Girls and Science in France

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Despite an increasing number of girls taking science subjects in high school, many countries suffer a problem of attraction and retention of girls in science majors in college, combined with a problem of transition to the labour market. This paper aims at testing the validity of the assumption of such a progressive 'leaking pipeline' effect on the French case. Using the French Labour Force Survey of 2011, we find that, after controlling for the influence of the family background, the French gender gap in science is not due to a progressive leak. Instead, it is mainly due to a filter at the entrance level into the science pipeline. No major gender difference is identified during the course of studies at university nor during the transition to the labour market. This result points at a problem of attractiveness of science majors for girls at the school level. We find that the scientific nature of the profession of the mother plays a more significant role in the choice of her children's major and occupation than that of the father, which confirms the importance of including mother's occupation in analyses of children's choices. Hence, as the number of scientific women will increase, the number of pupils of both genders choosing science subjects and majors will also increase.

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1. INTRODUCTION

There is evidence that women leak out more than men from the science pipeline (including physics, biology, technology, engineering and mathematics) leading from high school through university to the first job in science (Blickenstaff, 2005). Cronin and Roger (1999) describe the absence of women in science as both progressive (the farther along the pipeline, the fewer women) and persistent.

Among the reasons for this leak is the role played by societal beliefs and by the learning environment on girls' achievements and interest in science (AAUW, 2010). This argument is supported by the results from the OECD's Programme for International Student Assessment (PISA) that reveal a sustainable underperformance of girls in science compared to boys. The PISA data show that girls' perceptions of themselves as learners of science does determine how well they motivate themselves and persevere in the face of difficulties when learning science. They also influence the choices girls make about coursework, additional classes, and even educational and career paths. Many girls choose not to pursue careers in science because they do not have the confidence in their ability to excel in science, despite having the capacity and skills to do so (OECD, 2014).

Beyond the lack of self-confidence, the literature in education and labour economics has provided empirical evidence of a strong correlation between education and income of parents and their children's educational prospects. This link has traditionally been explained by genetic mechanisms, socioeconomic resources and cultural capital (Bowles and Gintis, 2002; Piketty, 2000). Still, intergenerational correlations are not equal across genders. They have been found to be lower for daughters than for sons (Bowles and Gintis, 2002). This is partly explained by the fact that gender roles have been found to be less strict for women, and women are more likely to make less conventional choices (Trusty et al., 2000; Valian, 1999). Kleinjans (2010) finds that the education level of a parent is positively correlated with higher expected education of his/her child, especially if the child is of the same gender as the parent. But she also finds that the income level of the parents influences only the sons' educational expectations, not the daughters'.

Furthermore, the literature on status attainment has confirmed a positive correlation between the occupational status of the father and that of the son (Rijken, 1999; Goldthorpe, 1987; Ganzeboom and de Graaf, 1983; Blau and Duncan, 1967). However, these studies excluded the influence of the mothers' occupational status on the children's job, which may have induced an overestimation bias of the role played by the father's occupational status. Among the studies including mothers' occupational status, it has been found that the mother influenced positively the daughters' job status (Korupp et al., 2002a; Khazzoom, 1997; Rosenfeld, 1978; Treiman and Terrell, 1975). Some other studies have, however, found either no gender orientation (Crook, 1995), or that professionally employed mothers tend to help professionally more their sons than their daughters (Aschaffenburg, 1995).

As investigated by Korupp et al. (2002b), these differences between the influence of fathers and mothers on their children's occupation may be biased by the gender-typing nature of the occupations of the parents. A gender-typing occupation is defined as the ratio of female to male incumbents in a job. Jobs with more male incumbents are male sex-typed occupations, whereas jobs with more female incumbents are considered female sex-typed. Studying the Dutch labour market of the 1990s, they find evidence of a same-gender orientation in parent-child transmission of occupational status.

This gender-typing is also argued to pass through the professors. While many studies have established that professors may serve as role models in higher education and that their gender strongly affects female college students' likelihood to major in science (Canes and Rosen, 1995; Rothstein, 1994; Bettinger and Long, 2005; Hoffman and Oreopoulos, 2009; Carell et al., 2010), there is evidence of a negative effect of gender stereotypes on the way teachers perceive and evaluate their pupils (Bernard, 1979; Madon et al., 1998). This argument is, however, refutable in the French case, as demonstrated by Breda and Ly (2012). Focusing on the entrance exam of the Ecole Normale Supérieure (ENS), where students take a large set of tests in subjects with varying stereotypes against girls or boys, they find instead gender premiums going against gender stereotypes and in favour of a positive gender discrimination trend: the more masculine a subject, the more favored girls are.

From the literature on the intergenerational transmission of educational and occupational paths, we know that the mother's occupation tends to have a stronger effect on her daughter's educational choices and on her son's occupational choices. Conversely, we know that the father's occupation tends to have a stronger effect on his son's educational and occupational choices. However, the mother's occupation has so far been assumed to be female-typed. In this paper, we will test whether the mother's occupation influences daughters and sons in a similar way when the mother works in the science field (i.e. in a male-typed occupation) or not. If the hypothesis of a mother-daughter transmission of a gender-typed perception of education and occupations is true, then this would mean that more female role models in science could significantly increase the degree of attraction of science majors and careers for girls.

The last level of leak is argued to take place at the exit of the science pipeline (Blickenstaff, 2005), i.e. during the transition from the science studies to the first job. The school-to-work transition is defined as "the passage of a young person from the end of schooling to the first satisfactory employment" (ILO, 2010). Using the ad-hoc module of the Eurostat's Labour Force Survey, collected in 2000, Smyth (2003) estimated gender differences in labour market integration, controlling for educational level, degree field and family status. While she finds very little gender differentiation in the Scandinavian countries, the Netherlands and the Eastern European countries, there is evidence of strong gender differences in Belgium and the Mediterranean countries. Moreover, Smyth (ibid.) estimates gender differences in the gender-typing of the first significant job. She finds that young women are significantly less likely to enter predominantly male occupations and more likely to enter predominantly female occupations, even after controlling for the gender-typing of the educational degree. This means that among women who graduate from male-dominated majors, only a small share will pursue into a male-dominated occupation.

The persistence of occupational segregation by gender can be explained by three main theoretical perspectives. According to the human capital theory, women choose occupations with the lowest rate of penalty for labour market discontinuity (Mincer and Polacheck, 1974). Instead, the institutional perspective stipulates that it is the differentiation into different tracks or fields of study that yields the gender-typing of occupations (e.g., Borghans and Groot, 1999). This argument is supported by the comparative perspective, according to which the earliest the educational choices, the more likely they are to be gender-typical. Thus, given the strong education-labour market linkages, gender segregation is likely to be more pronounced in countries with highly differentiated, vocationally-oriented systems (Buchmann and Charles, 1995).

In this paper, we test whether it is true that women with a science degree (i.e. a male-typed degree) have a lower probability of working at a science occupation than their male peers. If the hypothesis turns out to be true, then it would mean that there is a significant leak in the transition from the science pipeline to the labour market.

In this paper, we explore the French Labour Force Survey of 2011. We start our analysis of the science pipeline with the role played by parents' occupation in the probability of completing a scientific Baccalauréat[255]. We proceed with its impact on the probability of graduating in science at the university level and on the probability of employment in a scientific occupation.

We identify a significant filter at the entrance of the pipeline affecting negatively the probability for girls to leave high school with a scientific degree, mainly caused by the parents' occupational status. Among those who pursue into science majors at university level, we find no significant gender differences in the probability of graduating at the Bachelor, Master or PhD level. We only find a gender difference, in favor of males in the completion of a tertiary degree that corresponds to a two years programme (i.e. less than a Bachelor). Moreover, we identify no significant gender gap at the exit of the education pipeline, i.e. during the transition from university to the labour market. Hence, unlike Cronin and Roger (1999) we do not find that the lack of women in science is progressive (the farther along the pipeline, the fewer women). Moreover, we find that the scientific nature of the profession of the mother influences significantly her children's choice of pursuing science majors at university, but even more her sons than her daughters. While this means that the classic mother-daughter transmission of occupational values is biased when the profession of the mother is more male-typed, it also highlights the potential snowball effect an increase in the number of scientific women could have in the attraction of both gender for science.

The paper proceeds with the econometric specifications of the analysis in section 2 and an overview of the data in section 3. The results are presented in section 3 and discussed in section 4.

[255] The Baccalauréat, often known in France colloquially as le Bac, is an academic qualification which French and international students take at the end of the lycée (High School) (secondary education). It was introduced by Napoleon I in 1808. It is the main diploma required to pursue university studies.

2. ECONOMETRIC APPROACH

2.1. Family background and science majors

In the French educational system, enrollment to tertiary education is conditioned by the completion of an upper secondary school leaving degree, called "Baccalauréat". There exist three types of Baccalauréats: the *baccalauréat général* (general baccalaureate); the *baccalauréat professionnel* (professional baccalaureate); and the *baccalauréat technologique* (technological baccalaureate). The Baccalauréat general is composed of three streams: sciences (Bac S); economics and social sciences (Bac ES); and literature (Bac L).

We start by estimating the probability of having completed a Bac S as opposed to any other type of Baccalauréat using a probit model. The propensity to have completed a Bac S is an unobserved response variable ϵ scaled so that

$$Y_i = \begin{cases} 0 \text{ when } \epsilon \leq 0 \\ 1 \text{ when } \epsilon > 0 \end{cases} \qquad (1)$$

The latent variable ϵ is assumed to be a linear function of the vector of explanatory variables $\boldsymbol{X}$ and the unobservable error variable ε:

$$\epsilon_i = \alpha + \beta \boldsymbol{X}_i - \varepsilon_i \qquad (2)$$

The probit model estimates α and β in the following way:

$$\pi_i \equiv \Pr(Y_i = 1) = \Pr(\epsilon_i > 0) = \Pr(\alpha + \beta \boldsymbol{X}_i - \varepsilon_i > 0)$$

$$\pi_i = \Pr(\varepsilon_i < \alpha + \beta \boldsymbol{X}_i) = \Phi(\alpha + \beta \boldsymbol{X}_i) \qquad (3)$$

where the errors are independently distributed according to the unit-normal distribution, $\varepsilon_i \sim N(0,1)$.

Our vector $\boldsymbol{X}_i$ of explanatory variables is composed of the age and gender of the respondent, the profession of the father, the profession of the mother (measured both by a dummy taking value 1 if the occupation is science-related and 0 otherwise), an interaction term between the occupational status of the father and the mother to capture the effect of having neither or both parents in a scientific profession. We also control for fixed effects α for the date of completion of the diploma (comprised between 2007 and 2011). We cluster the covariance of our error terms by region of residence to account for geographic structural and institutional specifications.

We continue our analysis with an estimation of the probability of graduating in a science major at college or university. From our sample, we find that in 2011, 39 percent of the 18-30 years old had completed a Baccalauréat. Among the Baccalauréat graduates 52 percent had pursued higher education, of which 7 percent had completed a scientific degree. Among the students having completed science degrees at university, 97 percent had a Bac S. Hence, the completion of a tertiary science degree is far from random.

We estimate the probability of having completed a science degree using a Heckman probit model with sample selection, called *Heckit* model (Van de Ven and Van Pragg, 1981). These models are specific cases of the Heckman model (Heckman, 1979) in which there exists a latent equation

$$y_j^* = \boldsymbol{x_j}\beta + u_{1j} \quad (4)$$

such that we observe only the binary outcome

$$y_j^{probit} = (y_j^* > 0) \quad (5)$$

The matrix $\boldsymbol{x_j}$ is a vector of exogenous covariates, for each individual *j*, affecting the probability of enrolling in sciences. y_j^{probit} takes value 1 if individual *j* reports having completed his or her highest degree in sciences in the four years preceding the time of the interview. It takes value 0 if the individual *j* reports a highest degree in another field than sciences. In the probit model, the inverse standard normal distribution of the probability is modeled as a linear combination of the predictors.

We know that the dependent variable is not always observed because it is strongly conditioned by the probability to have pursued higher education after the Baccalauréat. Instead, the dependent variable for individual *j* is observed only if

$$y_j^{select} = (\boldsymbol{z_j}\gamma + u_{2j} > 0) \quad (6)$$

where $\boldsymbol{z_j}$ is a vector of exogenous covariates affecting the probability of having pursued higher studies and where $u_1 \sim N(0,1)$, $u_2 \sim N(0,1)$ and $corr(u_1, u_2) = \rho$.

While standard probit techniques yield biased results for any estimation of equation (4) for any $\rho \neq 0$, the *Heckit* model provides consistent, asymptotically efficient, estimates for all parameters. In this paper, we estimate the *Heckit* model using the command *heckprobit* in Stata/SE 12.1 (for programme specifications, see Baum, 2006; Lokshin and Newson, 2011).

In this part of our analysis, we are interested in assessing whether there exists a gender difference in the role played by the nature of the job occupied by the father and the mother in the decision to enroll in sciences. As a consequence, in our model, we define the set of $\boldsymbol{z_j}$ covariates, explaining the selection condition (equation 6), as the age (truncated continuous between 18 and 30) and the gender (dummy taking value 1 if female and 0 if male). Because the completion of a Baccalauréat is a *sine qua non* condition for the registration at a French university, the only variation in the probability of pursuing further education is observed among those who have gained a Baccalauréat degree. It is therefore the type of Baccalauréat, rather than the fact of having a Baccalauréat, that will determine the probability of enrolling in university degrees. This choice factor is captured by the categorical variable *bac_type* converted into 0-1 dummy variables for each stream of Baccalauréat (Bac S, Bac ES, Bac L and other)[256].

[256] The selection equation includes one instrument variable that is not included in the $\boldsymbol{x_j}$ matrix, namely the categorical variable on the type of Baccalauréat. The inclusion of at least one exogenous instrument in the selection equation is a *sine qua non* condition for the proper identification of the probit selection model. In the absence of such an instrument the model would be identified only by functional form and the coefficients would have no structural interpretation.

In turn, the probability of enrolling into a science degree (equation 5) is explained by the set of $\boldsymbol{x_j}$ covariates. $\boldsymbol{x_j}$ includes the age and the gender of the respondent, plus the profession of the father, the profession of the mother (as before, measured both by a dummy taking value 1 if the occupation is science-related and 0 otherwise) and an interaction term between the profession of the father and the profession of the mother. We control for fixed effects of the year of graduation (comprised between 2007 and 2011) to account for cohort effects and cluster the covariance of our error terms by region of residence to account for geographic structural and institutional specifications. Finally, we re-run all the set of equations adding regional fixed effects to see whether some of the effects estimated on each of our covariates may be driven by specific regions. We also re-run each equation stratifying by gender to identify potential differences across gender in the way each parental variable affects the outcome variable.

2.1. Science majors and employment

We estimate the role played by the level of the science degree in the probability of having a science-oriented occupation. In this case, our model suffers a sampling selection bias due to the filtering of the sample to those who graduated in science. We therefore complement our probit model with a Heckit model in which the selection equation is the probability of having a science degree, defined as a function of the age and gender of the respondent and of the scientific orientation of the profession of the parents. The propensity to be employed at a scientific occupation is estimated as a function of the age and gender of the respondent, a dummy variable for science that takes value 1 if the respondent's highest degree was in science and 0 otherwise. We control for fixed effects α for the date of completion of the diploma (comprised between 2007 and 2011) and cluster the covariance of our error terms by region of residence to account for geographic structural and institutional specifications.

Table 1 Summary statistics for the sample used to estimate science attainment

	All		Female		Male	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Science degree	0.08	0.2652	0.07	0.2553	0.08	0.2770
Female	0.55	0.4970				
Baccalauréat s (bac s)	0.54	0.4986	0.43	0.4956	0.69	0.4635
Age [18;30]	24.34	2.5226	24.36	2.4925	24.32	2.5596
Scientific_job father	0.03	0.1669	0.03	0.1794	0.02	0.1497
Scientific_job mother	0.03	0.1704	0.03	0.1685	0.03	0.1726
Parents' csp_avg [0;82]	47.79	14.6171	47.86	14.6233	47.71	14.6103
Degree level						
<Bachelor (bac+2)	0.01	0.1027	0.01	0.0911	0.01	0.1156
Bachelor (bac+3)	0.02	0.1281	0.02	0.1318	0.02	0.1234
Master 1 (bac+4)	0.01	0.1171	0.01	0.1143	0.01	0.1206
Master 2 (bac+5)	0.02	0.1414	0.02	0.1339	0.02	0.1502
Grande école	0.00	0.0662	0.00	0.0527	0.01	0.0799

	All		Female		Male	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Phd (Bac+8)	0.01	0.0997	0.01	0.0983	0.01	0.1016
Year of Highest Degree						
2007	0.18	0.3811	0.17	0.3758	0.18	0.3868
2008	0.21	0.4047	0.21	0.4052	0.21	0.4042
2009	0.23	0.4195	0.23	0.4230	0.22	0.4156
2010	0.26	0.4402	0.26	0.4406	0.26	0.4399
2011	0.13	0.3324	0.13	0.3318	0.13	0.3328
Region of Residence						
Ile-de-France	0.26	0.4406	0.27	0.4455	0.25	0.4343
Champagne-ardenne	0.02	0.1505	0.02	0.1499	0.02	0.1513
Picardie	0.02	0.1529	0.03	0.1634	0.02	0.1387
Haute-normandie	0.03	0.1563	0.02	0.1555	0.03	0.1572
Centre	0.03	0.1729	0.03	0.1731	0.03	0.1726
Basse-normandie	0.02	0.1485	0.02	0.1490	0.02	0.1480
Bourgogne	0.02	0.1532	0.02	0.1516	0.02	0.1551
Nord-Pas de Calais	0.07	0.2543	0.07	0.2574	0.07	0.2504
Lorraine	0.04	0.1875	0.03	0.1830	0.04	0.1930
Alsace	0.04	0.2007	0.04	0.1949	0.05	0.2077
Franche-comté	0.02	0.1398	0.02	0.1463	0.02	0.1313
Pays de la Loire	0.05	0.2216	0.05	0.2180	0.05	0.2261
Bretagne	0.04	0.2028	0.05	0.2130	0.04	0.1892
Poitou-charentes	0.02	0.1296	0.02	0.1266	0.02	0.1332
Aquitaine	0.04	0.2005	0.04	0.2067	0.04	0.1925
Midi-pyrénées	0.04	0.2071	0.04	0.2033	0.05	0.2118
Limousin	0.02	0.1382	0.02	0.1266	0.02	0.1513
Rhône-alpes	0.10	0.2971	0.09	0.2870	0.11	0.3091
Auvergne	0.02	0.1243	0.01	0.1201	0.02	0.1294
Languedoc-roussillon	0.03	0.1658	0.03	0.1618	0.03	0.1707
Provence-alpes-côte-d'azur	0.06	0.2308	0.05	0.2272	0.06	0.2351
Corse	0.00	0.0465	0.00	0.0486	0.00	0.0437
Number of obs	46340		23466		22874	
Uncensored obs	12936		7178		5758	
Censored obs	33404		16288		17116	

In our 2011 sample, 10 percent of the science graduates stopped after two years of studies, i.e. at a level inferior to a BA degree (9 percent of girls vs. 12 percent of boys); 13 percent stopped after a BA (13 percent of girls vs. 12 percent of boys); 12 percent after the first year of Master (11 percent of girls and 12 percent of boys); 14 percent after the second year of Master (13 percent of girls vs. 15 percent of boys); 7 percent graduated from a Grande école (5 percent of girls vs. 8 percent of boys) and 10 percent completed a PhD (equally distributed among girls and boys) (see Table 2 for details).

Table 2 Summary statistics for the sample used to estimate employment

	All		Female		Male	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Employed	0.88	0.3257	0.88	0.3255	0.88	0.3259
Scientific_job	0.051	0.2210	0.056	0.2304	0.046	0.2091
Female	0.55	0.4972				
Age [18;30]	24.37	2.5173	24.40	2.4860	24.36	2.5555
Science degree	0.042	0.2006	0.039	0.1926	0.046	0.2100
Scientific_job father	0.029	0.1684	0.034	0.1814	0.023	0.1506
Scientific_job mother	0.029	0.1677	0.028	0.1664	0.030	0.1693
Level of Science degree						
<Bachelor (bac+2)	0.005	0.0691	0.005	0.0680	0.005	0.0704
Bachelor (bac+3)	0.009	0.0926	0.010	0.0998	0.007	0.0828
Master 1 (bac+4)	0.005	0.0709	0.005	0.0691	0.005	0.0731
Master 2 (bac+5)	0.012	0.1100	0.009	0.0935	0.016	0.1274
Grande école	0.002	0.0480	0.001	0.0352	0.004	0.0603
Phd (Bac+8)	0.009	0.0940	0.00	0.0396	0.009	0.0935
Year of Highest Degree						
2007	0.17	0.3748	0.16	0.3691	0.17	0.3817
2008	0.17	0.3756	0.18	0.3807	0.16	0.3692
2009	0.21	0.4099	0.22	0.4116	0.21	0.4077
2010	0.29	0.4554	0.29	0.4554	0.29	0.4556
2011	0.15	0.3607	0.15	0.3590	0.15	0.3602
Region of Residence						
Ile-de-France	0.26	0.4404	0.27	0.4422	0.26	0.4419
Champagne-ardenne	0.02	0.1509	0.02	0.1486	0.02	0.1466
Picardie	0.03	0.1562	0.03	0.1724	0.02	0.1410
Haute-normandie	0.02	0.1554	0.03	0.1607	0.03	0.1613
Centre	0.03	0.1717	0.03	0.1697	0.03	0.1662
Basse-normandie	0.02	0.1495	0.02	0.1448	0.02	0.1497
Bourgogne	0.02	0.1522	0.02	0.1536	0.02	0.1549
Nord-Pas de Calais	0.07	0.2579	0.08	0.2654	0.07	0.2518
Lorraine	0.04	0.1890	0.03	0.1797	0.04	0.2028
Alsace	0.04	0.2050	0.04	0.1862	0.05	0.2132
Franche-comté	0.02	0.1434	0.02	0.1560	0.02	0.1386
Pays de la Loire	0.05	0.2196	0.05	0.2218	0.05	0.2255
Bretagne	0.04	0.2021	0.05	0.2115	0.03	0.1804
Poitou-charentes	0.02	0.1279	0.02	0.1303	0.02	0.1291
Aquitaine	0.04	0.1931	0.04	0.1998	0.03	0.1688
Midi-pyrénées	0.04	0.2061	0.04	0.2042	0.05	0.2182
Limousin	0.02	0.1384	0.02	0.1251	0.02	0.1481
Rhône-alpes	0.10	0.2963	0.09	0.2923	0.11	0.3091

	All		Female		Male	
Variable	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Auvergne	0.02	0.1259	0.02	0.1259	0.02	0.1282
Languedoc-roussillon	0.03	0.1710	0.03	0.1647	0.03	0.1662
Provence-alpes-côte-d'azur	0.05	0.2278	0.05	0.2194	0.05	0.2221
Corse	0.002	0.0414	0.00	0.0420	0.00	0.0218
Number of obs	11672		6458		5214	
Uncensored obs	490		249		241	
Censored obs	11182		6209		4973	

The Grandes écoles (literally in French "Grand School" or "Elite School") of France are higher education establishments outside the main framework of the French university system. The Grandes écoles select students for admission based chiefly on national ranking in competitive written and oral exams. In contrast, French public universities have a legal obligation to accept all candidates of the region who hold a Baccalauréat. Usually candidates for the national exams have completed two years of dedicated preparatory classes, although this is not always the case. Some Grandes écoles concentrate on a single subject area, such as engineering, sciences or business. They are recognized as equivalent to a Master degree. Because of their specific professional content, we categorize them separately in our model to make a clearer distinction between their potential outcomes.

Finally, as before, we re-run all the set of equations adding regional fixed effects and then stratifying by gender. In this paper, we present the results for the full sample and by gender after controlling for regional fixed effects.

3. DATA: FRENCH EMPLOYMENT SURVEY 2011

We use the anonymized microdata from the French Labour Force Survey of 2011. Conducted by the INSEE (French National Institute of Statistics and Economic studies) since 1950, the Labour Force Survey is the statistical source used to measure unemployment as defined by the International Labour Organization (ILO). It also provides detailed data on the educational attainment, the occupational status, the family background and work conditions. Since 2003, the Labour Force Survey has been quarterly and the data has been collected from a sample of households on an ongoing basis each week in the course of the quarter. For this paper, we make use of its annually aggregated version for 2011.

Descriptive statistics about the sample used for the analysis of science attainment (i.e. probability of a scientific Baccalauréat and probability of a science major at university) are depicted in Table 1. The sample used to estimate the probability of employment in science and the returns to science professions is presented in Table 2.

Among the 8 percent of adults that declared having completed a science university degree between 2007 and 2011 (aged between 18 and 30 years old), 54 percent hold a scientific Baccalauréat (Bac S). In our sample, the distributions of all variables of interest are perfectly balanced across gender, except for the share of Bac S holders which is higher among men than women (69 percent vs. 43 percent). Women represent 55 percent of our sample. The largest share of respondents (26 percent) lives in the region Ile-de-France, which is the region of the capital city Paris. The second most represented region in our sample (10 percent) is the region of the city of Lyon (Rhone-Alpes). This regional bias is captured in our model in two ways. First, through the application of a clustering of the variance of the error terms at the regional level, to take into account the lack of variability within regions. Second, through the use of regional fixed effects, to estimate within the model the size of the variation in the outcome variable that is captured by regional settings.

In the French educational system, the Bac+2 degrees include the BTS (Brevet de Technicien Supérieur), the DUT (Diplôme Universitaire de Technologie) and the DEUG (Diplôme d'Etudes Universitaires Générales). The last one is progressively disappearing with the launch in 2003-2004 of the LMD (Licence, Master, Doctorat) reform of the classification of university degrees in response to the standardization of the degrees in Europe imposed by the Bologna Process. At the time of the survey used in this paper (2011), the majority of the students leaving tertiary education with a 2-year degree have therefore mainly completed a BTS or a DUT degree[257], which are both vocational degrees aiming at a fast and smooth insertion into the labour market. Among the Bac S laureates, about 6.5 percent enroll in a BTS and 12.5 percent in a DUT every year.

4. RESULTS

The first part of our analysis consisted in estimating potential gender differences in the attainment of science. From Table 3 we see that the odds for a female to have completed a scientific Baccalauréat in High School are significantly lower than for males. While the scientific nature of the occupation of the father and of the mother have both a positive impact on the scientific attainment of their children (either boy or girl), we find that the mother's scientific occupation plays an even stronger role than the one of the father. Thus, we find no gender difference in the way the parental occupation affects the child's science attainment. Instead, we find a gender difference across parents about their role model, in favour of mothers. These results hold after controlling for an interaction term between the father and the mother's scientific occupation and fixed effects of the region and year of highest graduation.

The second step of our analysis consisted in estimating the probability of completing a science major after high school. Table 4 synthesizes the results. We find no gender effect in the probability of pursuing university studies after high school (see selection equation estimates in the lower part of the tables). But we do find a significant gender effect in the probability of completing a science major in favour of male (see column (1), Table 4). This gender bias is

[257] The science-oriented BTS train for the following professions: Biomedical analyst, Technical Support Engineer, Assays and controls, Biotechnology, Chemist, Dietary, Surveyor, Optician, IT services organizations, Computers and networks for industry and technical services, audiovisual professions. The science-oriented DUT cover fields as diverse as Chemistry, Bioengineering, Chemical engineering, Civil engineering, Electrical engineering and Industrial informatics, Industrial engineering and maintenance, Mechanical and production engineering, Thermal engineering and energy, Health, safety and environment, IT, etc.

especially true for those who did not complete a degree higher than a two-year post Baccalauréat degree (see columns (4), Table 4). For any degree at Bachelor level or beyond, we find no gender difference in the probability of graduating in science (see columns (7), (10), (13) and (16), Table 4). This means that, at tertiary level, the gender gap is true only for short-term vocational degrees.

Table 3 Results for the probability of having a scientific Baccalauréat (Bac S): Probit estimates

Scientific baccalaureat						
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variables	**All**	**Female**	**Male**	**All**	**Female**	**Male**
Age	-0.00408	-0.0131	0.00882	-0.00291	-0.0112***	0.00995**
	(0.00730)	(0.0111)	(0.00581)	(0.00321)	(0.00423)	(0.00504)
Female	-0.548***			-0.551***		
	(0.0226)			(0.0187)		
Scientific_father	0.279***	0.275***	0.298**	0.277***	0.270***	0.301***
	(0.0516)	(0.0696)	(0.126)	(0.0551)	(0.0728)	(0.0856)
Scientific_mother	0.431***	0.445***	0.408***	0.436***	0.454***	0.409***
	(0.0741)	(0.0961)	(0.106)	(0.0556)	(0.0730)	(0.0851)
Scientific_parents	-0.247**	0.0609	-0.579**	-0.275**	0.0345	-0.619***
	(0.120)	(0.293)	(0.229)	(0.129)	(0.174)	(0.183)
Constant	0.568***	0.233	0.257*	0.486***	0.144	0.165
	(0.203)	(0.306)	(0.137)	(0.0852)	(0.111)	(0.132)
Fixed effects						
Year of highest degree	Yes	Yes	Yes	Yes	Yes	Yes
Region of residence	No	No	No	Yes	Yes	Yes
Observations	19.466	11.247	8.219	19.466	11.247	8.219
Log likelihood	-12894	-7705	-5175	-12843	-7673	-5139

Columns (1)-(3): Clustered covariance of errors by region of residence. Columns (4)-(6): Standard errors in parentheses. *** p<0.01. ** p<0.05. *p<0.1.

Table 4 Results for the probability of having a tertiary degree in a science major (all degrees and undergraduate degrees): Heckit estimates

	Science degree			**Less than Bachelor (Bac+2)**			**Bachelor (Bac+3)**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Variables	**All**	**Female**	**Male**	**All**	**Female**	**Male**	**All**	**Female**	**Male**
Age	0.0327***	0.0120	0.0523***	-0.126***	-0.0886***	-0.163***	-0.112***	-0.120***	-0.0978***
	(0.00820)	(0.0110)	(0.0125)	(0.0222)	(0.0256)	(0.0364)	(0.0164)	(0.0215)	(0.0254)
Female	-0.0719**			-0.153**			0.0781		
	(0.0328)			(0.0676)			(0.0570)		
Scientific_father	0.197**	0.317***	-0.0446	0.433**	0.360	0.536**	0.00222	0.168	-4.129***
	(0.101)	(0.122)	(0.179)	(0.179)	(0.270)	(0.232)	(0.193)	(0.205)	(0.106)
Scientific_mother	0.440***	0.358***	0.525***	0.341**	0.205	0.391*	0.461***	0.421**	0.564***

	Science degree			Less than Bachelor (Bac+2)			Bachelor (Bac+3)		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Variables	**All**	**Female**	**Male**	**All**	**Female**	**Male**	**All**	**Female**	**Male**
	(0.0857)	(0.122)	(0.121)	(0.170)	(0.273)	(0.209)	(0.133)	(0.199)	(0.181)
Scientific_parents	0.0760	0.0445	0.220	0.227	0.645	-5.187***	0.427	0.370	4.265***
	(0.209)	(0.265)	(0.332)	(0.334)	(0.431)	(0.452)	(0.321)	(0.393)	(0.409)
Constant	-2.515***	-2.000***	-3.091***	0.626	-0.711	1.754*	0.528	0.667	0.301
	(0.226)	(0.299)	(0.350)	(0.584)	(0.603)	(0.969)	(0.436)	(0.555)	(0.690)
Selection equation : Higher Education									
Age	0.414***	0.431***	0.397***	0.414***	0.432***	0.397***	0.414***	0.432***	0.397***
	(0.00528)	(0.00797)	(0.00697)	(0.00528)	(0.00807)	(0.00696)	(0.00530)	(0.00822)	(0.00697)
Female	-0.0154			-0.00984			-0.0104		
	(0.0174)			(0.0173)			(0.0173)		
Constant	-9.565***	-9.980***	-9.167***	-9.574***	-9.995***	-9.165***	-9.572***	-9.991***	-9.166***
	(0.115)	(0.174)	(0.151)	(0.115)	(0.176)	(0.151)	(0.116)	(0.180)	(0.151)
Athrho	0.265***	0.342***	0.177***	0.236***	0.265***	0.204***	0.172***	0.177***	0.191***
	(0.0236)	(0.0300)	(0.0429)	(0.0442)	(0.0465)	(0.0748)	(0.0330)	(0.0341)	(0.0675)
Observations	46.340	23.466	22.874	46.340	23.466	22.874	46.340	23.466	22.874
Rho	0.259	0.330	0.175	0.232	0.259	0.201	0.170	0.175	0.188
Log likelihood	-17356	-8880	-8413	-14634	-7425	-7151	-14978	-7702	-7218

Robust standard errors in parentheses. *** p<0.01. ** p<0.05. * p<0.1. Fixed effects included in the selection equation: Type of Baccalauréat (S. L. ES or Technological). Fixed effects included in the output equation: Year of highest degree (2007. 2008. 2009. 2010. 2011) and Region of residence.

Table 4 Results for the probability of having a tertiary degree in a science major (graduate degrees): Heckit estimates

	Master 1 (Bac+4)			Master 2 (Bac+5)			Phd (Bac+8)		
	(10)	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**	**(16)**	**(17)**	**(18)**
VARIABLES	**All**	**Female**	**Male**	**All**	**Female**	**Male**	**All**	**Female**	**Male**
Age	-0.0170	-0.0555**	0.0133	0.0836***	0.0659***	0.0772***	0.205***	0.178***	0.256***
	(0.0145)	(0.0248)	(0.0195)	(0.0114)	(0.0159)	(0.0214)	(0.0154)	(0.0203)	(0.0301)
Female	-0.0368			-0.0784			-0.0244		
	(0.0591)			(0.0511)			(0.0704)		
Scientific_father	0.0186	-0.312	0.321	0.0769	0.235	-0.346	0.393**	0.718***	-7.013
	(0.193)	(0.337)	(0.248)	(0.164)	(0.185)	(0.379)	(0.165)	(0.179)	(0)
Scientific_mother	0.628***	0.786***	0.433**	0.261**	-0.518	0.650***	-0.387	-0.0405	-6.595***
	(0.126)	(0.161)	(0.210)	(0.132)	(0.351)	(0.163)	(0.263)	(0.284)	(0.995)
Scientific_parents	0.0848	-0.189	0.319	-4.656***	-10.05	-6.768***	-5.436***	-4.806***	-4.700
	(0.312)	(0.549)	(0.423)	(0.221)	(0)	(0.493)	(0.340)	(0.365)	(0)
Constant	-1.999***	-0.837	-3.080***	-4.402***	-3.726***	-4.602***	-7.888***	-7.482***	-9.261***
	(0.409)	(0.673)	(0.565)	(0.314)	(0.438)	(0.587)	(0.417)	(0.573)	(0.830)
Selection equation : Higher Education									
Age	0.414***	0.432***	0.397***	0.414***	0.431***	0.397***	0.414***	0.432***	0.397***

	(0.00529)	(0.00799)	(0.00696)	(0.00532)	(0.00797)	(0.00698)	(0.00529)	(0.00810)	(0.00696)
Female	-0.0102			-0.0100			-0.00908		
	(0.0173)			(0.0173)			(0.0173)		
Constant	-9.573***	-9.993***	-9.166***	-9.572***	-9.989***	-9.171***	-9.575***	-9.996***	-9.166***
	(0.115)	(0.174)	(0.151)	(0.116)	(0.174)	(0.151)	(0.115)	(0.177)	(0.151)
Athrho	0.127***	0.224***	0.0200	0.0864**	0.240***	-0.224**	-0.0624	0.00683	-0.209**
	(0.0256)	(0.0373)	(0.0514)	(0.0409)	(0.0468)	(0.0960)	(0.0487)	(0.0521)	(0.100)
Observations	46.340	23.466	22.874	46.340	23.466	22.874	46.340	23.466	22.874
Rho	0.127	0.221	0.0200	0.0862	0.235	-0.220	-0.0623	0.00683	-0.206
Log likelihood	-14859	-7576	-7216	-15203	-7738	-7383	-14575	-7442	-7058

Robust standard errors in parentheses. *** p<0.01. ** p<0.05. * p<0.1. Fixed effects included in the selection equation: Type of Baccalauréat (S. L. ES or Technological). Fixed effects included in the output equation: Year of highest degree (2007. 2008. 2009. 2010. 2011) and Region of residence.

The lower likelihood for girls than boys to have completed, as highest degree, such vocational degrees could be viewed in terms of (i) a higher incline of females for longer science studies; (ii) a higher gender discrimination by the more vocational degrees; or (iii) a stronger gender-typing of the occupations targeted by these degrees. Unfortunately, our data does not allow us to conclude on that point, but our results highlight a situation that would deserve further investigation.

Another interesting outcome of our analysis is the fact that, in France, the choice of a science major versus any other major proves to be strongly driven by the mother's occupational status, independently of the gender of the child. We find that the scientific nature of the profession of the mother influences even more the sons than the daughters in their choice of pursuing science majors at university. The only exception is observed for the Master 1 graduates (columns (10) to (12), Table 4), for which the mother's occupation drives more the daughters' decision than the sons'. Our results confirm to some extend the findings by Kleinjans (2010) that the socio-economic background of the parents influences more the sons' educational expectations than the daughters'. Still, the significant cross-gender differences we observe in the degree of influence of parents on children's educational choices questions the findings from previous studies. The fact that mothers' influence is stronger on their sons' than on their daughters' decisions may be driven by the masculine gender-typing of the scientific occupations, which blurs the gender roles. It is worth noticing that in the specific case of PhD degrees, the mothers play a negative role on their sons' choices. It is the only case for which we observe a negative impact of the scientific occupation of the mother on her children's likelihood to complete a science major.

Moreover, we find that the scientific nature of the fathers' occupation plays a limited role in the probability of completion of a scientific degree compared to the mothers', which is a non-expected result. Especially, the fact that it has a significant influence on the probability of completion of a PhD degree only for the daughters (column (17), Table 4)[258], and none for the sons, questions the father-son correlation observed so far in the literature.

Our analysis demonstrates the importance of controlling for both the father and the mother's occupational status in intergenerational transmission of human capital in order to truly identify the means of transmission. The predominant role of the mothers in our estimates confirms the virtuous impact of a feminization of the scientific stream on the attraction and retention of more boys and girls into science majors.

Table 5 Results for the probability of being employed at a scientific occupation: Heckit estimates

	Scientific Profession		
	(1)	**(2)**	**(3)**
Variables	**All**	**Female**	**Male**
Age	-0.072**	-0.177**	-0.046
	(0.028)	(0.065)	(0.028)
Female	0.203		
	(0.131)		
Level of the university degree (Reference category: lower than Bachelor (Bac+2))			
Bachelor (bac+3)	-0.131	-0.560	1.233*
	(0.175)	(0.462)	(0.525)
Master 1 (bac+4)	0.436	0.855	1.520*
	(0.253)	(0.607)	(0.599)
Master 2 (bac+5)	0.447	0.884	1.663**
	(0.277)	(0.527)	(0.585)
Grandes écoles	0.108	-2.622***	1.438*
	(0.202)	(0.597)	(0.583)
Phd (Bac+8)	1.280***	2.299**	2.389***
	(0.368)	(0.742)	(0.665)
Constant	3.053***	5.046***	1.294
	(0.649)	(1.187)	(1.150)
Selection equation: science degree			
Age	0.058***	0.033	0.082***
	(0.014)	(0.022)	(0.016)
Female	-0.079		
	(0.078)		
Scientific_father	0.027	0.185	-0.246
	(0.108)	(0.147)	(0.236)
Scientific_mother	0.433**	0.394	0.488**
	(0.140)	(0.226)	(0.151)

[258] Note: the coefficients estimated by the Heckit model in columns (12), (16) and (17) of Table 4 may be slightly biased by a lack of correlation between the error terms of the selection equation and the outcome equation (see the absence of statistical significance of the Athrho parameter at the bottom of these three columns). This bias affects only the size of the coefficient of the estimated parameters, not their level of significance.

	Scientific Profession		
	(1)	**(2)**	**(3)**
Variables	**All**	**Female**	**Male**
Constant	-3.128***	-2.602***	-3.728***
	(0.375)	(0.537)	(0.393)
Athrho	-1.904***	-1.022**	-2.060***
	(0.357)	(0.317)	(0.511)
Observations	11.672	6.458	5.214
Log likelihood	-2174	-1133	-1021
Rho	-0.957	-0.771	-0.968

Robust standard errors in parentheses. *** p<0.01. ** p<0.05. * p<0.1. Fixed effects included in the output equation: Year of highest degree (2007. 2008. 2009. 2010. 2011) and Region of residence.

The third step of our analysis aimed at identifying potential gender biases in the probability of being employed at a scientific occupation after having completed a science degree. As depicted in Table 5, we find no evidence of any gender differences in that case (column (1), Table 5). We find that the mother's occupation plays an indirect role on the sons' occupational choices through their educational choices[259]. Interestingly, a degree from a Grande école decreases significantly the likelihood of a scientific career for women (column (2), Table 5). Moreover, we observe a positive correlation between the level of the science degree and the probability of having a scientific position only for men (column (3), Table 5). For women, we find no statistically significant difference between having a Bachelor degree or a Master degree compared to a Bac+2 degree. Only a PhD degree makes a significant positive difference in the likelihood of a scientific career. This result can be interpreted as a sign that women tend to integrate scientific positions only at the highest level of competences, while men occupy a wider skills-range of scientific occupations.

Thus, from these results we find no clear evidence of any objective educational or professional disincentive for women to pursue scientific studies and careers.

5. CONCLUSIONS

This paper aimed at investigating the nature of the relationship between girls and science in the specific context of France and our results provide new insights into the reasons that might explain the relatively lower share of women in sciences. Our analysis started from the fact that there is evidence that the science stream can be assimilated to a 'leaking pipeline' with regard to girls in most occidental countries (Cronin and Roger, 1999). We tested the validity of that hypothesis in France using the French Labour Force Survey of 2011. More specifically, we investigated the role of the parents' occupation in the educational and professional choices made by their children. We also investigated the validity of the hypothesis that women have a lower probability of working at an occupation that matches their studies than men.

[259] Unlike Aschaffenburg (1995), our model does not allow us to make any direct inference between the parents' occupation and the children's occupation.

After controlling for the influence of the family background, we found that the French gender gap in science is mainly due to a filter at the entrance level of the pipeline, which means to a problem of attractiveness of science for girls at the school level. The main influential factor turned out to be parents' occupational status. Among those who do proceed into science majors at university level, we find no significant gender differences in the probability of graduating at the Bachelor, Master or PhD level. We only find a gender difference, in favor of males in the completion of the lowest tertiary degrees (Bac+2). Moreover, we identify no significant gender gap at the exit of the education pipeline, i.e. during the transition from university to the labour market. Hence, unlike Cronin and Roger (1999), we do not find that the leak of women from science is progressive (the farther along the pipeline, the fewer women). Instead, we find that, after controlling for the selection into university studies and the high-school major, there are no significant differences between men and women's likelihood to proceed along the different levels of the science pipeline, nor in their likelihood to be hired at a scientific occupation.

Among the hypotheses we tested was the mother-daughter and father-son intergenerational transmission of education and occupation. We found that the scientific nature of the profession of the mother influences more significantly her children's choice of pursuing science majors at university than the profession of the father. More interestingly, we found that this influence of the mother is even stronger on the sons than on the daughters. This means that the classic mother-daughter transmission of occupational values is biased when the profession of the mother is more male-typed. Hence, increasing the number of scientific women should yield an increase in the number of pupils of both genders choosing science subjects and majors.

Finally, we found no statistical differences between genders in the probability of working as a scientist after having graduated at the highest level in science. The main gender differences are observed at the undergraduate level, which reveals a slight bias in favor of men in the probability of occupation-education matching. However, our results can by no means support the hypothesis of the existence of gender discriminations on the labour market that could justify the lack of attractiveness of scientific career for women.

Therefore, overall, the only hypothesis that could be validated in the case of France to explain the current gender gap in scientific occupations is the existence of a filter at the entrance level of the science education pipeline, which reflects a failure of the compulsory educational system to attract girls into science majors. This bottleneck issue, although not negligible, is still more manageable than the progressive pipeline leak observed in other occidental countries. While it is difficult, if not impossible, to exogenously influence the parent-children transmissions of gender values; France may widen up this bottleneck, and increase the number of girls graduating in science, simply by redefining the pedagogical approaches and textbooks developed by its Ministry of Compulsory Education in a less gender-typed mode. Given the lack of leaks at the higher education level and during the transition phase to the labour market, such an investment would most likely yield positive returns.

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