
	(0.29)	(0.43)	(0.13)	(0.12)	-	-	-	-
Track in high school: technological	-	-0.43	-2.11***	-86,67	-1,56	-1,48	-	-
		(1.03)	(0.23)	-	-	-	-	-
Results in Baccalaureate: with very high honours	19.65***	0.21	37.56***	6610.67	-31,85	-8,05	-6,03	198.11***
	(2.86)	(1.44)	(2.55)	-	-	-	(6.48)	(77.50)
Receive a scholarship	-0.08		-0.39***					
	(0.17)		(0.08)					
Priority neigborhood			-0.13	-8.76	-0,16	-0,01	-1,12	2.90*
			(0.14)	-	(0.65)	(0.79)	(1.99)	(1.52)
Expected wages outside option					0,32	0,58	2,38	-2.68**
					(0.91)	(1.02)	(1.81)	(1.06)
Expected wages bachelor					1,63	1.90*	-3,04	-8.42*
					(1.18)	(1.07)	(3.46)	(4.40)
Expected wages master					0,04	-0,55	1,09	-0,45
					(0.59)	(0.67)	(1.41)	(1.47)
Expected wages BS/ES					1.05*	0,38	1,26	3.14*
					(0.61)	(0.66)	(0.94)	(1.61)
Probability to find a job outside option					-0,69	2,74	-3,12	-4
					(1.95)	(2.08)	(3.59)	(4.37)
Probability to find a job bachelor					2	2,04	-2,4	6,26
					(1.98)	(2.11)	(3.43)	-
Probability to find a job master					0,85	1,51	0,2	-5,91
					(1.31)	(1.18)	(1.77)	(4.53)
Probability to find a job BS/ES					-1.15**	0,17	-0,05	7.27*
					(0.52)	(0.67)	(0.47)	(4.08)
Place of residence during high school	No	No	No	Yes	Yes	Yes	Yes	Yes
Majors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Length of studies of parents	No	Yes	No	No	Yes	Yes	Yes	Yes
Constant	-2.88***	0,03	-1.22***	-485,81	-7,21	-19.54**	-11,38	33,84
	(0.40)	(0.40)	(0.17)	-	(7.71)	(8.47)	(7.58)	-
Number of observations: 2,450								

Note: the reference category corresponds to enter the labour market just after high school. Standard errors are given in parentheses: *** p<0.01, ** p<0.05, * p<0.1. For computational reasons, the dummy variable for receiving a scholarship was not included in the final selection equation.
Source: Céreq, *Enquête Génération* 2013 surveyed at year 3.

6. Simulations

In this section, I present simulations that may be of interest to policy-makers. Specifically, I examine two types of simulations: first, I explore the effect of increasing the probability of passing the university entrance exam in period 1 on students' final decisions. I also analyse the impact of increasing the probability of passing the competitive exam for preparatory classes in period 1. Second, I consider the effect of equalizing the proportion of seats allocated to the university track and the preparatory track in specialized schools. In other words, I examine the consequences on student choice of offering the same number of seats to students coming from the university track and to students attending a preparatory class. This involves simultaneously considering a decrease in the probability of passing the exam if one attends preparatory classes in the first period and an increase in the probability of passing the competitive exam if one attends university in the first period.

6.1. Change in probability of passing the exam

First, thanks to the estimates obtained from the structural estimation, I can recover the theoretical choice of the students (situation 0 in figure 2 represented by the yellow bars) under the assumption of a 0 mean for the stochastic components for all individuals. The total number of observations corresponds to the number of individuals for which I can compute the value function for each path (i.e. 2,450 observations). One can see that the model predicts that the most preferred choice is a master's degree in university, while the second most preferred choice is a bachelor's degree in university. On the contrary, for only a few students, the choice of entering the labour market immediately after high school beats the other paths. The theoretical choice of students is also a way to assess the goodness of fit of the model. It seems that the model is quite good at describing the choice of a master's degree in university, the preparatory class and the master's degree + specialized schools' path, but poor at predicting the Bachelor's in university and the option of entering the labour market directly after high school.

I first consider a change in the probability of passing the exam when attending university in the first period. This initial simulation is of particular interest due to recent development of new paths that allow university students to attend specialized schools in the second period. The results of a 50% increase in the probability of passing the exam when attending university in period 1, while keeping everything else equal, are represented by the orange bars in figure 2 (situation 1). The results show a notable increase in the number of students choosing the University + specialized schools track, with an increase of 9.92%, primarily at the expense of all other tracks, especially university tracks. Specifically, the proportion of students graduating with a bachelor's degree from university decreases by 0.83%, and those with a master's degree decreases by 0.36%. These results are consistent with the hypothesis that making it easier to pass the exam to enter specialized schools while attending university increases the proportion of students opting for this pathway. However, despite the substantial change in the probability of passing the competitive examination, the resulting shifts in student choices remain modest.

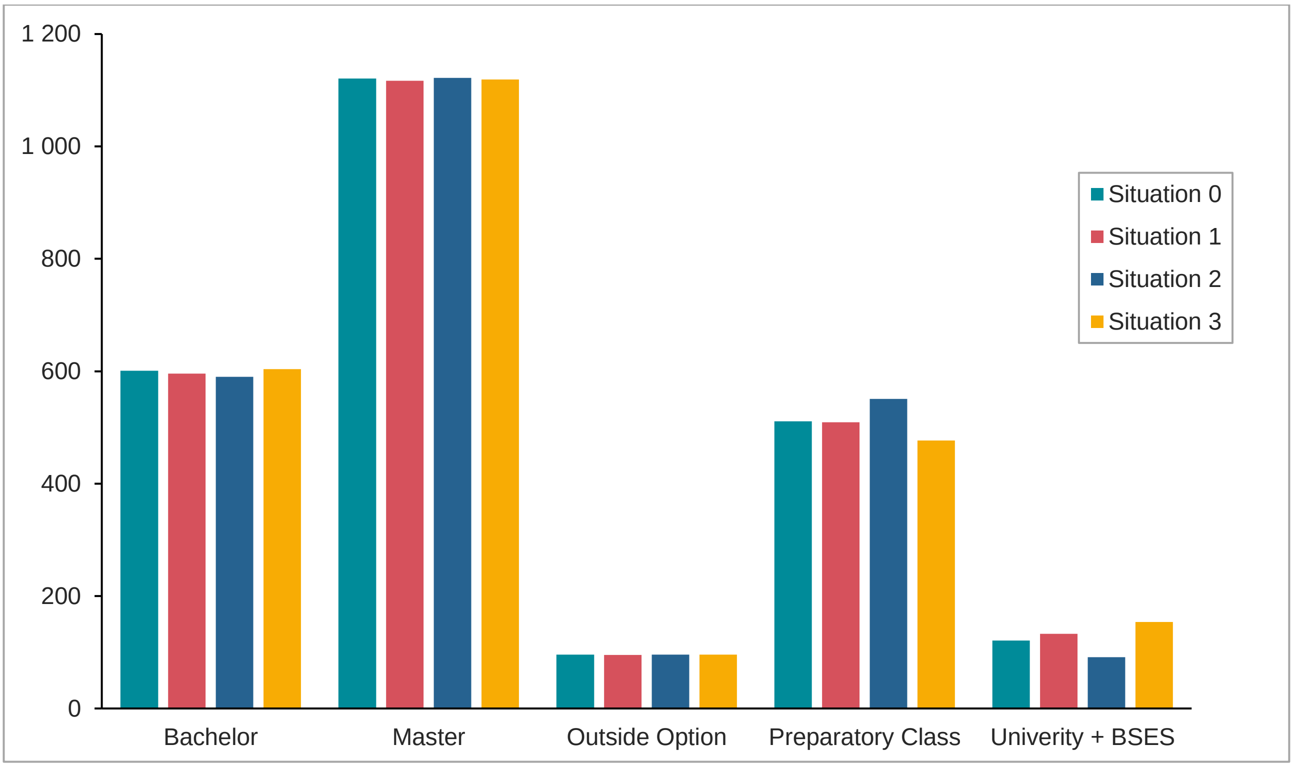
I then consider a change in the probability of passing the exam when attending a preparatory class (again assuming a 50% increase for all students), which should lead to an increase in the proportion of students enrolled in preparatory classes and a decrease in the number of students opting for university tracks. The results depicted by the green bar (situation 2) confirm this intuition, since the proportion of students enrolled in preparatory classes will increase significantly if it is easier to pass the competitive exam after a preparatory class (+7.83%). On the other hand, the proportion of students opting for the university track will fall sharply, especially for the bachelor's degree at university and the master's degree at specialized schools (-24.79%), while the other two university tracks show less variation. The share of those entering the labour market directly after high school does not change. Overall, the variation that occurs following a change in the probability of passing the exam appears to be more significant when modifying the probability of passing the competitive exam for students who attended a preparatory class. This suggests that individuals are more responsive to changes in the probability of passing the exam after completing a preparatory class when making decisions about which track to pursue after high school.

6.2. Change in the number of seats allocated to each path

Next, I focus on the change in the number of seats allocated to each option in the first period. From the data, it is possible to obtain the proportion of students graduating from specialized schools after a preparatory class and the proportion of students graduating from specialized schools after a bachelor's degree at university. There are two ways to calculate this proportion: either based on the sample or based on the theoretical choice of the students (situation 0). But first, one should find the proportion of students in path CP who graduate from specialized schools in period 2. According to the sample, a total of 1185 students enter and complete preparatory classes in period 1, but only 447 graduates from specialized schools, so only 37.73% of students who enter a preparatory class go to specialized schools in period 2. Therefore, starting from the baseline situation (situation 0) and applying the same distribution between university and specialized schools for preparatory class students as in the sample (i.e. 37.73% reach specialized schools in the second period), I find that 314 students graduate from specialized schools (coming from both university and preparatory class students) and 61% of these students come from preparatory classes. I now assume a policy of allocating the same number of seats to both tracks: i.e. the number of students entering *Grandes Écoles* through the university is exactly the same as the number of students entering *Grandes Écoles* through preparatory classes (157 seats for each track). This represents a decrease of about 19% in the number of seats allocated to preparatory classes and an increase of 29% in the number of places allocated to university, i.e. a decrease of 19% in the probability of passing the exam if one attends preparatory classes and an increase of 29% in the probability of passing the exam if one attends university. The results, illustrated by the blue bars in figure 2, show that the share of students taking a preparatory course will decrease (-6.65%) and, on the contrary, the number of students choosing the master's degree in University and the University + BS/ES path will increase significantly (+27.27%). One can note that not only the proportion of students graduating from specialized schools after a bachelor's degree in university will increase, but also the proportion of students graduating from both bachelor's degrees in university (+0.5%).

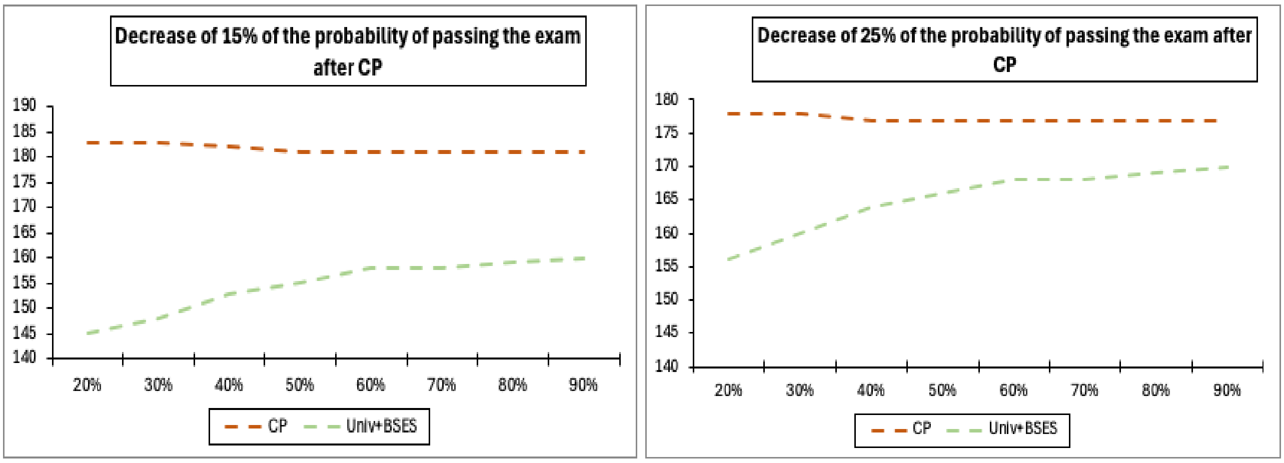
Lastly, considering a decrease in the share of the number of seats reserved for preparatory class students, one may be interested to see the increase in the probability of passing the university exam that is necessary to maintain the same number of students by promotion. I consider three policies: one that reduces the share of seats reserved for preparatory class students in specialized schools by 15%, one that reduces this probability by 25%, and a last one that reduces it by 30%. For these three policies, I am interested in finding how much the probability of passing the university entrance exam for specialized schools should be increased to maintain the same number of seats in these schools. The graphs in figure 3 depict the evolution of the number of seats for different increases in the probability of passing the university entrance exam for the three policies. The results indicate that increasing the probability of passing the exam after obtaining a bachelor's degree at university by 90% is insufficient to achieve equal proportions of students from both tracks in specialized schools when the probability of passing the exam after a preparatory class is reduced by 15% or 25%. However, if the probability of passing the exam after a preparatory class is reduced by 30%, the government would need to increase the probability of passing the exam after a bachelor's degree by 50% to achieve exactly the same proportion of students from both backgrounds.

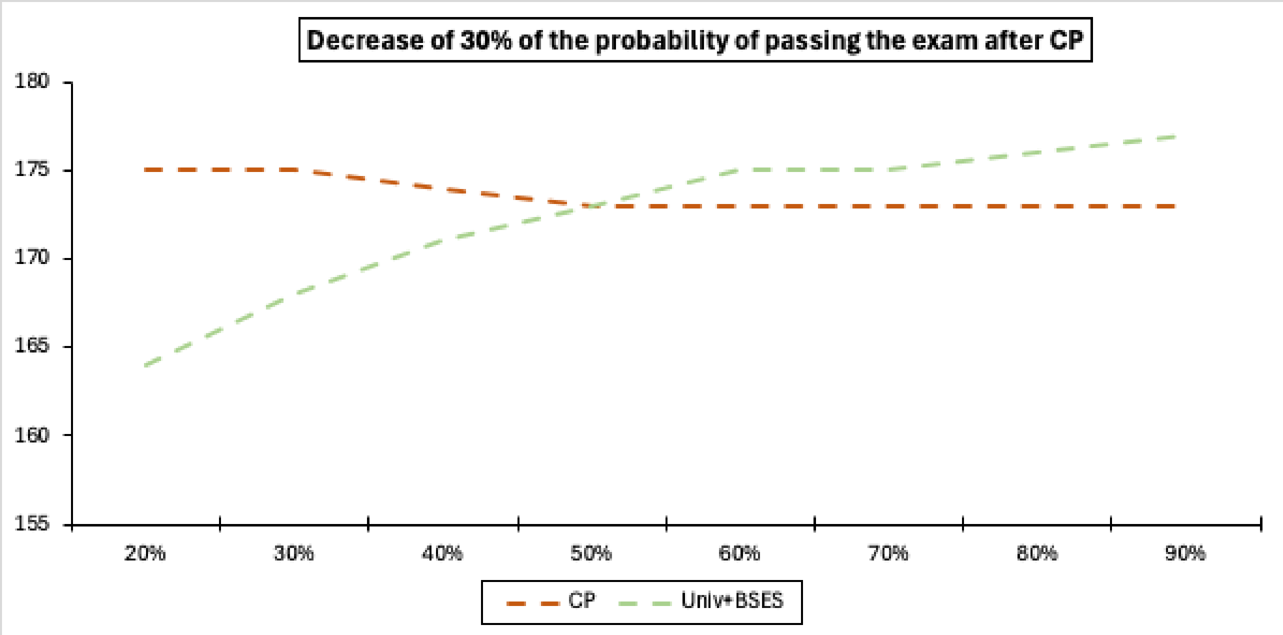
Figure 2 • Simulation results



Note: situation 0 corresponds to the baseline situation; situation 1 is the situation in which the probability of passing the exam increases when attending university track; situation 2 refers to the situation in which the probability of passing the exam increases when attending preparatory classes; situation 3 depicts the situation in which the same number of seats are allocated to both tracks. The figures represent the number of students who choose each path according to the situation considered.
Source: Céreq, *Enquête Génération* 2013 surveyed at year 3.

Figure 3 • Evolution of the probability of passing the university exam required after reducing the probability of passing the exam after a preparatory class by X% to maintain the same number of students per promotion for the BSES pathway.





Note: the orange line corresponds to the evolution of the number of students choosing to take a preparatory class and the green line corresponds to the number of students choosing the path bachelor in university + specialized schools.
Source: Céreq, *Enquête Génération* 2013 surveyed at year 3.

In addition to democratizing access to the *Grandes Écoles*, these policies can also affect the public budget devoted to higher education. Indeed, as mentioned in the introduction, a student in a preparatory class is more costly for the state than a student following a university track. But a preparatory class usually lasts 2 years, while a bachelor in university lasts 3 years, and once in specialized schools, the tuition fees are paid by the students themselves. Thus, one can quantify the impact of such a policy on government spending by assuming that a student in a preparatory class costs the government 15,500 euros per year and that a student in a university costs the state 10,000 euros per year. Since these policies also affect the other two university tracks, it is also necessary to consider the evolution of the number of students enrolled in these tracks (assuming that the cost per year of a student enrolled in a master's and a bachelor's degree at university is the same). The results are provided in table 3 and show that facilitating access to the *Grandes Écoles* for students with a university background reduces the cost to the state because more students will attend university in the first period. In fact, compared to the baseline situation, achieving the objective of equalizing the number of seats in specialized schools for students attending preparatory classes and for students with a university background leads to a decrease of 0.93% in government costs. Furthermore, given that the preparatory course lasts two years and the Bachelor's course at the University lasts three years, it is insightful to compare the costs to the government in the first period for students who graduate from specialized schools. In the baseline situation, the proportion of the government's cost dedicated to preparatory classes in the total cost of students graduating from *Grandes Écoles* is approximately 63%. However, in the situation where the number of seats in *Grandes Écoles* is equalized for both paths, this proportion decreases to about 52% (cf. table 4).

Table 3 • Costs to the government

	Baseline situation	$\gamma_{U_1} = \gamma_{U_1} \times 1.75$ and $\gamma_{CP} = \gamma_{CP} \times 0.85$	$\gamma_{U_1} = \gamma_{U_1} \times 1.7$ and $\gamma_{CP} = \gamma_{CP} \times 0.75$	$\gamma_{U_1} = \gamma_{U_1} \times 1.5$ and $\gamma_{CP} = \gamma_{CP} \times 0.7$
Outside option	96	95	95	95
Bachelor's degree	**601**	600	600	605
Master's degree	1 121	1 117	1 118	1 118
Univerity + BSES	121	158	168	173
Total number following university track	1 843	1 875	1 886	1 896
Preparatory class	511	480	469	460
Total	2 450	2 450	2 450	2 451
Number ending in uni. after prep. class	317	298	291	285
Cost university	77 710 000 €	78 590 000 €	78 940 000 €	79 240 000 €
Cost preparatory class	24 834 600 €	23 328 000 €	22 793 400 €	22 356 000 €
Total cost	102 544 600 €	101 918 000 €	101 733 400 €	101 596 000 €

Note: γ_k represents the probability of passing the exam after track k (either preparatory class or university's bachelor).
Source: Céreq, *Enquête Génération* 2013 surveyed at year 3.

Table 4 • First period cost for students graduating from specialized schools

	Baseline situation	$\gamma_{U_1} = \gamma_{U_1} \times 1.5$ *and* $\gamma_{CP} = \gamma_{CP} \times 0.7$
Bachelor + BSES	121	173
Preparatory class + BSES	194	175
Total cost university	3 630 000 €	5 190 000 €
Total cost preparatory class	6 019 580 €	5 418 800 €
Total cost	9 649 580 €	10 608 800 €

Note: γ_k represents the probability of passing the exam after track k (either preparatory class or university's bachelor).
Source: Céreq, *Enquête Génération* 2013 surveyed at year 3.

Conclusion

This paper presents a theoretical model and an empirical estimation of the choice of students of which type of school to attend after high school in France. The theoretical model is flexible, incorporating both non-pecuniary and monetary elements into the students' value function. Using a structural estimation, this paper estimates the impact of expected wages, the probability of graduating, the probability of passing the exam and the probability of finding a job on the schooling decision of students. Overall, students' decisions are influenced by both future labour market outcomes and their individual preferences, aligning with recent literature on students' choice of major. The probabilities of graduating and passing the exam are significantly influenced by students' educational backgrounds. However, the null hypothesis that these probabilities do not significantly affect the final decision cannot be rejected based on the analysis.

The model also opens for ex-ante simulations which, I believe, are useful for policy-makers. Increasing the probability of passing the competitive examination for university students increases the number of students enrolling in track: university in the first period and specialized school in the second period, while the share of students attending preparatory classes decreases. In addition, the increase in the probability of passing the exam when taking preparatory class raises the number of students enrolling in preparatory class in the first period to the detriment of the path bachelor's degree at university followed by a master's degree at specialized schools. Finally, when the same number of seats in specialized schools are allocated to students coming from university and to students coming from preparatory classes, the number of students following both the university + specialized school and the university bachelor's courses increase to the detriment of the number of students taking a preparatory class.

However, there are both theoretical and empirical limitations to this paper. First, from a theoretical perspective, some assumptions are questionable. For instance, in order to reduce the dimensionality of unobserved heterogeneity, I assume that the probability of graduation depends only on observables, but the latter is also likely to be a function of the unobserved part of ability (as the probability of passing the exam). It would have been wise to include it as another component of the capacity to pass the exam in the final decision of the students, but this would have made the model more complex and the estimation more computationally intensive. In the same line, for the purpose of keeping the dimensionality of the problem manageable, the unobserved intrinsic preferences for a particular type of school have been introduced only in period 1, but one can also introduce this preference in period 2 between master in university and specialized schools. Another interesting element that I omit from the analysis is the possibility of updating beliefs in each period. The updated beliefs could be about the probability of finding a job, but also about the probability of graduating or passing the exam, but one should therefore get rid of the assumption that the probability of completing the second period is one (Arcidiacono, 2004). From an empirical point of view, it is also possible to question some of the assumptions made about the path of choice and the probabilities of success. The assumption that every student takes the exam at university is unrealistic but is constrained by the data. One needs information on the complete path of students after high school to obtain more reliable results, in particular it is important to know who takes the competitive exam and who actually passes it. In addition, one may be interested in introducing non-pecuniary elements into the expected labour market outcomes of individuals, such as job satisfaction. I could not do this in this paper because the *Enquête Emploi* database does not ask respondents questions about job satisfaction. In the same vein, the *Enquête Emploi* database does not provide detailed information on the educational background of individuals, so I am not able to identify who actually attends a preparatory class. Consequently, I have implicitly assumed that there is no preparatory class premium in wages, i.e. graduates from specialized schools have on average same expected wages regardless of their choice in the first period (conditional on observables). Furthermore, the exclusion restriction variables for identifying the probabilities of graduating and passing the exam are quite poor and do not allow me to clearly identify which probabilities have a significant effect on the final choice of students, so better proxies are needed. For example, whether the exam location is in the same department as the preparatory class of the student can be used to identify the probability of passing the exam after a preparatory class, since students who take the exam in the same area as their preparatory class may perform better on the day of the exam. In addition, one may be interested in entering the black box of intrinsic preferences, but this requires a very detailed survey of the motivations underlying the choice of students (e.g. reputation/quality of the school, class size, school budget, distance to college, etc.). This can also be useful for conducting simulations, as one can investigate how students react when some elements of their intrinsic preferences are changed. This is of particular interest to the schools themselves, as it enables them to adapt their offer to attract students, just as in the development of new courses and pathways at university.

Finally, the simulations could have been conducted differently. Instead of assuming a zero mean for the distribution of stochastic components to recover student choices, one could have computed the probabilities predicted by the model for each pathway and then summed these probabilities to estimate the predicted number of students in each track. For instance, if the model predicts that two students each have a 50% probability of enrolling in a preparatory class, then it suggests that one student will enrol in a preparatory class. This approach avoids the assumption that stochastic elements are distributed with a zero mean. In the same line, the cost analysis proposed in the last section is very simple and does not aim at capturing general effects. Two possible extensions are worth emphasizing for further research. First it would have been interesting to introduce tuition fees in the final decision of agents. An extensive literature studied the effect of debt and loans on jobs, wages and length of studies. The main findings are that individuals in debt are more likely to start working earlier, to hold jobs with higher wages and to work more in the private sector (Rothstein & Rouse, 2011; Luo & Mongey, 2019; Chapman, 2015; Field, 2009). In addition, some papers have examined the importance of tuition fees on students' college decisions, showing that higher tuition fees may be negatively correlated with students' choices (Long, 2004; Skinner, 2019). In the French context, it is relevant as students graduating from business or engineering schools are likely to take a loan to finance their studies, which should be repaid once in the labour market. The *Enquête Génération* database does not provide direct measures of the effect of potential tuition fees on students' final decisions. One approach to address this limitation is to use proxies such as whether students worked during their studies or if they had to repay a loan during their initial years in the labour market. From a theoretical perspective, there are two ways to consider the impact of tuition fees. One approach is to incorporate tuition fees directly into future labour market outcomes. This reflects the idea that students typically finance specialized schools through loans, which can be viewed as reducing their expected future wages. In this case, only the formula for labour market outcomes needs to be adjusted to account for this financial burden. Alternatively, tuition fees can be directly integrated into students' utility considerations during their schooling decisions. This approach treats tuition fees akin to the psychological cost associated with taking an exam at university, influencing students' overall utility calculations. This second option has the advantage to separately estimate the effect of tuition fees on the final decision of students. For instance, if K is the cost of attending a business or engineering school, the value function of the path CP can be written as follows:

$$\mathcal{V}_{CP} = \beta\alpha_{CP} + \beta^3 p_{CP}\left[\gamma_{CP}\left[\mathcal{V}_{\{\mathrm{LM},B,2\}} - K\right] + (1-\gamma_{CP})\left[\mathcal{V}_{\{\mathrm{LM},U_2,2\}}\right]\right] + \beta^2(1-p_{CP})\mathcal{V}_{\{\mathrm{LM},O,1\}}$$

Another extension could be to take into account the impact of the quality of the institution in the choice of students to attend preparatory classes or university. Indeed, it is likely that the quality of the institution is one of the crucial elements in the final choice, while the latter may be related to future labour market flows. Scholars have shown that there is a premium in enrolling in higher education. In particular, students who graduate from elite institutions[27] earn higher wages and have better labour market outcomes (Sekhri, 2020; Anelli, 2016; Brewer *et al.*, 1999). The data do not provide an explicit measure of the quality of institutions, nor do they provide information on the actual school that students attend. However, there is a possible proxy for quality, which is a dummy variable indicating whether students graduate from a *Grandes Écoles* or not. It is generally accepted that *Grandes Écoles* are elite schools and therefore of high quality. This proxy is interesting but has some limitations: firstly, it only allows one to proxy the quality of some specialized schools (as the term *Grandes Écoles* mainly covers business and engineering schools), so one has to restrict the analysis to students graduating from specialized schools (i.e. the data does not provide a proxy for the quality of universities). Secondly, this proxy is only valid for second period colleges and cannot proxy the first period schools (i.e. preparatory classes and universities).

[27] In my context, this can refer to top business and engineering schools.

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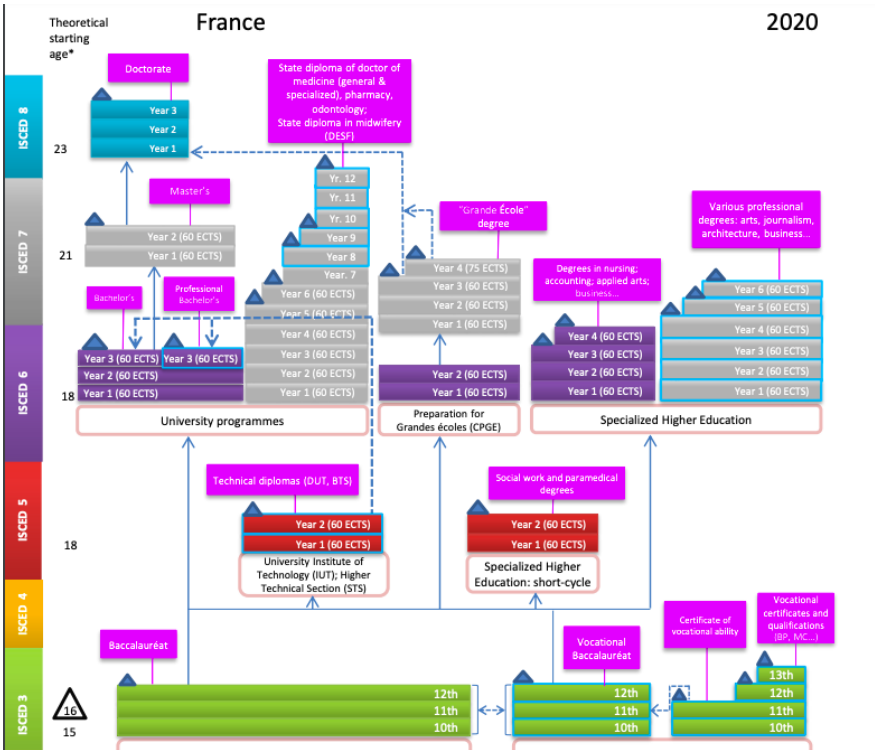
Appendix

Figure A1 ● Descriptive paths of French higher education system[28]



Source: OECD, 2023. Master's degree.

A.1. Value functions

This paragraph describes the value function not presented in the core text. The outside option corresponds simply to the discounted expected utility when entering the labour market, thus to equation 1. All the other options are a combination of labour market outcome graduating from school k and labour market outcome of the outside option if one does not graduate. The complete value function of a student who graduates from university in period 1 and goes on to obtain a master's degree at university (i.e. path U_1/U_2) is:

$$\mathcal{V}_{U_1/U_2} = \beta\alpha_{U_1} + \beta^3 \times p_{U_1} \times [\sum_{l=0}^{40}(1-\lambda_{U_2})^l \lambda_{U_2}^{\mathbf{1}(l<40)} [\mathbf{1}_{(l>0)} b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \mathbf{E}[w_t|U_2]]] + \beta^2 \times (1 - p_{U_1}) \times [\sum_{l=0}^{40}(1-\lambda_O)^l \lambda_O^{\mathbf{1}(l<40)} [\mathbf{1}_{(l>0)} b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \mathbf{E}[w_t|O]]]$$

The value function of the path U_1/O is given by:

$$\mathcal{V}_{U_1/O} = \beta\alpha_{U_1} + \beta^2 p_{U_1} \times [\sum_{l=0}^{40}(1-\lambda_{U_1})^l \lambda_{U_1}^{\mathbf{1}(l<40)} [\mathbf{1}_{(l>0)} b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \mathbf{E}[w_t|U_1]]] + \beta^2 (1 - p_{U_1}) \times [\sum_{l=0}^{40}(1-\lambda_O)^l \lambda_O^{\mathbf{1}(l<40)} [\mathbf{1}_{(l>0)} b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \mathbf{E}[w_t|O]]]$$

[28] Source: https://gpseducation.oecd.org/CountryProfile?primaryCountry=FRA&treshold=10&topic=EO.

The value function of path U_1/B is:

$$\mathcal{V}_{U_1/B} = \beta\alpha_{U_1} + \beta^3 p_{U_1} \times [(1 - \Phi(\hat{N}_{U_1} - \int_{\underline{n}_{U_1}}^{\bar{n}_{U_1}} n_{U_1} f(n_{U_1}) dn_{U_1}) - C) \times [\sum_{l=0}^{40} (1-\lambda_B)^l \lambda_B^{\mathbf{1}(l<40)} [\mathbf{1}_{(l>0)} b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \mathbf{E}[w_t|B]]] + (\Phi(\hat{N}_{U_1} - \int_{\underline{n}_{U_1}}^{\bar{n}_{U_1}} n_{U_1} f(n_{U_1}) dn_{U_1}) - C) \times \sum_{l=0}^{40} (1-\lambda_{U_2})^l \lambda_{U_2}^{\mathbf{1}(l<40)} [\mathbf{1}_{(l>0)} b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \mathbf{E}[w_t|U_2]]] + \beta^2 (1 - p_{U_1}) \times [\sum_{l=0}^{40} (1-\lambda_O)^l \lambda_O^{\mathbf{1}(l<40)} [\mathbf{1}_{(l>0)} b \sum_{j=1}^{l} \beta^j + \mathbf{1}_{(l<40)} \sum_{t=l+1}^{40} \beta^t \mathbf{E}[w_t|O]]]$$

A.2. Mathematical derivations

Details of Computation for covariance matrix of Σ'':

First, one can notice that the contribution of path CP can be decomposed into four terms. I use μ_i'' to denote the lower bound of each term. The distribution of these latter should be clearly expressed. More precisely, I make the following notations:

$$\nu_1'' = -\beta\alpha_{CP} + \beta^3 p_{CP}\epsilon_{CP}(\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}) \sim N(0, \beta^2\sigma_{\alpha_{CP}}^2 + (\beta^3 p_{CP})^2 [\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}]^2 \sigma_{\epsilon_{CP}}^2 - 2\beta\beta^3 p_{CP} [\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}] \sigma_{\alpha_{CP},\epsilon_{CP}})$$

$$\nu_2'' = \beta(\alpha_{U_1} - \alpha_{CP}) + (p_{U_1}\epsilon_{U_1} - \beta^3 p_{CP}\epsilon_{CP}) [\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}] \sim N(0, \beta^2[\sigma_{\alpha_{U_1}}^2 + \sigma_{\alpha_{CP}}^2 - 2\sigma_{\alpha_{U_1},\alpha_{CP}}] + [\beta^3[\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}]]^2 [p_{U_1}^2\sigma_{\epsilon_{U_1}}^2 + p_{CP}^2\sigma_{\epsilon_{CP}}^2 - 2p_{CP}p_{U_1}\sigma_{\epsilon_{U_1},\epsilon_{CP}}] + 2\beta\beta^3 [\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}] [p_{U_1}\sigma_{\alpha_{U_1},\epsilon_{U_1}} + p_{CP}\sigma_{\alpha_{CP},\epsilon_{CP}}]) + [p_{U_1}C]^2 \sigma_{\epsilon_{U_1}}^2 - 2[\beta p_{U_1} C \sigma_{\alpha_{U_1},\epsilon_{U_1}} + \beta^3 p_{U_1}^2 C [\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}] \sigma_{\epsilon_{U_1}} - \beta^3 p_{CP} p_{U_1} C [\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}] \sigma_{\epsilon_{CP},\epsilon_{U_1}}])$$

$$\nu_3'' = \beta(\alpha_{U_1} - \alpha_{CP}) + \beta^3 p_{CP}\epsilon_{CP} [\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}] \sim N(0, \beta^2\sigma_{\alpha_{U_1}}^2 + \beta^2\sigma_{\alpha_{CP}}^2 - 2\beta^2\sigma_{\alpha_{U_1},\alpha_{CP}} + (\beta^3 p_{CP})^2 [\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}]^2 \sigma_{\epsilon_{CP}}^2 - 2\beta\beta^3 p_{CP} [\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}] \sigma_{\alpha_{CP},\epsilon_{CP}})$$

$$\nu_4'' = \beta(\alpha_{U_1} - \alpha_{CP}) + \beta^3 p_{CP}\epsilon_{CP} [\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}] \sim N(0, \beta^2\sigma_{\alpha_{U_1}}^2 + \beta^2\sigma_{\alpha_{CP}}^2 - 2\beta^2\sigma_{\alpha_{U_1},\alpha_{CP}} + (\beta^3 p_{CP})^2 [\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}]^2 \sigma_{\epsilon_{CP}}^2 - 2\beta\beta^3 p_{CP} [\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}] \sigma_{\alpha_{CP},\epsilon_{CP}})$$

I only explicit the computation for the variance of ν_2'', but the computation of the other variance is similar.

The variance of ν_2'' is determined as follows:

$$\mathrm{Var}(\nu_2'') = \mathrm{Var}(\beta(\alpha_{U_1} - \alpha_{CP}) + (p_{U_1}\epsilon_{U_1} - p_{CP}\epsilon_{CP}) [\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}] - p_{U_1}\epsilon_{U_1} C)$$

It can be decomposed into three terms:

$$\alpha_{U_1} - \alpha_{CP} \sim N\left(0, \sigma_{\alpha_{U_1}}^2 + \sigma_{\alpha_{CP}}^2 - 2\sigma_{\alpha_{U_1},\alpha_{CP}}\right) \text{ (a)}$$
$$p_{U_1}\epsilon_{U_1} - p_{CP}\epsilon_{CP} \sim N(0, p_{U_1}^2\sigma_{\epsilon_{U_1}}^2 + p_{CP}^2\sigma_{\epsilon_{CP}}^2 - 2p_{CP}p_{U_1}\sigma_{\epsilon_{U_1},\epsilon_{CP}}) \text{ (b)}$$

Then as a sum of two normal distributions, (a) + (b) is also a normal distribution and can be expressed as follows:

$$(a)+(b)\ \sim N(0,\beta^2\mathrm{Var}(a)+[\mathcal{V}_{\{\mathrm{LM},B,2\}}-\mathcal{V}_{\{\mathrm{LM},U_2,2\}}]^2\mathrm{Var}(b)\ +\beta[\mathcal{V}_{\{\mathrm{LM},B,2\}}-\mathcal{V}_{\{\mathrm{LM},U_2,2\}}]\mathrm{Cov}(a,b))$$

with: $Cov(a,b)=\mathrm{Cov}(\alpha_{U_1}-\alpha_{CP},p_{U_1}\epsilon_{U_1}-p_{CP}\epsilon_{CP})=p_{U_1}\sigma_{\alpha_{U_1},\epsilon_{U_1}}+p_{CP}\sigma_{\alpha_{CP},\epsilon_{CP}}$.

Thus:

$$v''_2\ =(a)+(b)\sim N(0,\beta^2[\sigma^2_{\alpha_{U_1}}+\sigma^2_{\alpha_{CP}}-2\sigma_{\alpha_{U_1},\alpha_{CP}}]+[\mathcal{V}_{\{\mathrm{LM},B,2\}}-\mathcal{V}_{\{\mathrm{LM},U_2,2\}}]^2[p^2_{U_1}\sigma^2_{\epsilon_{U_1}}+p^2_{CP}\sigma^2_{\epsilon_{CP}}$$
$$-2p_{CP}p_{U_1}\sigma_{\epsilon_{U_1},\epsilon_{CP}}]+2\beta[\mathcal{V}_{\{\mathrm{LM},B,2\}}-\mathcal{V}_{\{\mathrm{LM},U_2,2\}}][p_{U_1}\sigma_{\alpha_{U_1},\epsilon_{U_1}}+p_{CP}\sigma_{\alpha_{CP},\epsilon_{CP}}])$$

The last step is to determine the covariance between the $\boldsymbol{v''_i}$. The covariances are given by the expressions below:

$$\mathbf{Cov}(\boldsymbol{v''_1},\boldsymbol{v''_2})\ =-\boldsymbol{\beta}^2\boldsymbol{\sigma}_{\alpha_{CP},\alpha_{U_1}}+\boldsymbol{\beta}^2\boldsymbol{\sigma}^2_{\alpha_{CP}}+\boldsymbol{\beta p}_{CP}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}]\boldsymbol{\sigma}_{\alpha_{CP},\epsilon_{CP}}+\boldsymbol{\beta p}_{CP}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}]\boldsymbol{\sigma}_{\alpha_{CP},\epsilon_{CP}}$$
$$-\boldsymbol{p}^2_{CP}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}]\ [\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}]\boldsymbol{\sigma}^2_{\epsilon_{CP}}$$
$$\mathbf{Cov}(\boldsymbol{v''_1},\boldsymbol{v''_3})\ =\mathbf{Cov}(\boldsymbol{v''_1},\boldsymbol{v''_4})$$
$$=-\boldsymbol{\beta}^2\boldsymbol{\sigma}_{\alpha_{CP},\alpha_{U_1}}+\boldsymbol{\beta}^2\boldsymbol{\sigma}^2_{\alpha_{CP}}-\boldsymbol{\beta p}_{CP}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}]\boldsymbol{\sigma}_{\epsilon_{CP},\alpha_{CP}}+\boldsymbol{p}^2_{CP}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}]^2\boldsymbol{\sigma}^2_{\epsilon_{CP}}$$
$$\mathbf{Cov}(\boldsymbol{v_2}'',\boldsymbol{v''_3})\ =\mathbf{Cov}(\boldsymbol{v''_2},\boldsymbol{v''_4})$$
$$=\boldsymbol{\beta}^2\boldsymbol{\sigma}^2_{\alpha_{U_1}}-2\boldsymbol{\beta}^2\boldsymbol{\sigma}_{\alpha_{U_1},\alpha_{CP}}-\boldsymbol{\beta p}_{CP}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}]\boldsymbol{\sigma}_{\alpha_{CP},\epsilon_{CP}}\ +\boldsymbol{\beta p}_{U_1}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}$$
$$-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}]\boldsymbol{\sigma}_{\epsilon_{U_1},\alpha_{U_1}}+\boldsymbol{p}_{U_1}\boldsymbol{p}_{CP}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}]\ [\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}]\boldsymbol{\sigma}_{\epsilon_{U_1},\epsilon_{CP}}$$
$$+\boldsymbol{p}_{CP}\boldsymbol{\beta}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}]\boldsymbol{\sigma}_{\alpha_{CP},\epsilon_{CP}}\ -\boldsymbol{p}^2_{CP}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}][\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}]\boldsymbol{\sigma}^2_{\epsilon_{CP}}$$
$$\mathbf{Cov}(\boldsymbol{v_3}'',\boldsymbol{v''_4})\ =\mathbf{Var}(\boldsymbol{v''_4})$$
$$=\boldsymbol{\beta}^2\boldsymbol{\sigma}^2_{\alpha_{U_1}}+\boldsymbol{\beta}^2\boldsymbol{\sigma}^2_{\alpha_{CP}}-2\boldsymbol{\beta}^2\boldsymbol{\sigma}_{\alpha_{U_1},\alpha_{CP}}+\boldsymbol{p}^2_{CP}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}]^2\boldsymbol{\sigma}^2_{\epsilon_{CP}}\ -2\boldsymbol{\beta p}_{CP}[\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}$$
$$-\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}]\boldsymbol{\sigma}_{\alpha_{CP},\epsilon_{CP}}$$

Finally one has the following covariance matrix for h: $\boldsymbol{\Sigma}''=\begin{bmatrix}\boldsymbol{M}_1 & \boldsymbol{M}_2 & \boldsymbol{M}_3 & \boldsymbol{M}_3\\ \boldsymbol{M}_2 & \boldsymbol{M}_4 & \boldsymbol{M}_5 & \boldsymbol{M}_5\\ \boldsymbol{M}_3 & \boldsymbol{M}_5 & \boldsymbol{M}_6 & \boldsymbol{M}_6\\ \boldsymbol{M}_3 & \boldsymbol{M}_5 & \boldsymbol{M}_6 & \boldsymbol{M}_6\end{bmatrix}$

With:

- $\boldsymbol{M}_1=\mathbf{Var}(\boldsymbol{v''_1})$
- $\boldsymbol{M}_2=\mathbf{Cov}(\boldsymbol{v''_1},\boldsymbol{v''_2})$
- $\boldsymbol{M}_3=\mathbf{Cov}(\boldsymbol{v''_1},\boldsymbol{v''_3})=\mathbf{Cov}(\boldsymbol{v''_1},\boldsymbol{v''_4})$
- $\boldsymbol{M}_4=\mathbf{Var}(\boldsymbol{v''_2})$
- $\boldsymbol{M}_5=\mathbf{Cov}(\boldsymbol{v''_2},\boldsymbol{v''_3})=\mathbf{Cov}(\boldsymbol{v''_2},\boldsymbol{v''_4})$
- $\boldsymbol{M}_6=\mathbf{Var}(\boldsymbol{v''_3})=\mathbf{Var}(\boldsymbol{v''_4})=\mathbf{Cov}(\boldsymbol{v''_3},\boldsymbol{v''_4})$

A.3. Contribution of each path

This paragraph aims to derive the contribution of each path to the likelihood function (the contribution of path *CP* has been written in the core text and proving in the previous appendix). The procedure to follow is exactly the same: first write the probability that a path is chosen (that is defeat all other options), then characterize the covariance matrix and the distribution of the unobserved heterogeneity and finally express the complete probability that the path is chosen.

The probability that the path $\mathrm{U_1/O}$ is chosen by individual *i* is given by:

$$\boldsymbol{Pr}[\mathrm{Choice}_i=\boldsymbol{U_1/O}]\ =\boldsymbol{Pr}[\boldsymbol{\beta}^2\boldsymbol{p}_{U_1}\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_1,1\}}\geq\boldsymbol{\beta}^3\boldsymbol{p}_{U_1}\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}]\boldsymbol{\beta}^2\cap[\boldsymbol{p}_{U_1}\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_1,1\}}$$
$$\geq\boldsymbol{\beta}^3\boldsymbol{p}_{U_1}[\boldsymbol{\gamma}_{U_1}\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}+(\mathbf{1}-\boldsymbol{\gamma}_{U_1})\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}]]\cap[\boldsymbol{\beta\alpha}_{U_1}+\boldsymbol{\beta}^2\boldsymbol{p}_{U_1}\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_1,1\}}+\boldsymbol{\beta}^2(\mathbf{1}-\boldsymbol{p}_{U_1})\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},O,1\}}$$
$$\geq\boldsymbol{\beta\alpha}_{CP}\ +\boldsymbol{\beta}^3\boldsymbol{p}_{CP}[\boldsymbol{\gamma}_{CP}\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}+(\mathbf{1}-\boldsymbol{\gamma}_{CP})\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}]+\boldsymbol{\beta}^2(\mathbf{1}-\boldsymbol{p}_{CP})\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},O,1\}}]$$
$$+\boldsymbol{\beta}^3\boldsymbol{p}_{CP}[\boldsymbol{\gamma}_{CP}\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},B,2\}}+(\mathbf{1}-\boldsymbol{\gamma}_{CP})\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_2,2\}}]+\boldsymbol{\beta}^2(\mathbf{1}-\boldsymbol{p}_{CP})\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},O,1\}}]\cap[\boldsymbol{\beta\alpha}_{U_1}+\boldsymbol{p}_{U_1}\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},U_1,1\}}$$
$$+(\mathbf{1}-\boldsymbol{p}_{U_1})\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},O,1\}}\geq\boldsymbol{\mathcal{V}}_{\{\mathrm{LM},O,0\}}]$$

$$\begin{aligned}\boldsymbol{Pr}[\text{Choice}_i = \boldsymbol{U_1/O}] = \boldsymbol{Pr}[[&\boldsymbol{p_{U_1}}[\boldsymbol{\beta^2}\mathcal{V}_{\{\text{LM},\boldsymbol{U_1},\boldsymbol{1}\}} - \boldsymbol{\beta^3}\mathcal{V}_{\{\text{LM},\boldsymbol{U_2},\boldsymbol{2}\}}] \\ &\geq \boldsymbol{0}] \cap [\boldsymbol{\beta^2}\mathcal{V}_{\{\text{LM},\boldsymbol{U_1},\boldsymbol{1}\}} - \boldsymbol{\beta^3}\mathcal{V}_{\{\text{LM},\boldsymbol{B},\boldsymbol{2}\}}\boldsymbol{\theta_{Z_{U_1}}Z_{U_1}} + \boldsymbol{\beta^3}\mathcal{V}_{\{\text{LM},\boldsymbol{U_2},\boldsymbol{2}\}}(\boldsymbol{\theta_{Z_{U_1}}Z_{U_1}} - \boldsymbol{1}) + \boldsymbol{C} \\ &\geq \boldsymbol{\epsilon_{U_1}\beta^3}[\mathcal{V}_{\{\text{LM},\boldsymbol{B},\boldsymbol{2}\}} - \mathcal{V}_{\{\text{LM},\boldsymbol{U_2},\boldsymbol{2}\}}]] \cap [\boldsymbol{\beta^2 p_{U_1}}\mathcal{V}_{\{\text{LM},\boldsymbol{U_1},\boldsymbol{1}\}} - \boldsymbol{\beta^2}\mathcal{V}_{\{\text{LM},\boldsymbol{O},\boldsymbol{1}\}}(\boldsymbol{p_{CP}} + \boldsymbol{p_{U_1}}) \\ &- \boldsymbol{\beta^3 p_{CP}\theta_{Z_{CP}}Z_{CP}}\mathcal{V}_{\{\text{LM},\boldsymbol{B},\boldsymbol{2}\}} - \boldsymbol{\beta^3}\mathcal{V}_{\{\text{LM},\boldsymbol{U_2},\boldsymbol{2}\}}\boldsymbol{p_{CP}}(\boldsymbol{\theta_{Z_{CP}}Z_{CP}} - \boldsymbol{1}) \\ &\geq \boldsymbol{\beta}(\boldsymbol{\alpha_{CP}} - \boldsymbol{\alpha_{U_1}}) + \boldsymbol{\beta^3 p_{CP}\epsilon_{CP}}[\mathcal{V}_{\{\text{LM},\boldsymbol{B},\boldsymbol{2}\}} - \mathcal{V}_{\{\text{LM},\boldsymbol{U_2},\boldsymbol{2}\}}]] \cap [\boldsymbol{\beta^2 p_{U_1}}[\mathcal{V}_{\{\text{LM},\boldsymbol{U_1},\boldsymbol{1}\}} - \mathcal{V}_{\{\text{LM},\boldsymbol{O},\boldsymbol{1}\}}] \\ &+ \boldsymbol{\beta^2}\mathcal{V}_{\{\text{LM},\boldsymbol{O},\boldsymbol{1}\}} - \boldsymbol{\beta}\mathcal{V}_{\{\text{LM},\boldsymbol{O},\boldsymbol{0}\}} \geq -\boldsymbol{\beta\alpha_{U_1}}]]\end{aligned}$$

One can use the following notations:

$$\begin{aligned}\boldsymbol{\nu_1} &= \boldsymbol{\beta^3\epsilon_{U_1}}[\mathcal{V}_{\text{LM},\boldsymbol{B},\boldsymbol{2}} - \mathcal{V}_{\text{LM},\boldsymbol{U_2},\boldsymbol{2}}] \\ \boldsymbol{\nu_2} &= \boldsymbol{\beta}(\boldsymbol{\alpha_{CP}} - \boldsymbol{\alpha_{U_1}}) + \boldsymbol{\beta^3 p_{CP}\epsilon_{CP}}[\mathcal{V}_{\text{LM},\boldsymbol{B},\boldsymbol{2}} - \mathcal{V}_{\text{LM},\boldsymbol{U_2},\boldsymbol{2}}] \\ \boldsymbol{\nu_3} &= -\boldsymbol{\beta\alpha_{U_1}}\end{aligned}$$

Using the same procedure as before, one can determine the covariance matrix $\boldsymbol{\Sigma}$.

One has therefore: $\boldsymbol{\Sigma} = \begin{bmatrix} \boldsymbol{E_1} & \boldsymbol{E_2} & \boldsymbol{E_3} \\ \boldsymbol{E_2} & \boldsymbol{E_4} & \boldsymbol{E_5} \\ \boldsymbol{E_3} & \boldsymbol{E_5} & \boldsymbol{E_6} \end{bmatrix}$

With:

- $\boldsymbol{E_1} = \mathbf{Var}(\boldsymbol{\nu_1}) = (\boldsymbol{\beta^3})^2\boldsymbol{\sigma^2_{\epsilon_{U_1}}}[\mathcal{V}_{\{\text{LM},\boldsymbol{B},\boldsymbol{2}\}} - \mathcal{V}_{\{\text{LM},\boldsymbol{U_2},\boldsymbol{2}\}}]^2$
- $\boldsymbol{E_2} = \mathbf{Cov}(\boldsymbol{\nu_1}, \boldsymbol{\nu_2}) = -\boldsymbol{\beta^3\beta}[\mathcal{V}_{\{\text{LM},\boldsymbol{B},\boldsymbol{2}\}} - \mathcal{V}_{\{\text{LM},\boldsymbol{U_2},\boldsymbol{2}\}}]\boldsymbol{\sigma_{\epsilon_{U_1},\alpha_{U_1}}}$
- $\boldsymbol{E_3} = \mathbf{Cov}(\boldsymbol{\nu_1}, \boldsymbol{\nu_3}) = -\boldsymbol{\beta^3\beta}[\mathcal{V}_{\{\text{LM},\boldsymbol{B},\boldsymbol{2}\}} - \mathcal{V}_{\{\text{LM},\boldsymbol{U_2},\boldsymbol{2}\}}]\boldsymbol{\sigma_{\epsilon_{U_1},\alpha_{U_1}}}$
- $\boldsymbol{E_4} = \mathbf{Var}(\boldsymbol{\nu_2}) = \boldsymbol{\beta^2}(\boldsymbol{\sigma^2_{\alpha_{CP}}} + \boldsymbol{\sigma^2_{\alpha_{U_1}}} - \boldsymbol{2\sigma_{\alpha_{U_1},\alpha_{CP}}}) + \boldsymbol{\beta^3 p^2_{CP}}[\mathcal{V}_{\{\text{LM},\boldsymbol{B},\boldsymbol{2}\}} - \mathcal{V}_{\{\text{LM},\boldsymbol{U_2},\boldsymbol{2}\}}]^2\boldsymbol{\sigma^2_{\epsilon_{CP}}} + \boldsymbol{2\beta\beta^3 p_{CP}}[\mathcal{V}_{\{\text{LM},\boldsymbol{B},\boldsymbol{2}\}} - \mathcal{V}_{\{\text{LM},\boldsymbol{U_2},\boldsymbol{2}\}}] + \boldsymbol{\sigma_{\alpha_{CP},\epsilon_{CP}}}$
- $\boldsymbol{E_5} = \mathbf{Cov}(\boldsymbol{\nu_2}, \boldsymbol{\nu_3}) = -\boldsymbol{\beta^2\sigma_{\alpha_{CP},\alpha_{U_1}}} + \boldsymbol{\beta^2\sigma^2_{\alpha_{CP}}}$
- $\boldsymbol{E_6} = \mathbf{Var}(\boldsymbol{\nu_3}) = \boldsymbol{\beta^2\sigma^2_{\alpha_{U_1}}}$

So the probability can be rewritten as follows:

$$\int_{-\infty}^{\boldsymbol{A_1}}\int_{-\infty}^{\boldsymbol{B_1}}\int_{-\infty}^{\boldsymbol{C_1}} \boldsymbol{f}(\boldsymbol{\nu_1}, \boldsymbol{\nu_2}, \boldsymbol{\nu_3})\boldsymbol{d\nu_1 d\nu_2 d\nu_3}$$

Where $\boldsymbol{f} \sim \boldsymbol{N}(\boldsymbol{0}, \boldsymbol{\Sigma})$.

The probability that path *O* is chosen by individual *i* is given by:

$Pr[\text{Choice}_i = O] = Pr[[\beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + p_{U_1}[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] \geq \beta\alpha_{U_1}] \cap [\beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + p_{U_1}[\beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta^2\mathcal{V}_{\{\text{LM},U_1,1\}} \geq \beta\alpha_{U_1}] \cap [\beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + p_{CP}[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] - \beta^3 p_{CP}\theta_{Z_{CP}}Z_{CP}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}] \geq \beta\alpha_{CP} + \beta^3\epsilon_{CP}p_{CP}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]] \cap [\beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + p_{U_1}[C + \beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] - \beta^3 p_{U_1}\theta_{Z_{U_1}}Z_{U_1}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}] \geq \beta\alpha_{U_1} + \beta^3\epsilon_{U_1}p_{U_1}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]]]$

One can use the following notations:

$$\begin{aligned}\nu'_1 &= \beta\alpha_{U_1} \\ \nu'_2 &= \beta\alpha_{U_1} \\ \nu'_3 &= \beta\alpha_{CP} + \beta^3\epsilon_{CP}p_{CP}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}] \\ \nu'_4 &= \beta\alpha_{U_1} + \beta^3\epsilon_{U_1}p_{U_1}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\end{aligned}$$

One has therefore: $\Sigma' = \begin{bmatrix} F_1 & F_2 & F_3 & F_4 \\ F_2 & F_5 & F_6 & F_7 \\ F_3 & F_6 & F_8 & F_9 \\ F_4 & F_7 & F_9 & F_{10} \end{bmatrix}$

with:

- $F_1 = \beta^2\sigma^2_{\alpha_{U_1}}$
- $F_2 = \beta^2\sigma^2_{\alpha_{U_1}}$
- $F_3 = \beta^2\sigma_{\alpha_{U_1},\alpha_{CP}}$
- $F_4 = \beta^2\sigma^2_{\alpha_{U_1}} + \beta^3\beta p_{U_1}[\mathcal{V}_{\text{LM},B,2} - \mathcal{V}_{\text{LM},U_2,2}]\sigma_{\alpha_{U_1},\epsilon_{U_1}}$
- $F_5 = \beta^2\sigma^2_{\alpha_{U_1}}$
- $F_6 = \beta^2\sigma_{\alpha_{U_1},\alpha_{CP}}$
- $F_7 = \beta^2\sigma^2_{\alpha_{U_1}} + \beta\beta^3 p_{U_1}[\mathcal{V}_{\text{LM},B,2} - \mathcal{V}_{\text{LM},U_2,2}]\sigma_{\alpha_{U_1},\epsilon_{U_1}}$
- $F_8 = \beta^2\sigma^2_{\alpha_{CP}} + (\beta^3)^2 p_{CP}[\mathcal{V}_{\text{LM},B,2} - \mathcal{V}_{\text{LM},U_2,2}]^2\sigma^2_{\epsilon_{CP}} + 2\beta^3 p_{CP}[\mathcal{V}_{\text{LM},B,2} - \mathcal{V}_{\text{LM},U_2,2}]\sigma_{\alpha_{CP},\epsilon_{CP}}$
- $F_9 = \beta^2\sigma_{\alpha_{U_1},\alpha_{CP}} + (\beta^3)^2 p_{CP} p_{U_1}[\mathcal{V}_{\text{LM},B,2} - \mathcal{V}_{\text{LM},U_2,2}]^2\sigma_{\epsilon_{CP},\epsilon_{U_1}}$
- $F_{10} = \beta^2\sigma^2_{\alpha_{U_1}} + (\beta^3)^2 p^2_{U_1}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]^2\sigma^2_{\epsilon_{U_1}} + 2\beta^3\beta p_{U_1}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\sigma_{\alpha_{U_1},\epsilon_{U_1}}$

So the probability can be rewritten as follows:

$$\int_{-\infty}^{A_2}\int_{-\infty}^{B_2}\int_{-\infty}^{C_2}\int_{-\infty}^{D_2} g(\nu'_1,\nu'_2,\nu'_3,\nu'_4)d\nu'_1 d\nu'_2 d\nu'_3 d\nu'_4$$

Where $g \sim N(0,\Sigma')$.

<u>The probability that path $\mathrm{U_1/B}$ is chosen by individual *i* is given by:</u>

$$\begin{aligned} Pr[\text{Choice}_i = U_1/B] &= Pr[\beta^2(1-p_{U_1})\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + \beta^3 p_{U_1}[\mathcal{V}_{\{\text{LM},U_2,2\}} - C] - \beta^3 p_{U_1}\theta_{Z_{U_1}}Z_{U_1}[\mathcal{V}_{\{\text{LM},U_2,2\}} \\ &- \mathcal{V}_{\{\text{LM},B,2\}}] \\ &\geq -\beta\alpha_{U_1} + \beta^3 p_{U_1}\epsilon_{U_1}[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}] \cap [(p_{U_1} - p_{CP})[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] - p_{U_1}C \\ &- (p_{CP}\theta_{Z_{CP}}Z_{CP} - \beta^3 p_{U_1}\theta_{Z_{U_1}}Z_{U_1})[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}] \\ &\geq \beta(\alpha_{CP} - \alpha_{U_1}) + \beta^3(p_{CP}\epsilon_{CP} - p_{U_1}\epsilon_{U_1})[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]] \cap \beta^3\theta_{Z_{U_1}}Z_{U_1}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}] \\ &- C \\ &\geq \beta^3\epsilon_{U_1}[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}] \cap \beta^3\theta_{Z_{U_1}}Z_{U_1}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}] + \beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},U_1,1\}} - C \\ &\geq \beta^3\epsilon_{U_1}[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}]] \end{aligned}$$

One can use the following notations:

$$\begin{aligned} \nu'''_1 &= -\beta\alpha_{U_1} + \beta^3 p_{U_1}\epsilon_{U_1}[\mathcal{V}_{\text{LM},U_2,2} - \mathcal{V}_{\text{LM},B,2}] \\ \nu'''_2 &= \beta(\alpha_{CP} - \alpha_{U_1}) + \beta^3(p_{CP}\epsilon_{CP} - p_{U_1}\epsilon_{U_1})[\mathcal{V}_{\text{LM},B,2} - \mathcal{V}_{\text{LM},U_2,2}] \\ \nu'''_3 &= \beta^3 p_{U_1}\epsilon_{U_1}(\mathcal{V}_{\text{LM},B,2} - \mathcal{V}_{\text{LM},U_2,2}) \\ \nu'''_4 &= \beta^3\epsilon_{U_1}[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}] \end{aligned}$$

$$\Lambda_1 = \text{Var}(\nu'''_1) = \beta^2\sigma^2_{\alpha_{U_1}} + (\beta^3)^2 p^2_{U_1}[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}]^2\sigma^2_{\epsilon_{U_1}} - 2\beta^3\beta p_{U_1}[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}]\sigma_{\alpha_{U_1},\epsilon_{U_1}}$$

$$\begin{aligned} \Lambda_2 &= \text{Cov}(\nu'''_1,\nu'''_2) \\ &= -\beta^2\sigma_{\alpha_{CP},\alpha_{U_1}} + \beta^2\sigma^2_{\alpha_{U_1}} + \beta\beta^3 p_{U_1}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\sigma_{\epsilon_{U_1},\alpha_{U_1}} - p_{U_1}\beta\beta^3[\mathcal{V}_{\{\text{LM},U_2,2\}} \\ &- \mathcal{V}_{\{\text{LM},B,2\}}]\sigma_{\epsilon_{U_1},\alpha_{U_1}} + (\beta^3)^2 p_{U_1}p_{CP}[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}]\,[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\sigma_{\epsilon_{U_1},\epsilon_{CP}} \\ &- (\beta^3)^2 p^2_{U_1}[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}][\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\sigma^2_{\epsilon_{U_1}} \end{aligned}$$

$$\begin{aligned}
\Lambda_3 &= \mathrm{Cov}(\nu_1''', \nu_3''') \\
&= -\beta\beta^3 p_{U_1}[\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}]\sigma_{\epsilon_{U_1},\alpha_{U_1}} + (\beta^3)^2 p_{U_1}^2[\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}][\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}} \\
&\quad - C]\sigma_{\epsilon_{U_1}}^2 \\
\Lambda_4 &= \mathrm{Cov}(\nu_1''', \nu_4''') \\
&= -\beta\beta^3[\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}]\sigma_{\epsilon_{U_1},\alpha_{U_1}} + (\beta^3)^2 p_{U_1}^2[\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}][\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \mathcal{V}_{\{\mathrm{LM},B,2\}}]\sigma_{\epsilon_{U_1}}^2 \\
\Lambda_5 &= Var(\nu_2''') = \beta^2\sigma_{\alpha_{CP}}^2 + \beta^2\sigma_{\alpha_{U_1}}^2 - 2\beta^2\sigma_{\alpha_{CP},\alpha_{U_1}} + (\beta^3)^2 p_{CP}^2[\mathcal{V}_{\mathrm{LM},B,2} - \mathcal{V}_{\mathrm{LM},U_2,2}]^2\sigma_{\epsilon_{CP}}^2 + (\beta^3)^2 p_{U_1}^2[\mathcal{V}_{\mathrm{LM},B,2} \\
&\quad - \mathcal{V}_{\mathrm{LM},U_2,2}]^2 - 2(\beta^3)^2 p_{CP} p_{U_1}[\mathcal{V}_{\mathrm{LM},B,2} - \mathcal{V}_{\mathrm{LM},U_2,2}]^2\sigma_{\epsilon_{CP},\epsilon_{U_1}} + 2[\beta\beta^3 p_{CP}[\mathcal{V}_{\mathrm{LM},B,2} - \mathcal{V}_{\mathrm{LM},U_2,2}]\sigma_{\epsilon_{CP},\alpha_{CP}} \\
&\quad + \beta p_{U_1}[\mathcal{V}_{\mathrm{LM},B,2} - \mathcal{V}_{\mathrm{LM},U_2,2}]\sigma_{\alpha_{U_1},\epsilon_{U_1}} \\
\Lambda_6 &= Cov(\nu_2''', \nu_3''') \\
&= -\beta\beta^3 p_{U_1}[\mathcal{V}_{\mathrm{LM},B,2} - \mathcal{V}_{\mathrm{LM},U_2,2}]\sigma_{\epsilon_{U_1},\alpha_{U_1}} + (\beta^3)^2 p_{CP} p_{U_1}[\mathcal{V}_{\mathrm{LM},B,2} - \mathcal{V}_{\mathrm{LM},U_2,2}]^2\sigma_{\epsilon_{U_1},\epsilon_{CP}} \\
&\quad - (\beta^3)^2 p_{U_1}[\mathcal{V}_{\mathrm{LM},B,2} - \mathcal{V}_{\mathrm{LM},U_2,2}][\mathcal{V}_{\mathrm{LM},U_2,2} - \mathcal{V}_{\mathrm{LM},B,2}]\sigma_{\epsilon_{U_1}}^2 \\
\Lambda_7 &= Cov(\nu_2''', \nu_4''') \\
&= -\beta\beta^3[\mathcal{V}_{\mathrm{LM},U_2,2} - \mathcal{V}_{\mathrm{LM},B,2}]\sigma_{\epsilon_{U_1},\alpha_{U_1}} + (\beta^3)^2 p_{CP}[\mathcal{V}_{\mathrm{LM},B,2} - \mathcal{V}_{\mathrm{LM},U_2,2}][\mathcal{V}_{\mathrm{LM},U_2,2} - \mathcal{V}_{\mathrm{LM},B,2}]\sigma_{\epsilon_{\alpha_{U_1}},\alpha_{CP}}^2 \\
&\quad - (\beta^3)^2 p_{U_1}[\mathcal{V}_{\mathrm{LM},B,2} - \mathcal{V}_{\mathrm{LM},U_2,2}]\,[\mathcal{V}_{\mathrm{LM},U_2,2} - \mathcal{V}_{\mathrm{LM},B,2}]\sigma_{\epsilon_{U_1}}^2 \\
\Lambda_8 &= (\beta^3)^2 Var(\nu_3''') = p_{U_1}^2[\mathcal{V}_{\mathrm{LM},B,2} - \mathcal{V}_{\mathrm{LM},U_2,2}]^2\sigma_{\epsilon_{U_1}}^2 \\
\Lambda_9 &= Cov(\nu_3''', \nu_4''') = (\beta^3)^2 p_{U_1}[\mathcal{V}_{\mathrm{LM},B,2} - \mathcal{V}_{\mathrm{LM},U_2,2}][\mathcal{V}_{\mathrm{LM},U_2,2} - \mathcal{V}_{\mathrm{LM},B,2}]\sigma_{\epsilon_{U_1}}^2 \\
\Lambda_{10} &= (\beta^3)^2 Var(\nu_4''') = [\mathcal{V}_{\mathrm{LM},U_2,2} - \mathcal{V}_{\mathrm{LM},B,2}]\sigma_{\epsilon_{U_1}}^2
\end{aligned}$$

One has therefore: $\Sigma''' = \begin{bmatrix} \Lambda_1 & \Lambda_2 & \Lambda_3 & \Lambda_4 \\ \Lambda_2 & \Lambda_5 & \Lambda_6 & \Lambda_7 \\ \Lambda_3 & \Lambda_6 & \Lambda_8 & \Lambda_9 \\ \Lambda_4 & \Lambda_7 & \Lambda_8 & \Lambda_{10} \end{bmatrix}$

So the probability can be rewritten as follows:

$$\int_{-\infty}^{A_4}\int_{-\infty}^{B_4}\int_{-\infty}^{C_4}\int_{-\infty}^{D_4} m(\nu_1''', \nu_2''', \nu_3''', \nu_4''')d\nu_1''' d\nu_2''' d\nu_3''' d\nu_4'''$$

Where $m \sim N(0, \Sigma''')$.

<u>The probability that path $\mathrm{U_1/U_2}$ is chosen by individual i is:</u>

$$\begin{aligned}
Pr[\text{Choice}_i = U_1/U_2] &= Pr[\beta^3(1 + \theta_{Z_{U_1}} Z_{U_1})\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \beta^3\theta_{Z_{U_1}} Z_{U_1}\mathcal{V}_{\{\mathrm{LM},B,2\}} + C \\
&\geq \beta^3\epsilon_{U_1}[\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}] \cap [p_{U_1}[\beta^3\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\mathrm{LM},U_1,1\}} \\
&\geq 0]] \cap [p_{U_1}[\beta^3\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\mathrm{LM},O,1\}}] + \beta^2\mathcal{V}_{\{\mathrm{LM},O,1\}} - \beta\mathcal{V}_{\{\mathrm{LM},O,0\}} \\
&\geq -\beta\alpha_{U_1}] \cap (p_{U_1} - p_{CP})[\beta^3\mathcal{V}_{\{\mathrm{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\mathrm{LM},O,1\}}] - \beta^3[\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}]p_{CP}\theta_{Z_{CP}} Z_{CP} \\
&\geq \beta(\alpha_{CP} - \alpha_{U_1}) + \beta^3 p_{CP}\epsilon_{CP}[\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}]]
\end{aligned}$$

One can use the following notations:

$$\begin{aligned}
\nu_1^* &= \beta^3\epsilon_{U_1}[\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}] \\
\nu_2^* &= -\beta\alpha_{U_1} \\
\nu_3^* &= \beta(\alpha_{CP} - \alpha_{U_1}) + \beta^3 p_{CP}\epsilon_{CP}[\mathcal{V}_{\{\mathrm{LM},B,2\}} - \mathcal{V}_{\{\mathrm{LM},U_2,2\}}]
\end{aligned}$$

One has therefore: $\Sigma^* = \begin{bmatrix} G_1 & G_2 & G_3 \\ G_2 & G_4 & G_5 \\ G_3 & G_5 & G_6 \end{bmatrix}$

with:

- $G_1 = (\beta^3)^2[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]^2\sigma^2_{\epsilon_{U_1}}$
- $G_2 = -\beta\beta^3[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\sigma_{\epsilon_{U_1},\alpha_{U_1}}$
- $G_3 = -\beta^3\beta p_{CP}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\sigma_{\epsilon_{U_1},\alpha_{U_1}} + (\beta^3)^2[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]^2\sigma_{\epsilon_{U_1},\epsilon_{CP}}$
- $G_4 = \beta^2\sigma^2_{\alpha_{U_1}}$
- $G_5 = \beta^2\sigma^2_{\alpha_{U_1}} - \beta^2\sigma_{\alpha_{U_1},\alpha_{CP}}$
- $G_6 = \beta^2\sigma^2_{\alpha_{CP}} + \beta^2\sigma^2_{\alpha_{U_1}} - 2\beta^2\sigma_{\alpha_{CP},\alpha_{U_1}} + (\beta^3)^2p^2_{CP}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]^2\sigma^2_{\epsilon_{CP}} + 2[\beta(\beta^3)^2p_{CP}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\sigma_{\alpha_{CP},\epsilon_{CP}}]$

$$\int_{-\infty}^{0}\int_{-\infty}^{A_5}\int_{-\infty}^{B_5} n(v_1^*, v_2^*, v_3^*)dv_1^*dv_2^*dv_3^*$$

Where $n \sim N(0, \Sigma^*)$

A.4. Upper bounds of the likelihood function

This appendix expresses the upper bounds of the likelihood function (cf. equation 4).

$$
\begin{aligned}
A_1 &= p_{U_1}[\beta^2\mathcal{V}_{\{\text{LM},U_1,1\}} - \beta^3\mathcal{V}_{\{\text{LM},U_2,2\}}\\
B_1 &= \beta^2\mathcal{V}_{\{\text{LM},U_1,1\}} - \beta^3\mathcal{V}_{\{\text{LM},B,2\}}\theta_{Z_{U_1}}Z_{U_1} + \beta^3\mathcal{V}_{\{\text{LM},U_2,2\}}(\theta_{Z_{U_1}}Z_{U_1} - 1) + C\\
C_1 &= \beta^2 p_{U_1}\mathcal{V}_{\{\text{LM},U_1,1\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}(p_{CP} + p_{U_1}) - \beta^3 p_{CP}\theta_{Z_{CP}}Z_{CP}\mathcal{V}_{\{\text{LM},B,2\}} - \beta^3\mathcal{V}_{\{\text{LM},U_2,2\}}p_{CP}(\theta_{Z_{CP}}Z_{CP} - 1)\\
D_1 &= \beta^2 p_{U_1}[\mathcal{V}_{\{\text{LM},U_1,1\}} - \mathcal{V}_{\{\text{LM},O,1\}}] + \beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}}\\
A_2 &= \beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + p_{U_1}[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}\\
B_2 &= \beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + p_{U_1}[\beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta^2\mathcal{V}_{\{\text{LM},U_1,1\}}\\
C_2 &= \beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + p_{CP}[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] - \beta^3 p_{CP}\theta_{Z_{CP}}Z_{CP}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\\
D_2 &= \beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + p_{U_1}[C + \beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}\\
A_3 &= \beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + p_{CP}[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}]\\
B_3 &= (p_{CP} - p_{U_1})[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] + \beta^3[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\,[p_{CP}\theta_{Z_{CP}}Z_{CP} - p_{U_1}\theta_{Z_{U_1}}Z_{U_1}] + p_{U_1}C\\
C_3 &= (p_{CP} - p_{U_1})[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] - p_{CP}\theta_{Z_{CP}}Z_{CP}\beta^3[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}]\\
D_3 &= p_{CP}\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - p_{U_1}\beta^2\mathcal{V}_{\{\text{LM},U_1,1\}} - (p_{CP} - p_{U_1})\beta^2\mathcal{V}_{\{\text{LM},O,1\}} - p_{CP}\theta_{Z_{CP}}Z_{CP}\beta^3[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}]\\
A_4 &= \beta^2(1 - p_{U_1})\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}} + \beta^3 p_{U_1}[\mathcal{V}_{\{\text{LM},U_2,2\}} - C] - \beta^3 p_{U_1}\theta_{Z_{U_1}}Z_{U_1}[\mathcal{V}_{\{\text{LM},U_2,2\}} - \mathcal{V}_{\{\text{LM},B,2\}}]\\
B_4 &= [(p_{U_1} - p_{CP})[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] - p_{U_1}C - (p_{CP}\theta_{Z_{CP}}Z_{CP} - \beta^3 p_{U_1}\theta_{Z_{U_1}}Z_{U_1})\,[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]\\
C_4 &= \beta^3\theta_{Z_{U_1}}Z_{U_1}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}] - C\\
D_4 &= \beta^3\theta_{Z_{U_1}}Z_{U_1}[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}] + \beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},U_1,1\}} - C\\
A_5 &= \beta^3(1 + \theta_{Z_{U_1}}Z_{U_1})\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^3\theta_{Z_{U_1}}Z_{U_1}\mathcal{V}_{\{\text{LM},B,2\}} + C\\
B_5 &= [p_{U_1}[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},U_1,1\}}\\
C_5 &= [p_{U_1}[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] + \beta^2\mathcal{V}_{\{\text{LM},O,1\}} - \beta\mathcal{V}_{\{\text{LM},O,0\}}\\
D_5 &= (p_{U_1} - p_{CP})[\beta^3\mathcal{V}_{\{\text{LM},U_2,2\}} - \beta^2\mathcal{V}_{\{\text{LM},O,1\}}] - \beta^3[\mathcal{V}_{\{\text{LM},B,2\}} - \mathcal{V}_{\{\text{LM},U_2,2\}}]p_{CP}\theta_{Z_{CP}}Z_{CP}
\end{aligned}
$$

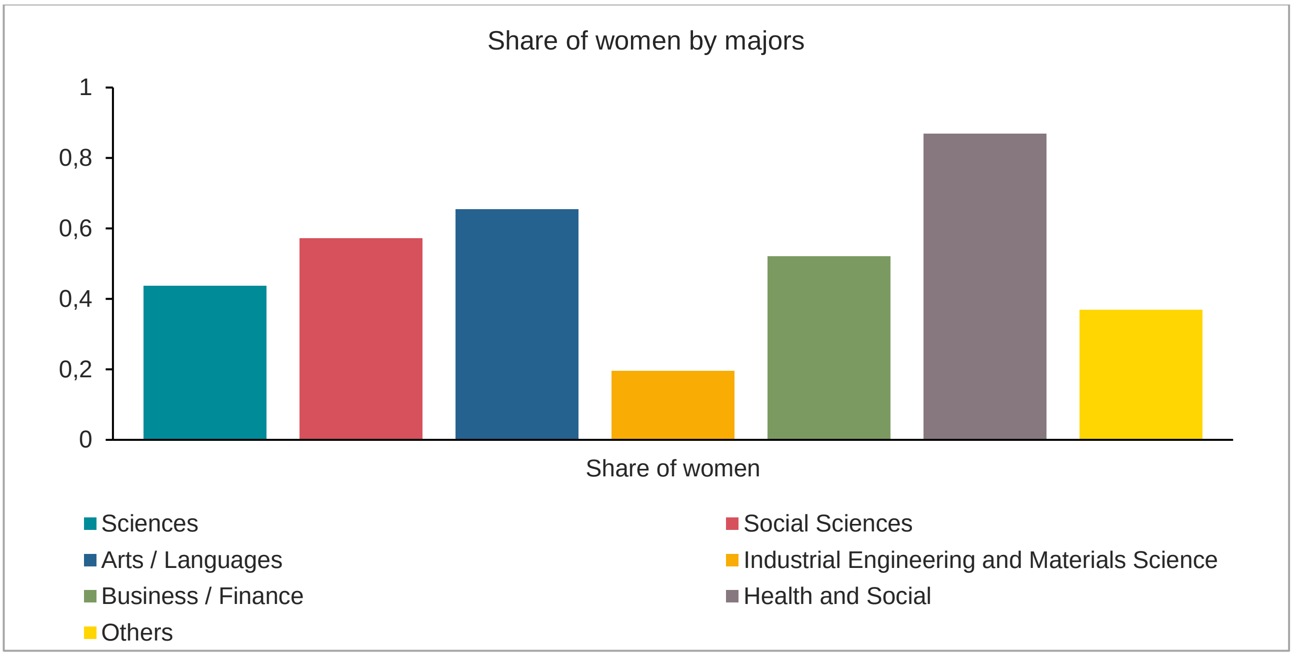
A.5. Descriptive statistics

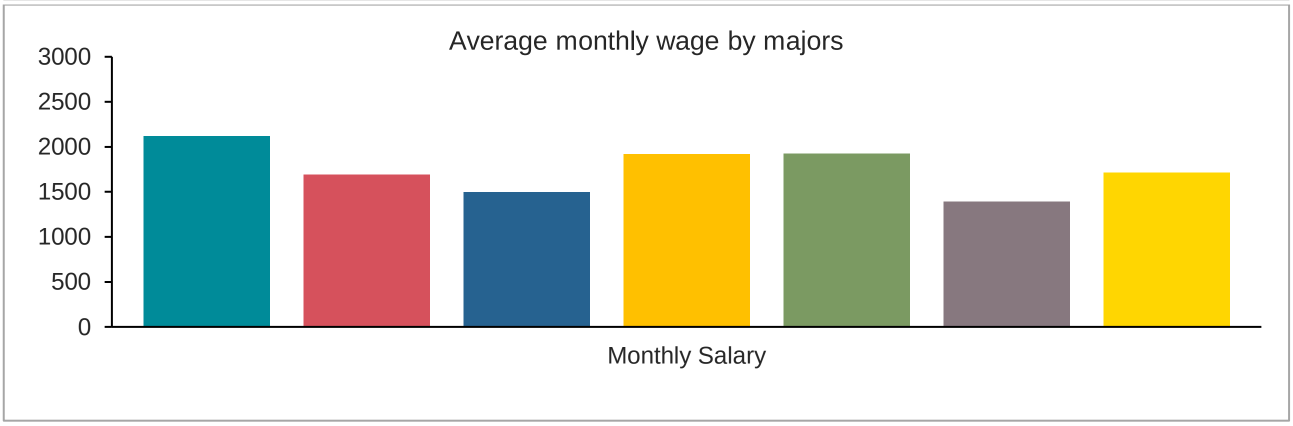
Table A1 • Descriptive statistics (continued)

	Path in high school			Results in high school			
	General	Vocational	Technical	No honours	With honours	With high honours	With very high honours
1st period choice							
Outside option	0,01	0,82	0,31	0,03	0,01	0,00	0,00
Univeristy	0,68	0,18	0,61	0,90	0,73	0,39	0,22
Prepa	0,31	0,01	0,08	0,07	0,26	0,61	0,78
Path choice							
No higher education diploma	0,15	0,89	0,73	0,36	0,13	0,05	0,01
Univ 3	0,15	0,05	0,12	0,21	0,14	0,05	0,01
Univ 5	0,38	0,05	0,08	0,36	0,45	0,29	0,20
Univ + BSES	0,02	0,00	0,01	0,02	0,03	0,02	0,00
CP + Univ	0,18	0,01	0,04	0,04	0,16	0,38	0,44
CP + BSES	0,12	0,01	0,01	0,02	0,10	0,22	0,39
Probabilities of success							
Proba prepa grad	0,98	0,22	0,68	0,85	0,97	0,98	1,00
Proba univ grad	0,82	0,06	0,35	0,65	0,84	0,91	0,97
Proba exam prepa	0,38	0,18	0,11	0,26	0,37	0,36	0,43
Proba exam univ	0,03	0,00	0,01	0,02	0,04	0,05	0,01

Source: Céreq, *Enquête Génération* 2013 surveyed at year 3.

Figure A2 • Descriptive graphs by majors





Source: Céreq, *Enquête Génération* 2013 surveyed at year 3.

A.6. Information regarding the estimation of the probability of high honours in high school baccalaureate

Due to a significant number of missing values regarding the honours obtained in the high school Baccalaureate in the *Enquête Génération* 2013 database, I estimated the probability of graduating with very high honours using data from the *Enquête Génération* 2017. This estimation was conducted using a probit model, which assumes that the probability of graduating with very high honours depends on several factors: the student's sex, high school track, the socio-professional category of the father and mother at the end of the student's high school, and the student's higher education pathway. These estimated probabilities were then incorporated into the *Enquête Génération* 2013 database.

A.7. Heckman equation

Table A2 ● Heckman equation

	Outside option	$E_O \times D_O$	University 3 years	$E_{U_1} \times D_{U_1}$	University 5 years	$E_{U_2} \times D_{U_2}$	BS/ES	$E_B \times D_B$
Age	0.1*** (0.02)		0.08*** (0.02)		0.10*** (0.02)		0.06** (0.02)	
Age^2	-0.001*** (0.0001)		-0.001*** (0.0001)		-0.001*** (0.0008)		-0.001** (0.0002)	
Seniority	0.011*** (0.0001)		0.002*** (0.0002)		0.001*** (0.0002)		0.001** (0.0003)	
Gender: women	-0.26*** (0.03)		-0.09** (0.04)		-0.22*** (0.04)		-0.23*** (0.06)	
Nationality: French	0,22 (0.17)		0.18* (0.10)		0,01 (0.10)		0.28** (0.12)	
Employed × Outside option		0,1 (0.20)						
Employed × University 3 years				0,09 (0.19)				
Employed × University 5 years						0,03 (0.18)		
Employed × BS/ES								-0,6 (0.20)
Specialities								
Region of residence								
Socio-professional categories								
Constant	4.44*** (0.69)		5.56*** (0.56)		6.40*** (0.64)		5.42*** (0.54)	
Number of observations	**1 690**		**755**		**609**		**230**	

Note: standard errors are given in parentheses: *** p<0.01, ** p<0.05, * p<0.1.
Source: Céreq, *Enquête Génération* 2013 surveyed at year 3.

A.8. Gender comparison

Table A3 ● Structural estimation on women

	Final Choice			
	University 3 years	University 5 years	University + BS/ES	Preparatory class
Expected wages outside option	0,22	0,52	0,18	-0,06
	(1.56)	(2.06)	(1.36)	(1.48)
Expected wages bachelor	0,98	0,95	-0,65	0,12
	(1.77)	(2.47)	(3.33)	(1.82)
Expected wages master	0,09	-0,42	-0,36	0,7
	(0.92)	(1.66)	(0.77)	(1.14)
Expected wages BS/ES	-1,33	-0,01	0,56	1,32
	(1.28)	(1.06)	(0.94)	(0.98)
Probability to find a job outside option	-0,18	0,55	-3,12	0,9
	(3.22)	(2.70)	(7.30)	(2.92)
Probability to find a job bachelor	0,65	3,43	-3,68	-1,23
	(2.88)	(10.62)	(7.59)	(3.62)
Probability to find a job master	0,21	1,9	5,01	-1,21
	(2.08)	(4.90)	(9.28)	(2.00)
Probability to find a job BS/ES	-0,2	0,65	-1,09	0,25
	(0.8)	(2.36)	(1.61)	(1.03)
Controlling for probabilities	Yes	Yes	Yes	Yes
Constant	-0,51	-11,49	2,08	-12,63
	(11.84)	(11.47)	(21.17)	(11.26)
Number of observations	**2 187**			

Note: the reference category corresponds to enter the labour market just after high school. Standard errors are given in parentheses: *** p<0.01, ** p<0.05, * p<0.1. This Table only reports the results of the choice equation but has been run as before, i.e. running the choice equation and the four probabilities of success simultaneously.
Source: Céreq, *Enquête Génération* 2013 surveyed at year 3.

Table A4 • Structural estimation on men

	Final Choice			
	University 3 years	University 5 years	University + BS/ES	Preparatory class
Expected wages outside option	0,84	0,83	11,55	-0,14
	(2.02)	(1.99)	(9.56)	(1.70)
Expected wages bachelor	1,31	2,83	-2,83	-2,04
	(2.45)	(5.34)	(7.47)	(2.46)
Expected wages master	0,47	-0,6	-0,82	-0,65
	(1.59)	(3.30)	(2.25)	(1.38)
Expected wages BS/ES	-1.29	-0,53	-0,18	2.07**
	(1.02)	(1.30)	(1.00)	(1.02)
Probability to find a job outside option	-1,6	4,66	-11.05**	-2,63
	(3.40)	-	(4.44)	-
Probability to find a job bachelor	1,71	-0,28	-15,96	0,65
	(4.17)	(6.16)	(11.41)	(6.06)
Probability to find a job master	0,9	0,28	-7,16	1,5
	(4.53)	(2.81)	-	(2.95)
Probability to find a job BS/ES	-1,02	0,1	0,88	-0,28
	(1.06)	(1.37)	(3.16)	(0.99)
Controlling for probabilities	Yes	Yes	Yes	Yes
Constant	-9,26	-18,72	-58.91**	6,09
	(12.08)	-	(21.66)	-
Number of observations	**1 907**			

Note: the reference category corresponds to enter the labour market just after high school. Standard errors are given in parentheses: *** p<0.01, ** p<0.05, * p<0.1. This Table only reports the results of the choice equation but has been run as before, i.e. running the choice equation and the four probabilities of success simultaneously.
Source: Céreq, *Enquête Génération* 2013 surveyed at year 3.

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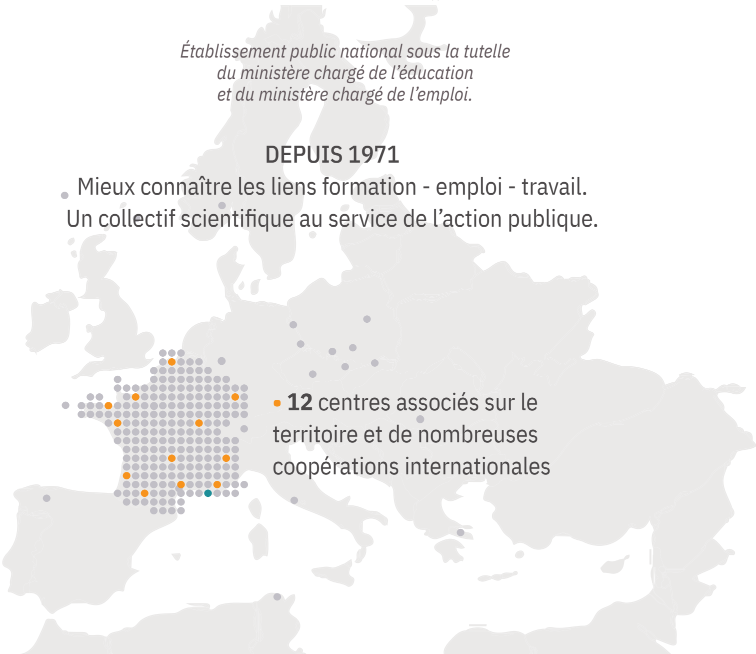

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