Graduates' opium? Cultural values, religiosity and gender segregation by field of study*

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Abstract

This paper studies the relationship between cultural values and gender distribution across fields of study in higher education. I compute national, field and subfield-level gender segregation indices for a panel dataset of 26 OECD countries for 1998-2012. This panel dataset expands the focus of previous macro-level research by exploiting data on gender segregation in specific subfields of study. I consider two focal cultural traits: gender equality and religiosity, and control for potential segregation factors, such as labour market and educational institutions, and aggregate-level gender disparities in math performance and beliefs among young people. The estimates fail to associate gender equality measures with gender segregation in higher education. Religiosity is significantly associated with lower gender segregation in higher education. However, gender gaps in math beliefs seem to be stronger predictors of national-level gender segregation. Field and subfield-level analyses reveal that religiosity is associated with less gender-segregated fields of education, science, and health, and specifically with the subfield of social services.

Keywords: horizontal gender segregation, higher education, cultural values, religiosity, math beliefs, association index.

JEL: A13, I24, J16

*The title pays tribute to one of the main references of the paper, *People's opium? Religion and economic attitudes* by Guiso et al. (2003) in J. Monet. Econ.

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1 Introduction

Women currently outnumber men in virtually all higher education systems in Western countries. Nevertheless, women and men are strikingly concentrated in specific fields of study. This horizontal gender segregation in higher education results in the over-representation of women in some specific fields (generally in care and humanistic-related fields) and the over-representation of men in others (generally, in technical and science-related fields) (Barone, 2011).

Horizontal gender segregation in education is considered an issue of first-order importance insofar as it shapes the skill composition of the future workforce (Altonji et al., 2015) and thus may represent a hurdle for labour market productivity gains and economic development (Dollar and Gatti, 1999; Knowles et al., 2002). Furthermore, gender segregation in education accounts for a notable share of the gender wage gap (Brown and Corcoran, 1997; Blau and Kahn, 2000; Bobbitt-Zeher, 2007). Indeed, the female shortfall in the fields of science, technology, engineering, and math (STEM) has recently attracted the attention of scholars (Sassler et al., 2017; Card and Payne, 2017; Kahn and Ginther, 2017) and is a major concern in educational and labour market policy-making (EIGE, 2014; SheFigures, 2012).

Social scientists from different disciplines point to socio-economic factors, such as gender differentials in career and family aspirations, gender-based discrimination, and cultural values as major causes of horizontal gender segregation in education (Ceci et al., 2014). Yet, the theories of horizontal gender segregation in education have not been systematically examined using actual trends (Mann and DiPrete, 2013). Bertrand (2017) argues that the scarcity of women on particular educational tracks might be partly driven by constraints expected by women in the jobs associated with those tracks, and highlights the need for further research to help understand the full set of determinants of current gender disparities in educational outcomes.

This paper seeks to close this gap by focusing on the role that cultural values play in horizontal gender segregation in higher education from a cross-country time-series econometric approach. Anti-egalitarian gender attitudes have previously been found to slowdown gender convergence in labour market outcomes (Fortin, 2005). The literature also associates religiosity with more traditional gender roles and less favourable attitudes towards working women (Guiso et al., 2003; Algan and Cahuc, 2006). These accounts motivate the current paper to assess the impact of two focal cultural values, namely gender-egalitarian social norms and levels of religiosity, on the gender distribution of higher education graduates across fields of study.

To map segregation trends, I combine national-level measures of gender segregation with disaggregated indices of gender segregation in 9 fields and 23 subfields of study for a panel of 26 Organisation for

Economic Co-operation and Development (OECD) countries for 1998-2012. This combination of data allows us to uncover patterns of gender segregation that remain concealed when aggregate data on higher education are used. Hence, I am able to identify the precise fields and subfields that drive national-level gender segregation. Cases in point are of agriculture, a generally male-dominated field made up of a highly male-dominated subfield (*agriculture, forestry and fishery*) and a highly female-dominated subfield (*veterinary*), among other fields of study.

I link the data on horizontal gender segregation in higher education with information on two focal cultural traits: gender equality and religious beliefs. I measure country-level gender equality -or the lack thereof- by means of either the Gender Inequality Index of the United Nations Development Programme (UNDP) or the Gender Equality index of the International Institute for Democracy and Electoral Assistance (IDEA). I use the level of religiosity obtained from five waves (1990-94; 1995-98; 2000-04; 2004-09; 2010-2014) of the World Value Survey (WVS) as a measure of the extent to which social norms are attached to traditional gender roles (Inglehart, 2014).

To isolate the impact of cultural values, I control for economic structural changes, labour market and education system features, along with marriage market indicators, such as fertility and divorce rates, as potential determinants of gender disparities in education choices. Finally, I attempt to control for gender gaps in academic performance and self-reported math beliefs among young people that might relate to choices at later stages of their education (Ceci et al., 2014; Eccles and Wang, 2016). I use two waves of survey data (2003 and 2012) collected from the Programme for International Student Assessment (PISA) to construct aggregate indices of gender differences in anxiety, self-concept and self-efficacy towards mathematics.

The main finding suggests that there is a significant relationship between religiosity and lower levels of gender segregation. The indices of gender equality or inequality are not found to be significantly related to horizontal gender segregation. Gender gaps in math beliefs among young people are found to be correlated with higher gender segregation, which hints at an important link between attitudes acquired in early stages of the life-time and later education choices. Field and subfield-specific analyses provide a bigger picture of these correlations. The disaggregated results suggest that religiosity might be conducive to lower gender segregation in the fields of agriculture and health and welfare, and more specifically in the subfields of *mathematics and statistics*, *agriculture, forestry and fishery* and *social services*.

The remainder of the paper is structured as follows. Section 2 provides reasons for considering a link between culture and gender segregation. Section 3 describes the data. Section 4 specifies the empirical strategy. Section 5 shows national, field and subfield-level results. Section 6 concludes.

2 Gendered choices of field of study

Standard economic literature considers the choice of major as a dynamic process of decision-taking under uncertainty in which individuals make assumptions so as to infer the outcomes of their specific, field-of-study choices (Altonji, 1993; Arcidiacono, 2004; Zafar, 2013). Those assumptions may include neoclassical economic explanations such as foreseen family burdens and discrimination to explain gender disparities in education choices[1]. Experimental economics, for its part, seems to debunk the often-repeated arguments of innate gender differentials in cognitive skills by showing that gender gaps in risk-taking, competitive-leaning and social beliefs drive gendered choices of fields of study (Croson and Gneezy, 2009; Buser et al., 2014).

Parallel to these explanations, economic research on cultural values emphasizes the role of gender identity and social norms in shaping the economic behaviour of people (Guiso et al., 2006; Blau et al., 2013; Giuliano, 2017)[2]. The shift from traditional to egalitarian social norms regarding gender roles has paved the way towards gender convergence in educational investment and labour market outcomes (Fortin, 2005; Mandel and Semyonov, 2006). On this bedrock of cultural values, Guiso et al. (2003) affirms that religion is likely to affect every aspect of life in society. Using World Value Survey data, they associate religiosity with less favourable attitudes towards working women. Algan and Cahuc (2006) assess the attachment of religion to traditional family values that favour a male breadwinner division of labour. They document differences between religion denominations, in which Catholics and Muslims are more likely to agree with traditional gender role prescriptions than Protestants or non-religious people. Based on these different prescriptions on the role of working women across societies, one might consider that culture can either encourage or hinder gender divergence in choices of major in higher education.

The epidemiological methodology developed in Fernández (2008) reinforces the explanatory power of the intergenerational transmission of gender norms on gender disparities in both individual and constrained preferences in the labour market and educational choices (Farré and Vella, 2013; van de Werfhorst, 2017; Charles et al., 2018). However, the role of culture has not been addressed in international comparisons of horizontal gender segregation in education in depth due to scarcity of data available. Drawing on the empirical evidence supporting the idea that economic outcomes and social beliefs are correlated

[1] The canonical arguments of gender segregation are framed in rational choice theory and are divided into demand-side factors (Mincer and Polachek, 1974) and supply-side factors (Becker, 1957). For recent research see Goldin (2006, 2014a,b)

[2] Akerlof and Kranton (2000) provide a game theoretical model that defines an identity-based utility of individual choices. Obeying social prescriptions of one's identity as a "man" or as a "woman" is rewarded while violating them evokes anxiety and discomfort. Hence, this model defines non-pecuniary benefits derived from the choice of educational paths, as formulated for instance by Humlum et al. (2012) and Beffy et al. (2012).

(Fernández, 2011), the current paper considers whether cultural values (e.g. gender equality and religion) play a role in horizontal gender segregation in higher education.

Gender segregation explanations drawn from prior mathematical achievement have been steadily replaced by findings suggesting that gender disparities in perceived ability have stronger effects (Friedman-Sokuler and Justman, 2016; Justman and Méndez, 2018). Eccles and Wang (2016) use survey data on 1,200 college-bound students in Michigan (U.S.) to study whether their self-concept of math ability in 12th-grade (age 17-18) encouraged them to choose STEM occupations at age 29. Their results indicate that gender differences in the likelihood of entering STEM careers were strongly predicted by math self-concept, together with lifestyle expectations, demographics and high school course-taking, rather than by actual math performance. In a similar vein, Shi (2018) uses data in the transition from high school to college for North Carolina (U.S.) to study female under-representation in engineering. She finds that the scarcity of women in engineering is partly explained by their relative lack of confidence in math abilities, but she finds gender disparities in preferences and professional goals to have stronger explanatory power. Ultimately, these analyses disentangle the segregative effects of sex differences in preferences and aspirations from those arising from disparities in math performance and math-ability perceptions.

This paper adopts a macro-level approach grounded on two earlier works on gender segregation across fields of study: First, the paper by Charles and Bradley (2009), which uses a cross-country analysis of gender segregation in four fields of study for 44 countries in 1999; and second, the panel data analysis of US graduates in 225 fields between 1975-2002 by England and Li (2006). I depart from these previous papers by conducting a panel data analysis of gender segregation at national, field and subfield levels and focusing on cultural values while using more nuanced measures of gender gaps in math beliefs. Hence, my approach is intended to tackle both within-country time dynamics of segregation and by-subfield heterogeneity within gender-dominated fields (e.g. *veterinary* versus *forestry* within agriculture).

Due to data limitations, I can only test macro-level relationships between cultural values and horizontal gender segregation in higher education. Cohort-data research finds gender differentials in education outcomes on the basis of demographics, such as immigration (Alonso-Villar et al., 2012), socioeconomic status (Bailey and Dynarski, 2011; van de Werfhorst, 2017), parents' educational attainment and labor market participation rates (Fernández, 2013; Farré and Vella, 2013), role models of teachers and parental expectations (Bettinger and Long, 2005; Xie et al., 2003), and peer-related processes (Schoon and Eccles, 2014). The potential intersection between gender and demographics is left for future research.

3 Data on Gender Segregation

The OECD Education Database classifies the number of female and male graduates based on the International Standard Classification of Education (ISCED1997) in 9 broad fields of study (1 digit-level) and 23 narrow fields of study (2 digit-level), which I refer to as subfields (see Table A1 in Appendix). I collect data for 26 OECD countries for 1998-2012[3]. Using data on graduate completion instead of enrolment rates mitigates issues of attrition in gender-atypical choices, specifically in female students (Mastekaasa and Smeby, 2008). To the best of my knowledge, this data allows for the greatest country coverage, time span and data disaggregation to compute gender segregation indices. I use two nominal measures of gender segregation: The Dissimilarity Index (Duncan and Duncan, 1955) and the Association Index (Charles and Grusky, 1995). The former provides information at national-level and the latter at field or subfield-levels of segregation[4].

3.1 Country-level segregation: Dissimilarity index

The index of dissimilarity (ID hereafter) was first developed in racial segregation studies by Duncan and Duncan (1955). The ID is one of the primary measures of segregation applied to the context of gender segregation in labour markets and education (Gelbgiser and Albert, 2017). It is given by the following formula[5]:

$$ID = \frac{1}{2} \sum_i \mid \frac{F_i}{F} - \frac{M_i}{M} \mid *100 \tag{1}$$

where F_i and M_i are females and males in field or subfield i, F and M are the total numbers of female and total male graduates respectively. As defined in Duncan and Duncan (1955), the ID provides the

[3]See Andersson and Olsson (1999) for an explicit definition of the subfields considered in each of field of study.

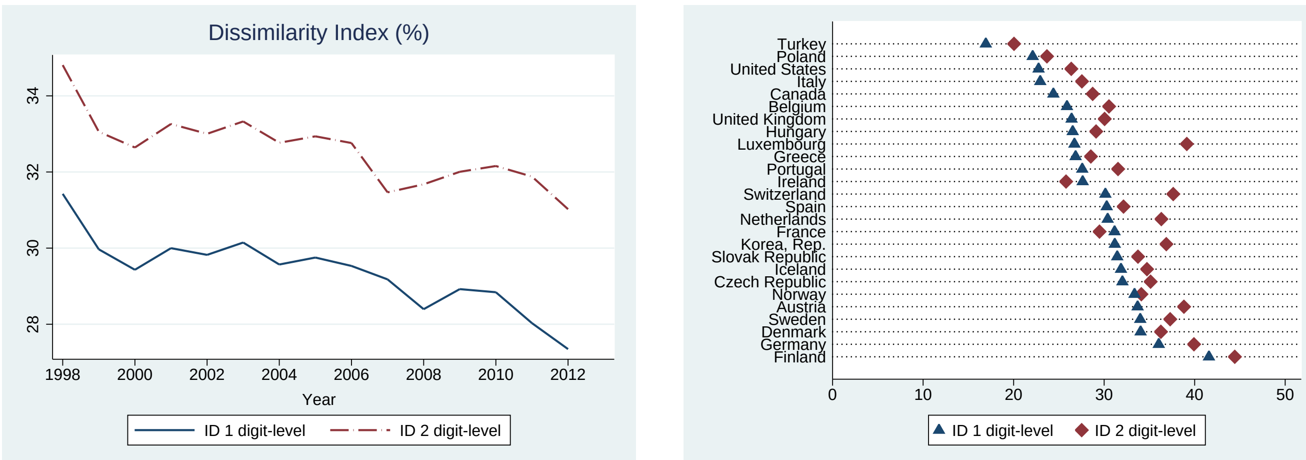
[4]In sharp contrast to ordinal measures, nominal measures of segregation do not take into account a hierarchical ordering of the education system (Semyonov and Jones, 1999). A large body of American literature on the pay-offs to human capital suggests that generally female-dominated fields (humanities and social science) result in lower incomes than male-dominated fields (scientific and technical fields) (Charles and Bradley, 2009). Nevertheless, given the lack of specific data on wages associated with each field or subfield for the sample of countries, the current paper does not distinguish between female and male-dominated fields in any income or social status ordering.

[5]Cross-national and inter-temporal comparisons using the ID might entail computational issues due to its sensitivity to the share of fields in total higher education (Charles and Grusky, 1995; Watts, 1998). If education systems are dominated by one highly segregated field, the ID would yield higher values than if the dominant field was evenly composed by women and men, and numerous small fields were highly segregated. Note that the number of graduates in each field as a proportion of the total graduate body remain stable over the period analysed, as shown in Figure A1, Appendix A.

percentage of women who would have to change fields without replacement in order to make their distribution identical to that of men. The index takes values from 0%, indicating total gender integration across fields, to 100%, indicating complete gender segregation.

Figure (1.a) shows the trend of the sample average ID computed based on broad (ID at 1 digit-level,

Figure 1: Country-level Horizontal Gender Segregation



(a) Trend

(b) By country

blue line) and narrow (ID at 2 digit-level, red line) classifications of higher education. The ID is sensitive to the techniques and categorizations used in defining fields (Reskin, 1993; Nelson, 2017). Consequently, the ID can be manipulated into being smaller (by using very broad categories) or larger (by using narrow categories). This sensitivity is evident in the different average levels taken by the ID in broad or narrow categorizations (disaggregation at 1 digit-level *vs* 2 digit-level), where the latter give higher figures for segregation. Regardless of the category used to compute the ID, the indices show a decreasing trend in 1998-2012, with a drop of around 3 percentage points (pp) by the end of the period. However, ID values remain quite stable throughout this period in comparison with de-segregative fashion taken from 1970 to 1990 (England and Li, 2006; Mann and DiPrete, 2013; Bronson, 2014). This might feed into the afore-mentioned slowdown in gender integration in higher education and other areas of society since the mid-1990s (see *inter alia* Blau et al. (2006); Olivetti and Petrongolo (2016)).

Figure (1.b) shows average levels of the ID computed at 1 digit-level (blue) and 2 digit-level (red) for each country in the sample. Turkey is the least segregated country in the sample (an ID of 17.1% at 1 digit-level), whereas Finland is the most segregated (42.1%). Cross-country comparisons show that more affluent, more gender-egalitarian countries have greater segregation (e.g. Scandinavian countries[6]). This

[6]Studies on Scandinavian labour markets (Albrecht et al., 2003; Evertsson et al., 2009; Carlsson, 2011) suggest that the disparities in expansion of the welfare state across developed countries (e.g. care work transfers from families to the public

observation challenges rational choice theories that predict less segregation as societies become economically richer and gender egalitarian (see Estevez-Abe (2005)). Economists note that gender disparities that do not clearly define hierarchical structures relative to vertical disparities are less easily undermined (Goldin, 2006; Shavit et al., 2007). Thus, horizontal segregation in higher education can reconcile gender-egalitarian and gender-essentialist values to a greater extent[7]. Indeed, this conundrum is already formulated as the *education-gender-equality* paradox in other social science disciplines (Stoet and Geary, 2018).

3.2 Field and subfield-level segregation: Association index

I combine the data on country-level gender segregation with data on field-level segregation and subfield-level segregation. To that end, I use the log-linear modelling approach from Charles and Grusky (1995), namely the Association Index (A_i henceforth), which provides the factor at which each field or subfield of study is associated with a gender (female or male)[8]. The A_i index is computed as follows[9]:

$$A_i = ln\frac{F_i}{M_i} - [\frac{1}{j} * \sum ln(\frac{F_i}{M_i})] \qquad (2)$$

where ln is the natural logarithm, j is the number of fields (this number is 9 when the ISCED1997 1 digit-level is used and 23 for the ISCED1997 2 digit-level), F_i is the number of women in field i and M_i is the number of men in field or subfield i. Positive values of the A_i indicate that the field is associated with women, near zero values indicate gender-neutrality, and negative values that the field is associated with men. A well-suited feature of the association index is that it compares the extent of segregation of male-dominated and female-dominated fields or subfields.

Figure 2 shows the average factor of gender-labelling of fields ordered from most male-dominated to the most female-dominated for 1998-2006 and 2007-2012. Engineering is the most segregated field, that happens to be male-dominated showing an A_i of -1.5. Science and agriculture are also male-dominated, although to a lesser extent than engineering. Fields placed in the middle of the table, with values

sectors), might be a potential driver of cross-country differences in women's concentration by fields of study.

[7]This logic corresponds to "separate-but-equal" gender beliefs as a cause of persisting horizontal gender segregation as suggested by Charles and Bradley (2009) and England (2010).

[8]See Charles and Bradley (2002, 2009), Barone (2011) and Mann and DiPrete (2013) for applications of the index in the context of segregation in education. Following the sociological literature in which this index was developed, I use the term of "gender-labelling" of fields, although the term "gender-typing" is also used in the literature.

[9]One technical advantage of this measure is that using log-linear techniques means that the measure is affected by neither the share of each field in different countries nor the proportion of women among graduates. Hence, the A_i index outperforms ID in cross-country and inter-temporal comparisons. See Watts (1998); Blackburn et al. (1993) for these computational issues of segregation indices.

Figure 2: Field Segregation - Association Index

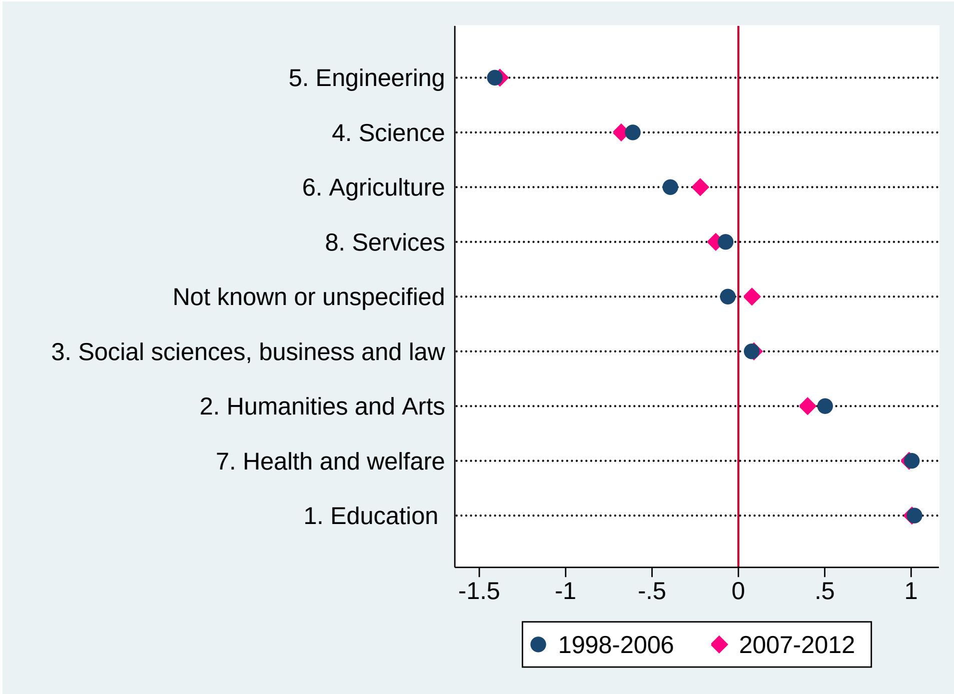
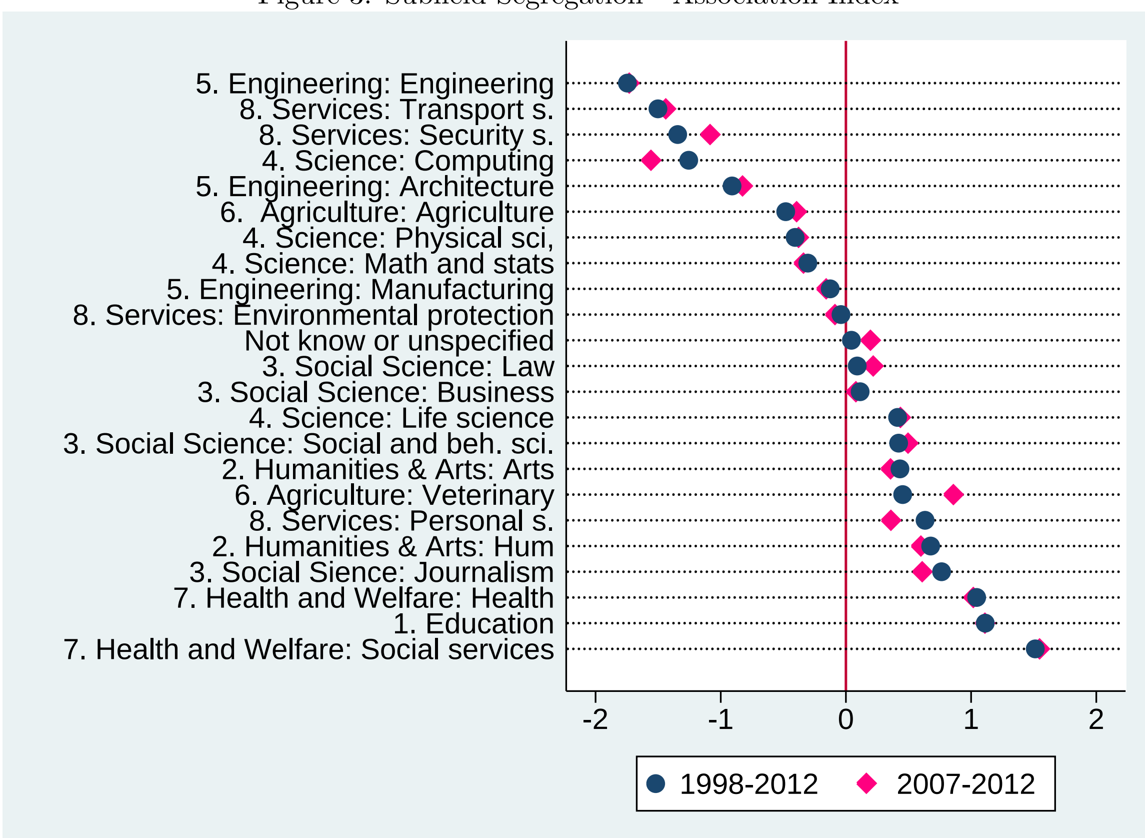


Figure 3: Subfield Segregation - Association Index



around zero, are gender-neutral fields (services and social sciences). Humanities and arts comprises a female-dominated field, with values close to 0.5. Finally, education and health and welfare are the most female-dominated fields with values around 1, and the most segregated fields after engineering. The gender labelling of fields remains similar before and after the Great Recession, although agriculture and humanities are slightly less segregated and science is more segregated on average in 2007-2012. This descriptive data is consistent with the care-technical and humanistic-scientific divides highlighted in Barone (2011).

Figure 3 reveals high heterogeneity in gender-labelling within fields of study. The field of engineering is divided into three subfields with varying factors of gender-labelling: *Manufacturing* is slightly male-dominated, with an index close to zero (-.16), whereas *engineering* and *architecture* are more male-dominated with values of -1.7 and -0.83. The overall male-dominated fields of science and agriculture have also female-dominated subfields, such as *life science* and *veterinary* studies. Similarly, the field of services is made up of highly male-labelled subfields (*transport services* and *security services*) plus a female-labelled subfield (*personal services*). The most segregated subfields are *engineering* (male-labelled) and *social services* (female-labelled). Averages from before-and-after the Great Recession show that *computing* and *veterinary* are more segregated in 2007-2012, whereas *security services* and *personal services* are less segregated in this latter period.

4 Empirical Strategy

The hypothesis that I test is whether cultural values play a role in the gender distribution across fields of study in higher education. I first specify panel data regression models using country-level segregation (ID) as the left-hand-side (LHS) variable, computed using either a broad (field) or narrow (subfield) classification of higher education.

$$ID_{ct} = \beta_0 + \beta_1 CulturalValues_{c,t-4} + X'_{c,t-4}\beta_2 + \gamma_t + \alpha_c + u_{ct}$$
$$c = country; t = year \tag{3}$$

where ID_{ct} is the dissimilarity index in country c in year t, γ_t and α_c are time and country fixed-effects respectively. $CulturalValues_{c,t-4}$ is the focal explanatory variable referring to either country-level gender equality or religiosity. $X_{c,t-4}$ is a set of control variables. Following England and Li (2006), I lag the full set of independent variables four years behind the dependent variable to alleviate causality issues. Considering that the data covers all types of higher education graduates (2-year college, bachelor degrees, masters and Ph.D.) a time span of four years to completion might be reasonable. I am aware of the difficulty of interpreting the results below as causal effects, so I follow the literature to ease the exposition of the results by talking about "impacts" or "effects". The reader should interpret the results below as mere correlations. Baseline models are computed based on information for 26 countries, although the sample of countries is reduced to 18 when WVS data are used and to 17 for PISA data (see summary statistics and sample countries in Table A2, Appendix A).

4.1 Measures of cultural values: Gender (in)equality and religion

I employ the Gender Inequality Index (GII hereafter) taken from the UNDP (see Jāhāna (2016) for methodology). This index measures the loss of human development derived from gender-based discrimination in three main dimensions (health, empowerment and the labour market), where higher values mean greater gender inequality[10]. As an alternative measure of gender-egalitarian values, I use the IDEA Gender Equality index. This index is operationalized using five indicators: Power distribution by gender, female participation in civil society organizations, the ratio between mean years of schooling for women and men, the proportion of lower chamber female legislators, and the proportion of women in ministerial-level positions (Skaaning, 2017).

I use five waves (1990-94; 1995-98; 1999-04; 2005-08; 2010-12) of the WVS to measure country-level religiosity. It is measured by the proportion of WVS respondents who, on a 0-10 scale, give a score of 10 for the statement *"God is very important in my life"*. This statement is present in all WVS waves, whereas other religion-related WVS questions were asked in fewer waves. Average values for GII, Gender Equality and religiosity by country can be found in Figure B1 in Appendix B.

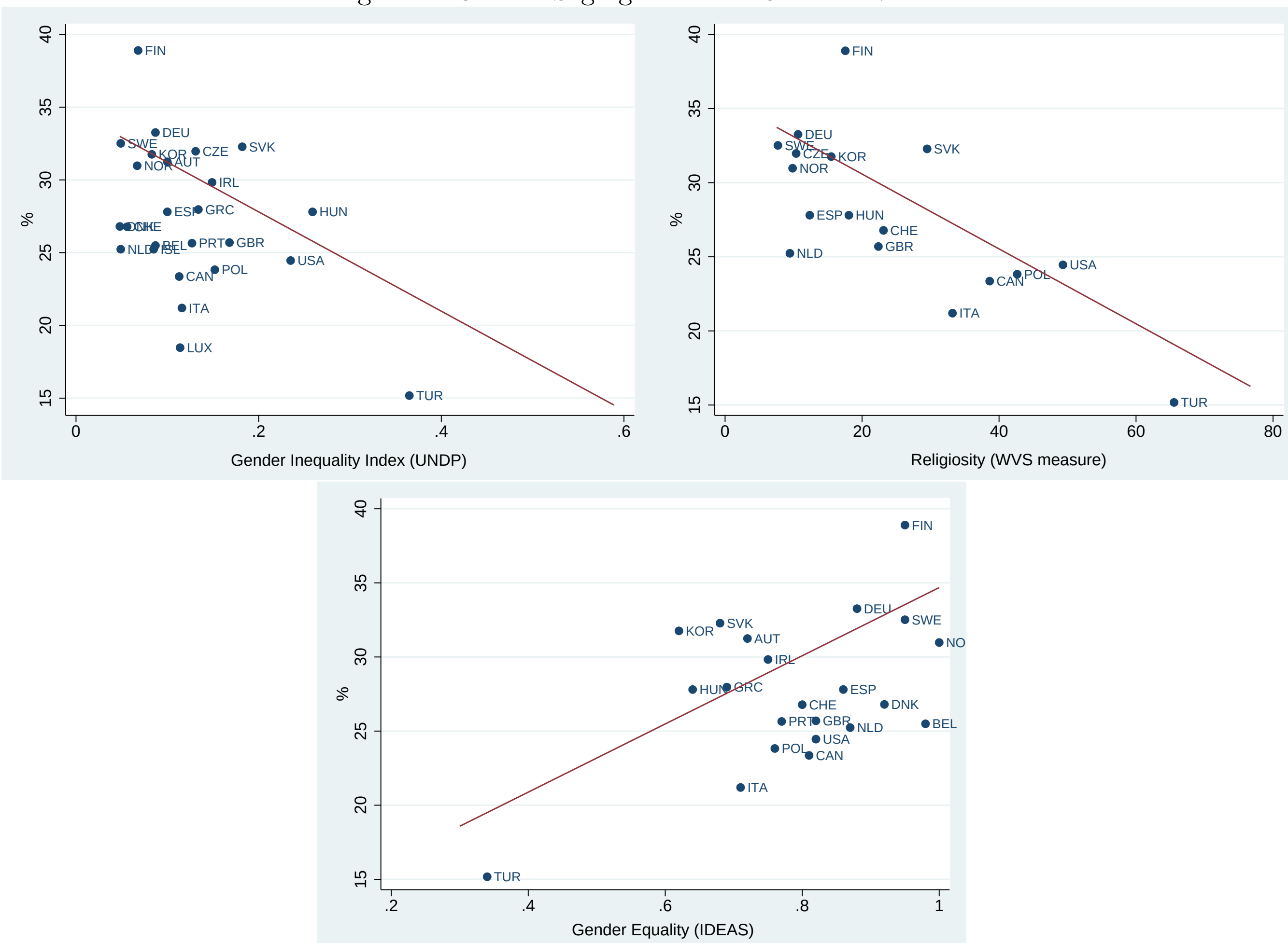
Gender-unequal cultural values are thought to reinforce gender-essentialist ideals, i.e. widely shared beliefs that women are better at caring, nurturing, and human interaction whereas men excel at abstract thinking, problem solving, and analysis (Sikora and Pokropek, 2012; Charles et al., 2015). Anti-egalitarian values might be expected to shape gendered identities of individual men and women to encourage the choice of gender-confirming fields of study, and thus increase segregation. At the same time, the evidence states that more religious ideologies go in lockstep with traditional division of labour and gender roles, which might lead to the expectation of higher levels of segregation in more religious societies.

Figure (4) challenges this view by showing scatter plots of the three alternative proxies of cultural values and gender segregation at national level (dissimilarity index) in 2012. Both higher gender inequality and

[10] In spite of other measures used in related literature, such as the World Economic Forum's gender gap index in González de San Román and de La Rica (2016); Rodríguez-Planas and Nollenberger (2018), the GII is available for a longer period (2000, 2005, 2010, 2011 and 2012).

religiosity are negatively correlated with segregation, meaning that in less gender-egalitarian and more religious societies gender segregation is lower. By contrast, greater gender equality is positively correlated with horizontal gender segregation in higher education.

Figure 4: Gender Segregation and Cultural Values



Links between GII (UNDP), Religiosity (WVS) and Gender Equality (IDEA) and Dissimilarity Index at 1 digit-level, for 2012

4.2 Control variables

The term $X_{c,t-4}$ is a vector of variables measuring economic, labour market and educational institutions that previous literature has related to horizontal gender segregation. The marriage market and gender gaps in math beliefs are also considered. Data sources and pairwise correlations of the explanatory variables are relegated to Tables A3 and A4 in Appendix A.

4.2.1 Economic and labour market features

Flexibility in gender divisions of labour in interconnected and densely populated areas might affect gendered choices of educational paths (Stockemer and Sundström, 2016; Evans, 2018). That mechanism is controlled for here by including the population density (Pop. density), measured by the number of people per km^2 of land area. Structural changes in post-industrial economies are everywhere associated with increases in the weight of the service sector, rising female employment and changes in social norms (Goldin, 1990; Olivetti and Petrongolo, 2014, 2016; Ngai and Petrongolo, 2017). I control for the share of employees in the service sector to total employment (% Services) and the female labour force participation rate (Female Labour Force). At the same time, I include the percentage of professionals who are female (% Prof. Fem) in an effort to capture how upgrading female occupational status may predispose women to seek training in male-dominated fields, such as engineering or science (Polachek, 1987; Ramirez and Wotipka, 2001)[11].

4.2.2 Education system and performance

The models include three main features of higher education: The number of graduates as a proportion of the total population (Size Grads), the percentage of women in the total graduate student body (% Grad. Fem) and the breadth of vocational education via the number of graduates in ISCDE1997 level 5 Type B as a proportion of total higher education (Diversification). Charles and Bradley (2009) suggest that the democratization of higher education might erode the elite luster of universities, therefore reducing the proportion of students who possess an elite identity and sense of self-efficacy, which might be required to transgress gender social norms governing educational choices. A similar logic is provided regarding the greater proportion of women in the whole graduate body[12]. Finally, the expansion of vocational studies in higher education, proxied by diversification, has been previously found to increase gender segregation (Brunello and Checchi, 2007; Blossfeld et al., 2015; Hillmert, 2015).

[11] Gender disparities in labour market outcomes provide newcomers to higher education with information on labour market pay-offs of educational choices (Xie and Shauman, 1997), and female labour status has indeed been used in earlier studies to proxy societal attitudes towards gender roles (Fortin, 2005).

[12] Previous studies are inconclusive on whether the dominance of women in overall higher education is positively or negatively related to gender segregation. As women increase their presence in higher education, fewer female students might regard themselves as exceptional or pioneers, so they will be less likely to opt for male-dominated fields (Charles and Bradley, 2009) and thus, increasing horizontal gender segregation. On the contrary, if vertical and horizontal gender ascription move together according to common social conditions (England and Li, 2006), the proportion of women in higher education and segregation by fields should be negatively related.

To rule out gender segregative effects of disparities in boys and girls' academic performances, I include the gender gap in academic performance (boys' scores minus those of girls) in secondary education (Performance Gap), taken from the panel database in the Quality of Education Database from Altinok et al. (2014). These authors develop a new methodology to combine the math and science scores from PISA and the Trends in International Mathematics and Science Study (TIMSS). Whenever possible, their database focuses on math scores, but it takes into account growth rates of scores in science for countries which did not take part in an evaluation in maths[13].

4.2.3 Marriage market

The set of controls also includes fertility and divorce rates. Goldin (2006) argues that these indicators were among the underpinnings of the transformation of women's role in the labour market from a job-focus to a career-design in the aftermath of World War II. They might in turn foster a convergence between men and women's choices of education paths.[14]. Along these lines, past papers find that gender discrepancies in marriage aspirations and family formation plans to impact on the share of women in math-related and female higher educational attainment (Badgett and Folbre, 2003; Ceci et al., 2014; Bronson, 2014; Attanasio and Kaufmann, 2017). The current paper controls for these marriage market features, supplementing existing international analyses of segregation such as that of Charles and Bradley (2009).

4.2.4 Attitudes of young people towards math

I use the 2003 and 2012 waves of PISA surveys which focused on mathematics (OECD, 2013). This in-depth focus provides data on self-reported beliefs regarding math anxiety (measured by means of students' responses about feelings of stress and helplessness when dealing with mathematics), math self-concept (based on students' responses about their perceived competence in mathematics), and math self-efficacy (based on students' perceived ability to solve a range of pure and applied mathematical problems).
PISA assesses these self-reported math beliefs on the basis of strong agreement or agreement on a number of items in each dimension, which are relegated here to Appendix C. I compute gender gaps in national-level indices of math anxiety, self-concept and self-efficacy based on average agreement with the items for

[13]The sample average score for boys is 567.7 whereas for girls is 563.0.

[14]Goldin (2006) accounts for a *quiet revolution* that transformed American women's horizon, identity and decision-making in the aftermath of World War II. Increasing divorce rates, age of first marriage and more agency about female reproductive decisions were among the major underpinnings of that revolution.

each dimension[15]. In virtually all the countries in the sample girls are more likely to report math anxiety and less likely to report a self-concept of math than boys. As for math self-efficacy, boys generally report higher levels than girls, although there is some heterogeneity depending on the item in question. Based on the sample of countries, girls show higher levels of self-efficacy in items related to equations (first and second order linear equations). However, boys score higher than girls in the rest of the self-efficacy items. I compute gender gaps for these indices based on the gender that shows higher levels of these self-reported math beliefs: Math anxiety gender gaps are computed as girls' indices of math anxiety minus that of boys, whereas gender gaps in self-concept and self-efficacy are computed as boys' indices minus those of girls.

Figure 5: Gender Gaps in Self-reported Math Beliefs

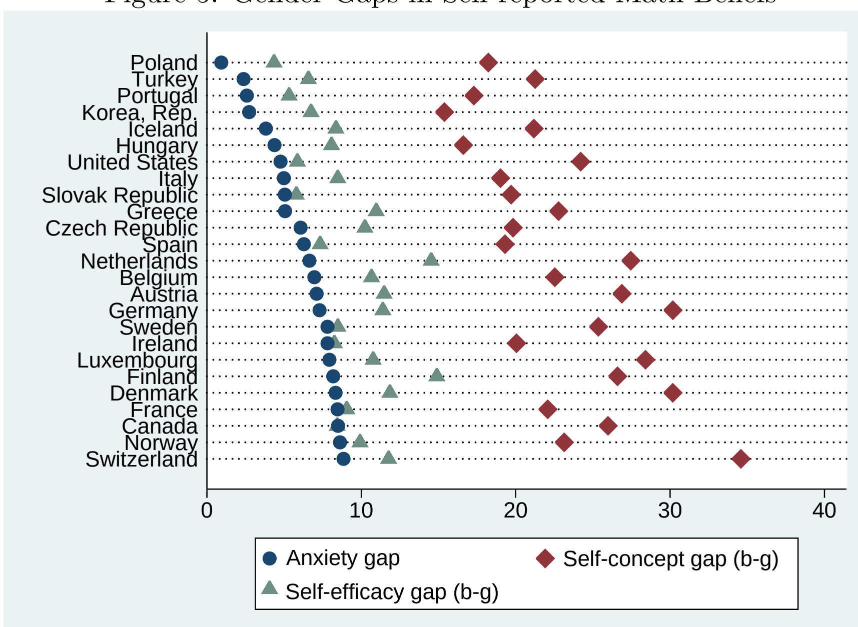


Figure (5) shows average gender gaps between 2003 and 2012 in math anxiety (blue points), math self-concept (red diamonds) and math self-efficacy (green triangles) in the sample of countries, which are listed from lower to higher gender gaps in math anxiety. Switzerland, Norway, France and Canada show the biggest levels of gender gaps in math anxiety, while Poland, Turkey, Portugal and the Republic of Korea show the lowest. Gender gaps in math self-concept are larger than for math anxiety, gender gaps in math self-efficacy are closer to those of math anxiety. The data displays a pattern in which affluent

[15]PISA provides scale indices of self-reported math beliefs measuring the distance from national levels to average of the total sample of countries participating in PISA surveys. It would be misleading to link these scale indices with my database of gender segregation because my panel is unbalanced and only covers a cluster of OECD countries. Thus, I construct aggregate-level gender gaps in self-reported math beliefs instead of using scale indices in OECD (2013)

and more gender-egalitarian countries generally have wider national gender gaps in self-reported math beliefs than less affluent countries, as found by Stoet et al. (2016). Figure C1 in Appendix C provides scatter plots of ID and gender gaps in self-reported math beliefs. In all three cases, the plots tend to positively correlate wider gender gaps for young people with gender segregation in higher education.

To control for gender gaps in math beliefs, I apply a linear adjustment for 2003-2012 under the assumption of an equal year by year change in math beliefs over that time. Notice that segregation data spans 1998-2012 and using lags of math beliefs would substantially reduce the number of years (2008-2012) and thus of observations. Hence, following previous literature, I study the contemporaneous effect of math attitudes of young people and gender segregation in higher education graduates. This data does not measure the effects of gendered attitudes towards math at individual level, but it enables me to assess to a certain extent whether patterns of gender segregation correspond to aggregate-level gender differences in math anxiety, self-concept or self-efficacy. The approach here seeks to supplement the cross-country analysis in Charles and Bradley (2009), in which they include TIMSS data on disparities in affinity for math between boys and girls.

$$ID_{ct} = \beta_0 + \beta_1 CulturalValues_{c,t-4} + \beta_2 MathBeliefs_{ct} + X'_{c,t-4}\beta_3 + \gamma_t + \alpha_c + u_{ct}$$
$$c = country; t = year \quad (4)$$

As in Equation (3) ID_{ct} is the dissimilarity index in country c in year t, γ_t and α_c are time and country fixed-effects respectively. Note that the model includes contemporaneous $MathBeliefs$ (e.g. gender gaps in math anxiety, self-concept and self-efficacy), whereas the rest of independent variables are four years lagged.

5 Results

5.1 Country-level analysis

I estimate the model in (3) using the within-group estimator. The Breusch and Pagan post-estimation test confirms the presence of conditional heteroskedasticity in the data, so I use cluster standard errors at country-level and allow residuals to be correlated within but uncorrelated between countries (Cameron and Miller, 2015). The Hausman test' initial hypothesis that individual-level effects are adequately modelled by a random-effects model- is resoundingly rejected. Among other post-estimation tests, I take the issue of outliers by identifying observations with very large leverage or squared residuals. I use the lvr2plot Stata command (Cox et al., 2004) to analyse high leverage observations such as those for Turkey and Sweden separately. Excluding these two countries from the sample the results are unchanged.

A potential caveat on the validity of the estimation is concerned with endogeneity issues arising from the relationship between the ID (dependent variable) and the regressor $\%Grad.Fem$. In separate models I use the Two Step Least Squared (2SLS) and the number of women in parliaments to instrument the share of female graduates (see Stockemer and Byrne (2011) for a justification of this instrument), and corroborate the main results of the paper. Indeed, post-estimation tests of the 2SLS approach fail to reject the hypothesis that the proportion of females in the graduate body is an exogenous covariate.

Table 1 shows that greater religiosity is associated with lower gender segregation four periods later. Yet the estimates of this effect become less significant when gender gaps in self-reported math beliefs are accounted for. Column 1 estimates a baseline model that includes the main set of control variables. The female labour force variable is associated with a negative impact on segregation which is consistent with previous research (Ramirez and Wotipka, 2001). Increasing female participation in higher education seems to be related to greater segregation by field of study, which is consistent with Charles and Bradley (2009). Nevertheless, that association is not robust to the inclusion of religiosity. The revolutionary indicators in Goldin's parlance, fertility and divorce, are associated with a significant negative and positive effect respectively on segregation. The effect of fertility is highly robust and challenges the idea that reducing fertility might foster a convergence between the educational choices of men and women.

Columns 2 and 3 (Table 1) introduce the GII and the Gender Equality index respectively, and are not associated with significant coefficients. Column 4 uses instead the level of religiosity, which enters with a negative and significant coefficient. This finding is in line with recent evidence on the link between more traditional societies and greater participation of women in math-related fields (Friedman-Sokuler, 2016), and the findings related to closer gender gaps in math performance in Muslim countries (Fryer Jr and Levitt, 2010). Ultimately, this negative correlation suggests that gender is less salient in higher education systems in more religious societies. This finding is consistent with that brought by Falk and Hermle (2018), who use survey data to provide evidence on that higher gender equality favour the manifestation of gender differences in preferences across countries.

I provide two mechanisms to tentatively explain the negative association between religiosity and gender segregation[16]: i) In more religious societies women play traditional role in the labour market (e.g. low female labour force participation rates and high fertility rates). As argued in Bertrand (2017), the constraints and challenges that women expect in the jobs associated with certain education tracks make women reluctant to choose them. Thus, if women expect to play a minor role in the labour market, their

[16] See Figure C2 in the Appendix for scatter plots of female participation in the labour force, share of graduates and fertility with religiosity.

choices of majors may be less influenced by these future constraints and they will be more likely to opt for male-dominated education paths (e.g. STEM). ii) In more religious societies female participation in higher education is relatively lower. Therefore, those women who do access higher education possess an elite identity that encourages them to transgress gender-confirming norms and opt for male-dominated fields (Charles and Bradley, 2009)[17].

I test these potential mechanisms by interacting religiosity with either fertility, female labour force participation rate or the proportion of women in the total number of graduates in separate models. These interactions are not associated with a significant effect, but estimates on the constitutive terms remain similar to the additive model in Eq. (3). Due to the limitations of macro-level data used here, it goes beyond the scope of this paper to go further in these explanations.

Column 5 studies whether different religion denominations explain gender segregation by using four waves of WVS data on the proportion of Catholics, Muslims, Protestants and Jews as the main religion denominations in the sample of countries[18]. However, none of them are associated with a significant coefficient. Columns 6-8 show within-group estimates of Equation (4). The results positively associate gender gaps in math beliefs of the youth with gender segregation. Recall that anxiety index is composed by girls' index minus that of boys whereas self-concept and self-efficacy are based on boys' index minus that of girls. As girls report higher levels of anxiety, the gender segregation of higher education graduates across fields is also higher. Similarly, as boys surpass girls in their sense of self-concept and efficacy towards math, higher education graduates tend to be more segregated. Note that religiosity is not significant when accounting for math anxiety and self-concept gender disparities (Columns 6 and 7) but it remains statistically significant at the 0.10 level when including self-efficacy (Column 8). Table 2 checks the robustness of these results by estimating Equation (3) using the ID at 2 digit-level as the LHS variable. The results are similar to those found using the ID at the broader level.

5.2 Field and subfield-level analyses

Thus far the estimates provide evidence that religiosity may partly matter to country-level horizontal gender segregation, and that gender gaps in math beliefs among young could be a more decisive factor of segregation in later education choices. This subsection seeks to identify whether religiosity and math beliefs matter to the level of gender segregation in specific fields or subfields. The models specified in

[17]These tentative explanations are focused on the role of women. However, we can similarly assume that the role of men might also differ in religious and non-religious societies.

[18]I use the percentage of the total WVS respondents over the five waves used here who claim to belong to a specific religion.

Equation (4) employ the association index of either field or subfield i, in country c in year t as the LHS variable.

$$\begin{aligned} Ai_{ct} &= \beta_0 + \beta_1 Religiosity_{c,t-4} + \beta_2 FieldWeight_{c,t-4} + X'_{c,t-4}\beta_3 + \gamma_t + \alpha_c + u_{ct} \\ & i = field(subfield); c = country; t = year \end{aligned} \tag{5}$$

where Ai_{ct} is the gender association of field or subfield i in country c and year t, with α_c and γ_t being country and time fixed-effects. $X_{c,t-4}$ is the same set of controls as described above. To alleviate potential omitted variables bias issues, I include the proportion of graduates in each field or subfield of study in the whole of higher education in the set of control variables ($FieldWeight_{ct}$). By doing so, I also attempt to account for preferences towards specific fields of study of the whole graduate body, which might differ across countries (Alesina et al., 2013).

I first compute 9 models corresponding the 9 fields (broad classification). This step helps to narrow down the focus to estimate the impact of religiosity in specific subfields[19].

Before I review the results, it is worth noting that the Ai_{ct} is a continuous variable: positive values mean over-representation of women in the field, negative values mean over-representation of men and values close to zero mean gender neutrality. Thus, to accurately interpret a significant coefficient of the regressors, one needs to know ex-ante whether the field or subfield at stake is male-labelled or female-labelled. Positive coefficients associated with the regressors in female-dominated fields would imply a positive relation with gender segregation in that it means a perpetuation of females in female-dominated fields. Negative values for the same coefficients would imply a negative effect on gender segregation. In considering male-dominated fields, positive (negative) values associated with the regressors would imply a negative (positive) correlation with segregation. To ease the interpretation, tables of results (Tables 3 and 4) provide the average gender-label of each field or subfield, with "F" female-domination and "M" male-domination.

Table 3 shows that religiosity seems to be associated with lower gender segregation in specifically four fields of study, namely education, science, agriculture, and health and welfare. These findings might shed some light on the correlation between religiosity and lower horizontal gender segregation at national levels. All the models in Table 3 introduce the full set of controls of Equation (5), but I report the coefficients of religiosity, fertility and gender gaps in math beliefs as they are the main contribution of the paper. Models in Panel A (Table 3) exclude math beliefs. Fertility is not associated with a significant role in gender-labelling in any field. Religiosity is significantly associated with gender segregation in four out of the eight fields: Education and health and welfare (Columns 1 and 7), *Religiosity* enters with a negative coefficient, thus *Religiosity* is associated with reducing segregation; and science and agriculture

[19] For the sake of space, all the models of the 23 subfields are not included here but they are available upon request.

(Columns 4 and 6), the sign is positive and the fields are male-dominated, thus *Religiosity* is associated with lower segregation in these fields.

Panels B, C and D (Table 3) introduce gender gaps in math anxiety, self-concept and self-efficacy, respectively. Field-level estimates tend to corroborate the finding that higher gender gaps in math beliefs are associated with higher horizontal gender segregation. Increasing gender gaps in math beliefs are persistently associated with higher male-labelling in the field of science (Column 4), but their explanatory power varies across math beliefs. However, Column (5) in Panel B associates higher math anxiety gender gaps with lower male-labelled engineering. When gender gaps in math beliefs are accounted for, religiosity is still significantly associated with lower male-labelling in agriculture (Column 6) and female-labelling in health and welfare (Column 7). That is, the negative association between religiosity and gender segregation is also found in field-level estimates.

The final step in this paper is to regress Equation (5) against the A_{ict} at subfield level. The results in Table 3 suggest that religiosity and gender gaps might be important for the gender-labelling of agriculture, health and welfare, and to a lesser extent education and science. Thus, Table 4 focus on the subfields that make up these specific fields: Science is divided into *life science*, *physical science*, *mathematics and statistics* and *computing*. Agriculture is divided into *agriculture, forestry and fishery* and *veterinary* studies. Health and welfare is divided into *health* and *social services*. Recall that education stands alone on the basis of ISCED97; it is dropped from the subfield-level analysis to avoid repetition.

Panel A in Table 4 identifies a significant link between religiosity and lower levels of male-labelling in *mathematics and statistics* (Column 3) and *agriculture, forestry and fishery* (Column 5), whereas religiosity is associated with lower female-labelling in *social services* (Column 8). These estimates suggest the same direction of the link between religiosity and segregation as previously found. When accounting for math beliefs gender gaps (Panels B, C and D), only the link between religiosity and *social services* remains significant at the 0.01 level. The estimates in Table 4 (Panel B) provide little evidence of a link between anxiety gaps and segregation by subfields. However, Panel C significantly associates gender disparities in math self-concept with greater segregation in *computing* and *veterinary* studies. Panel D associates math self-efficacy gaps with lower segregation in *agriculture, forestry and fishery* and *veterinary* studies.

6 Conclusion

Persisting levels of gender segregation across fields of study in Western countries seem at odds with the increase in female participation in higher education. This observation is particularly puzzling against the backdrop of affirmative action, anti-discrimination policies, and gender-egalitarian ideals in developed countries. The literature highlights individual factors (gender gaps in preferences and foreseeing family obligations) and external factors (economic structure, institutions, discrimination) as causes of gender segregation. This paper studies whether cultural values, in particular gender equality and religion, play a role in horizontal gender segregation in higher education.

I construct a panel dataset with information on gender segregation indices at national level, at 9-field level and at 23-subfield level for 26 OECD countries for 1998-2012. I link this data with two focal cultural traits: Gender equality, measured alternatively on the basis of either the Gender Inequality Index (UNDP) or the Gender Equality measure (IDEA), and religiosity, taken from the World Value Survey. I propose fixed-effects models that control for potential segregative factors such as economic structural change, labour market and educational systems features. The estimates fail to associate gender (in)equality measures with a significant role in horizontal gender segregation. By contrast, religiosity is significantly associated with lower levels of horizontal gender segregation.

I expand the models seeking to control for gender gaps in math beliefs developed during the youthhood. Using two waves of data taken from PISA surveys, I find a contemporaneous association between gender gaps in anxiety, self-concept and self-efficacy with higher gender segregation of graduates across fields of study. These gaps seem to be stronger predictors of national-level gender segregation than religiosity. Field and subfield-levels analyses pinpoint to a robust association between religiosity and lower segregation levels in the fields of agriculture and health and welfare, and more specifically in the subfield of *social services*.

From a policy viewpoint, the role of religiosity may be controversial. However, the findings regarding gender gaps in math beliefs tend to indicate that efforts to close gaps between boys and girls might enhance a more gender-equal distribution across fields of study in higher education. Nevertheless, it should be stressed that the findings above are based on macro-level data on segregation, and should be taken with caution. Two natural ways to extend this paper would be first to scrutinize whether there is any link between cultural traits and vertical segregation, i.e. gender segregation at different attainment levels within higher education; and second to expand the gender gaps in ability perceptions among young people into other dimensions, such as reading and science.

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Table 1: Country-level Gender Segregation

Dependent variable: Dissimilarity index (1 digit-level)	Baseline	Cultural Values				Math Beliefs		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L4.Pop. density	-0.002	0.066	0.018	-0.012	-0.220	-0.114	-0.152	-0.092
	(0.126)	(0.114)	(0.132)	(0.102)	(0.232)	(0.089)	(0.107)	(0.097)
L4.% Services	-0.074	0.010	-0.035	-0.031	-0.239	-0.207	0.012	-0.111
	(0.198)	(0.175)	(0.188)	(0.142)	(0.173)	(0.170)	(0.162)	(0.152)
L4.% Prof. Fem.	-0.038	-0.037	-0.037	-0.061	0.171*	0.003	0.082	-0.077
	(0.072)	(0.077)	(0.080)	(0.098)	(0.095)	(0.077)	(0.105)	(0.100)
L4.Fem. Labour Force	-0.881**	-0.747	-0.887**	-0.801***	-0.929	0.371	-1.228***	-0.592*
	(0.396)	(0.510)	(0.386)	(0.259)	(0.791)	(0.532)	(0.266)	(0.321)
L4.Grads Size	-1.796	-1.746	-2.818	1.470	-7.311***	2.692	1.974	1.317
	(2.351)	(1.961)	(2.496)	(2.389)	(2.106)	(2.371)	(2.518)	(2.173)
L4.Diversification	0.034	0.011	0.042	0.026	0.067***	-0.009	-0.009	0.019
	(0.032)	(0.022)	(0.032)	(0.036)	(0.020)	(0.032)	(0.033)	(0.034)
L4.% Grad. Fem.	0.117***	0.153**	0.124**	0.047	0.037	-0.001	0.054*	0.043
	(0.038)	(0.061)	(0.045)	(0.031)	(0.178)	(0.029)	(0.028)	(0.031)
L4.Performance gap	-0.072	-0.084	-0.037	-0.071**	-0.040	-0.029	-0.003	-0.058*
	(0.042)	(0.050)	(0.040)	(0.030)	(0.064)	(0.036)	(0.046)	(0.031)
L4.Fertility	-7.147***	-6.146**	-8.241***	-7.017***	-11.102*	-9.806***	-6.013***	-9.575***

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Table 1: Country-level Gender Segregation

Dependent variable: Dissimilarity index (1 digit-level)	Baseline	Cultural Values				Math Beliefs		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(2.501)	(2.438)	(2.608)	(2.251)	(5.593)	(3.129)	(1.592)	(2.570)
L4.Divorce rate	1.020**	0.836	0.934*	0.268	0.036	0.332	0.264	0.667**
	(0.460)	(0.531)	(0.451)	(0.325)	(1.136)	(0.270)	(0.235)	(0.255)
L4.GII		-12.406						
		(14.070)						
L4.Gender Equality			-18.475					
			(0.260)					
L4.Religiosity				-0.231***		-0.033	-0.081	-0.181**
				(0.062)		(0.065)	(0.050)	(0.068)
L4.% Catholic					1.353			
					(18.047)			
L4.% Protest.					18.116			
					(14.690)			
L4.% Muslim					-25.867			
					(237.958)			
L4.% Jew					34.634			
					(316.463)			
Anxiety gap						0.637***		

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Table 1: Country-level Gender Segregation

Dependent variable: Dissimilarity index (1 digit-level)	Baseline	Cultural Values				Math Beliefs		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
						(0.193)		
Self-concept gap							0.367^{***}	
							(0.109)	
Self-efficacy gap								0.550^{*}
								(0.280)
No. of Obs.	218	180	196	136	75	128	128	128
No. of Groups	26	26	23	18	12	17	17	17
log-likelihood	-391.491	-299.735	-347.718	-214.043	-104.929	-194.005	-195.702	-200.472
Within R-squared	0.337	0.363	0.363	0.408	0.579	0.470	0.456	0.414

Country-level clustered standard errors in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$. Within-group estimates including time fixed-effects, constant terms not reported. Fourth period lagged explanatory variables except for variables of math beliefs.

Table 2: Country-level Gender Segregation

Dependent variable: Dissimilarity index (2 digit-level)						
	Cultural Values			Math Beliefs		
	(1)	(2)	(3)	(4)	(5)	(6)
L4.Performance gap	-0.191	-0.042	-0.031	-0.004	0.016	-0.032
	(0.158)	(0.070)	(0.033)	(0.036)	(0.044)	(0.031)
L4.Fertility	-16.005*	-10.627**	-8.639***	-10.886***	-8.046***	-9.110***
	(8.866)	(4.764)	(2.650)	(3.298)	(2.324)	(2.858)
L4.GII	60.189					
	(61.692)					
L4.Gender Equality		-25.743				
		(22.314)				
L4.Religiosity			-0.195**	-0.024	-0.060	-0.155*
			(0.080)	(0.084)	(0.083)	(0.081)
Anxiety gap				0.477*		
				(0.233)		
Self-concept gap					0.274**	
					(0.108)	
Self-efficacy gap						-0.045
						(0.331)
No. of Obs.	179	195	136	128	128	128
No. of Groups	26	23	18	17	17	17
log-likelihood	-435.438	-479.668	-204.972	-188.434	-189.500	-193.537
Within R-squared	0.148	0.132	0.480	0.513	0.505	0.472

Country-level clustered standard errors in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$. Within-group estimates including time fixed-effects, constant terms not reported. Fourth period lagged explanatory variables except for variables of math beliefs. The models include the full set of controls but are not reported.

Table 3: Field-level Gender Segregation

Dependent variable: Association Index (fields)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Educ	Hum & Arts	Soc. Sci	Science	Eng.	Agri.	Health	Serv
Gender-label	F	F	F	M	M	M	F	M
PANEL A:								
L4.Fertility	-0.125	-0.166	0.024	-0.183	0.226	0.453	-0.085	-0.410
	(0.222)	(0.186)	(0.138)	(0.187)	(0.247)	(0.350)	(0.119)	(0.359)
L4.Religiosity	-0.016***	-0.001	0.002	0.012*	0.005	0.016**	-0.015**	0.005
	(0.005)	(0.005)	(0.005)	(0.006)	(0.007)	(0.007)	(0.006)	(0.004)
No. of Obs.	136	136	136	136	136	136	136	136
No. of Groups	18	18	18	18	18	18	18	18
log-likelihood	131.314	185.155	201.917	123.755	168.061	91.927	159.399	92.940
Within R-squared	0.305	0.304	0.228	0.276	0.473	0.272	0.240	0.267
PANEL B: Math Anxiety Gender Gaps								
Anxiety gap	0.031*	-0.013	-0.002	-0.044**	0.040***	0.008	0.039***	0.057**
	(0.015)	(0.016)	(0.011)	(0.018)	(0.014)	(0.034)	(0.012)	(0.023)
L4.Fertility	-0.230	-0.118	0.071	-0.121	0.089	0.325	-0.236	-0.537
	(0.218)	(0.145)	(0.149)	(0.211)	(0.202)	(0.385)	(0.154)	(0.347)
L4.Religiosity	-0.007	-0.005	-0.001	0.001	0.021***	0.026**	-0.013***	0.015**
	(0.009)	(0.008)	(0.008)	(0.008)	(0.006)	(0.011)	(0.004)	(0.006)

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Table 3: Field-level Gender Segregation

Dependent variable: Association Index (fields)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Educ	Hum & Arts	Soc. Sci	Science	Eng.	Agri.	Health	Serv
Gender-label	F	F	F	M	M	M	F	M
log-likelihood	124.510	175.381	188.541	136.085	174.281	85.535	155.713	99.945
Within R-squared	0.317	0.338	0.198	0.425	0.498	0.271	0.327	0.342
PANEL C: Math Self-concept Gender Gaps								
Self-concept gap	0.015*	-0.004	0.006	-0.015*	-0.009	-0.005	0.005	0.051***
	(0.008)	(0.007)	(0.005)	(0.008)	(0.010)	(0.021)	(0.011)	(0.017)
L4.Fertility	-0.067	-0.179	0.088	-0.326*	0.211	0.344	-0.069	-0.119
	(0.202)	(0.185)	(0.164)	(0.185)	(0.195)	(0.365)	(0.132)	(0.291)
L4.Religiosity	-0.009	-0.003	0.002	0.007	0.007	0.023***	-0.019***	0.016***
	(0.007)	(0.007)	(0.007)	(0.006)	(0.009)	(0.006)	(0.006)	(0.005)
log-likelihood	123.322	174.441	189.128	131.181	165.998	85.529	149.416	106.066
Within R-squared	0.304	0.328	0.205	0.379	0.429	0.270	0.258	0.402
PANEL D: Math Self-efficacy Gender Gaps								
Self-efficacy gap	0.044	0.000	0.026	-0.069***	0.008	-0.020	0.009	-0.005
	(0.028)	(0.028)	(0.025)	(0.021)	(0.028)	(0.042)	(0.024)	(0.050)
L4.Fertility	-0.266	-0.160	-0.025	-0.070	0.213	0.434	-0.122	-0.324
	(0.214)	(0.136)	(0.154)	(0.191)	(0.193)	(0.414)	(0.127)	(0.414)
L4.Religiosity	-0.013*	-0.001	0.001	0.009*	0.010	0.023***	-0.020***	-0.000

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Table 3: Field-level Gender Segregation

Dependent variable: Association Index (fields)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Educ	Hum & Arts	Soc. Sci	Science	Eng.	Agri.	Health	Serv
Gender-label	F	F	F	M	M	M	F	M
	(0.007)	(0.007)	(0.006)	(0.005)	(0.007)	(0.007)	(0.006)	(0.007)
log-likelihood	123.267	174.188	190.117	133.821	165.054	85.637	149.198	93.625
Within R-squared	0.303	0.325	0.217	0.404	0.420	0.272	0.255	0.274
N	128	128	128	128	128	128	128	128
No. of Groups	17	17	17	17	17	17	17	17

Country-level clustered standard errors in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$. Within-group estimates including time fixed-effects, constant terms not reported. Fourth period lagged explanatory variables except for variables of math beliefs. The models include the full set of controls but are not reported. Panels B-D include math beliefs and the number of clusters and observations are the same across fields. Educ (Education); Hum & Arts (Humanities and Arts); Soc. Sci (Social Sciences, Business and Law); Science (Science, Mathematics and Computing); Eng. (Engineering, Manufacturing and Construction); Agri. (Agriculture and Veterinary); Health (Health and Welfare); Serv. (Services). To ease the interpretation of the coefficients, behind the name of each field is the sample average gender label of M (male) and F (female), meaning whether the field is male-dominated or female-dominated respectively. Recall that the dependent variable is a continuous variable ranging negative values for male-dominated fields and positive values for female-dominated fields.

Table 4: Subfield-level Segregation (selected subfields)

Dependent variable: Association Index (subfields)								
	Science				Agriculture		Health & Welfare	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Life S.	Phy S.	Math.	Comp.	Agri.	Vet.	Health	Soc. Serv.
Gender label	F	M	M	M	M	F	F	F
PANEL A:								
L4.Fertility	-0.005	0.009	0.144	-0.338	0.389	0.322	0.234**	-0.425
	(0.200)	(0.171)	(0.224)	(0.346)	(0.493)	(0.452)	(0.107)	(0.330)
L4.Religiosity	0.009	0.001	0.024**	0.008	0.018**	0.015	-0.008	-0.034***
	(0.007)	(0.006)	(0.011)	(0.009)	(0.007)	(0.020)	(0.006)	(0.010)
No. of Obs.	136	136	136	136	136	136	136	136
No. of Groups	18	18	18	18	18	18	18	18
log-likelihood	109.827	143.737	87.493	88.301	104.287	2.154	163.987	78.003
Within R-squared	0.309	0.210	0.239	0.731	0.262	0.370	0.332	0.476
PANEL B: Math Anxiety Gender Gaps								
Anxiety gap	-0.042	0.001	-0.012	-0.023	0.009	-0.030	0.027*	0.029
	(0.025)	(0.010)	(0.032)	(0.024)	(0.019)	(0.051)	(0.013)	(0.022)
L4.Fertility	0.168	-0.072	0.151	-0.123	0.180	0.477	0.123	-0.727*
	(0.286)	(0.190)	(0.210)	(0.316)	(0.454)	(0.503)	(0.124)	(0.416)
L4.Religiosity	-0.006	0.004	0.022	-0.001	0.018*	0.027	-0.008	-0.043***

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Table 4: Subfield-level Segregation (selected subfields)

Dependent variable: Association Index (subfields)								
	Science				Agriculture		Health & Welfare	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Life S.	Phy S.	Math.	Comp.	Agri.	Vet.	Health	Soc. Serv.
Gender label	F	M	M	M	M	F	F	F
	(0.007)	(0.006)	(0.015)	(0.014)	(0.010)	(0.016)	(0.004)	(0.011)
log-likelihood	104.780	137.053	81.975	89.082	102.642	12.700	159.604	77.704
Within R-squared	0.340	0.240	0.185	0.751	0.249	0.453	0.379	0.528
PANEL C: Math Self-concept Gender Gaps								
Self-concept gap	0.017	0.002	-0.019	-0.031***	-0.020	0.044***	-0.006	0.016
	(0.014)	(0.010)	(0.014)	(0.010)	(0.012)	(0.012)	(0.012)	(0.010)
L4.Fertility	0.109	-0.063	0.030	-0.324	0.176	0.568	0.170	-0.556
	(0.257)	(0.180)	(0.147)	(0.309)	(0.440)	(0.334)	(0.101)	(0.356)
L4.Religiosity	0.011	0.004	0.018	-0.005	0.011	0.049**	-0.016**	-0.045***
	(0.008)	(0.004)	(0.015)	(0.010)	(0.006)	(0.017)	(0.007)	(0.009)
log-likelihood	102.345	137.080	83.245	92.443	104.165	14.792	156.630	77.316
Within R-squared	0.314	0.241	0.201	0.764	0.266	0.471	0.350	0.525
PANEL D: Math Self-efficacy Gender Gaps								
Self-efficacy gap	0.021	0.013	0.070	-0.040	0.061**	-0.124**	0.024	-0.063
	(0.036)	(0.023)	(0.043)	(0.030)	(0.025)	(0.047)	(0.017)	(0.044)
continues on next page								

Table 4: Subfield-level Segregation (selected subfields)

Dependent variable: Association Index (subfields)								
	Science				Agriculture		Health & Welfare	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Life S.	Phy S.	Math.	Comp.	Agri.	Vet.	Health	Soc. Serv.
Gender label	F	M	M	M	M	F	F	F
L4.Fertility	-0.040	-0.111	-0.139	-0.076	-0.016	0.812	0.103	-0.438
	(0.226)	(0.200)	(0.160)	(0.348)	(0.436)	(0.532)	(0.104)	(0.330)
L4.Religiosity	0.006	0.004	0.028**	0.003	0.018**	0.030*	-0.012*	-0.054***
	(0.007)	(0.005)	(0.012)	(0.011)	(0.006)	(0.016)	(0.006)	(0.008)
log-likelihood	101.141	137.232	84.019	88.948	104.892	14.668	157.020	78.043
Within R-squared	0.301	0.243	0.211	0.751	0.275	0.470	0.354	0.531
No. of Obs.	128	128	128	128	128	128	128	128
No. of Groups	17	17	17	17	17	17	17	17

Country-level clustered standard errors in parentheses, * $p < .1$, ** $p < .05$, *** $p < .01$. Within-group estimates including time fixed-effects, constant terms not reported. Fourth period lagged explanatory variables except for variables of math beliefs. The models include the full set of controls but are not reported. Panels B-D include math beliefs and the number of clusters and observations are the same across subfields. Life S. (Life Science); Phys. S. (Physical Science); Maths. (Mathematics and statistics); Comp. (Computing); Agri. (Agriculture, forestry and fishery); Vet. (Veterinary); Soc. Serv. (Social Services). To ease the interpretation of the coefficients, behind the name of each subfield is the sample average gender label of M (male) and F (female), meaning whether the subfield is male-dominated or female-dominated respectively. Recall that the dependent variable is a continuous variable ranging negative values for male-dominated fields and positive values for female-dominated fields.

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Appendices

Appendix A

Table A1: Fields and Subfields Classification (ISCED 1997)

1 digit-level	2 digit-level
Education	Teacher training and education science
Humanities and arts	Arts
	Humanities
Social Sciences, business and law	Social and behavioural science
	Journalism and information
	Business and administration
	Law
Science	Life science
	Physical science
	Mathematics and statistics
	Computing
Engineering, manufacturing and construction	Engineering and engineering trades
	Manufacturing and processing
	Architecture and building
Agriculture	Agriculture, forestry and fishery
	Veterinary
Health and welfare	Health
	Social services
Services	Personal services
	Transport services
	Environmental protection
	Security services
Not known or unspecified	Not known or unspecified

Table A2: Summary Statistics of Explanatory Variables

	Mean	**Std. Dev.**	**Min.**	**Max.**	**N**
Gender Inequality Index	0.148	0.068	0.051	0.564	215
Gender Equality (IDEA)	0.789	0.123	0.31	1	196
Religiosity	22.138	15.799	7.532	75.78	168
% Jew	0.746	1.534	0.052	7.378	168
% Catholic	36.032	29.524	0.157	94.400	168
% Protestant	22.39	23.451	0.157	84.117	168
% Muslim	7.58	23.584	0.066	98.886	168
Pop. density	142.32	132.518	2.734	505.562	218
Fem. Labour Force	44.879	2.65	29.186	48.452	218
% Services	67.321	7.36	49.171	82.964	218
% Prof. Female	49.424	7.415	30.51	64.707	218
Size Grads	11.569	1.471	5.823	15.012	218
Diversification	19.1	16.042	0.04	60.004	218
% Graduates Fem.	57.254	5.673	25.391	67.5	218
Performance gap	4.984	7.413	-21.05	21.36	218
Divorce rate	2.167	0.687	0.4	3.8	218
Fertility	1.594	0.29	1.076	2.23	218
Marri. Age (females)	28.339	2.048	23.3	32.8	218
Field weight	0.118	0.097	0.000	0.463	970
Subfield weight	0.045	0.053	0.000	0.32	2556
Anxiety gap	5.32	4.726	-5.042	14.174	50
Self-concept gap	21.51	9.658	4.493	41.84	50
Self-efficacy gap	9.14	2.899	3.159	15.783	50

Sample of Countries (Columns 1, Table 1): Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Korea, Rep., Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

Sample of Countries (Data on WVS and math beliefs): Canada, Czech Republic, Finland, France, Germany, Hungary, Italy, Korea, Rep., Netherlands, Norway, Poland, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom (not in PISA), United States.

Table A3: Data Sources

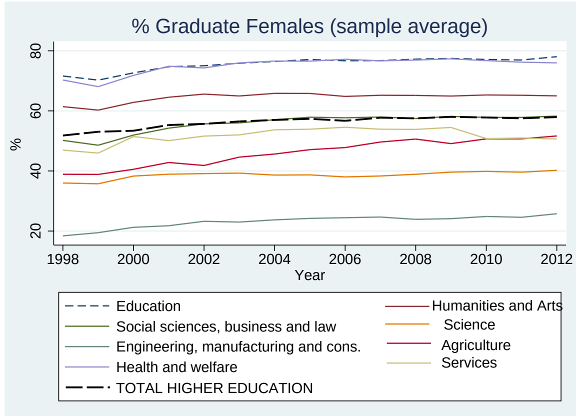
Variable	Description	Data Source
Population Density	Number of people per square kilometer	World Bank data
Female Labour Force	Female labour force participation rate	ILOSTAT database
% Service Economy	Share of employment in service sector to total employment using the International Standard Classification of Occupations (ISCO-88)	”
% Prof. Female	Share of females in the occupational status of ”professionals” (ISCO-88: group 2)	”
Size Grads	Share of total graduates in higher education to total population in percentages	OECD Education Database, World Bank
% Graduates Fem.	Share of females in total graduates in higher education	OECD Education Database
Performance gap	Female to male ratio of mean scores in PISA, TIMSS and PIRLS international tests from Quality of Education Database	Altinok et al. (2014)
Religiosity	Share of WVS respondents who say that *”God is important in my life”* equal to 10 on a 0 to 10 scale that	World Value Survey
Gender Inequality Index (GII)	This measure reflects gender-based disadvantage regarding reproductive health, empowerment and the labour market. Higher values mean greater gender inequality.	United Nations Development Program
Gender Equality (GE)	Measure of gender equality in participation in civil society organizations and politics and education (Skaaning, 2017)	International IDEA
Divorce rate	Number of divorces during the year per 1,000 people	OECD Family Database
Fertility	Total number of births per woman	World Bank

Table A4: Cross-correlation table

	PD	Ser	Prof	FL	Grad	Diver	GFem	PG	Fert	Div	Cath	Prot	Mus	Jew	Rel	GII	GE
Ser	0.017																
Prof	-0.281	-0.367															
FL	-0.161	0.443	0.317														
Grad	0.066	-0.048	0.282	0.232													
Diver	0.242	0.082	-0.420	-0.333	0.044												
GFem	-0.279	0.064	0.491	0.471	0.295	-0.519											
PG	0.354	0.073	-0.216	-0.128	-0.314	0.300	-0.280										
Fert	-0.281	0.409	-0.219	-0.145	0.100	0.069	-0.028	-0.242									
Div	0.131	0.217	-0.082	0.428	-0.014	0.124	0.016	-0.066	-0.025								
Cath	0.001	-0.423	0.482	0.081	0.173	-0.230	0.156	0.178	-0.619	-0.417							
Prot	-0.184	0.415	-0.204	0.398	0.025	-0.096	0.137	-0.130	0.186	0.276	-0.458						
Mus	-0.095	-0.651	-0.389	-0.790	-0.287	0.263	-0.539	-0.133	0.576	-0.446	-0.302	-0.303					
Jew	-0.330	0.277	0.333	0.228	-0.001	-0.154	0.171	0.107	0.297	0.505	-0.118	0.379	-0.114				
Rel	-0.243	-0.321	0.169	-0.560	0.107	0.040	-0.252	-0.164	0.389	-0.323	0.099	-0.311	0.684	0.031			
GII	-0.139	-0.509	-0.057	-0.747	-0.109	0.137	-0.266	-0.094	0.249	-0.244	-0.037	-0.330	0.813	0.018	0.765		
GE	-0.131	0.665	0.076	0.748	0.023	-0.221	0.443	0.057	0.003	0.327	0.012	0.452	-0.598	0.167	-0.633	-0.817	
Anx	-0.108	0.323	-0.388	0.209	-0.266	0.098	-0.090	0.009	0.122	0.110	-0.177	0.340	-0.376	0.140	-0.375	-0.235	0.399
Con	-0.002	0.285	-0.511	0.120	-0.378	0.142	-0.257	0.184	0.080	0.169	-0.231	0.305	-0.152	0.268	-0.099	-0.150	0.244
Effi	0.212	0.451	-0.509	0.247	-0.350	0.010	-0.163	0.315	0.147	0.138	-0.439	0.527	-0.322	0.005	-0.561	-0.459	0.489

PD (Pop. density); Ser (% Services); Prof (% Prof. Fem.); FL (Fem. Labour Force); Grad (Grads Size); Diver. (Diversif.); GFem (% Grads Female); PG (Performance gap); Fert (Fertility); Div (Divorce); Cath (% Catholic); Prot (% Protest.); Mus (% Muslims); Jew (% Jew); Rel (Religiosity); GII; GE.

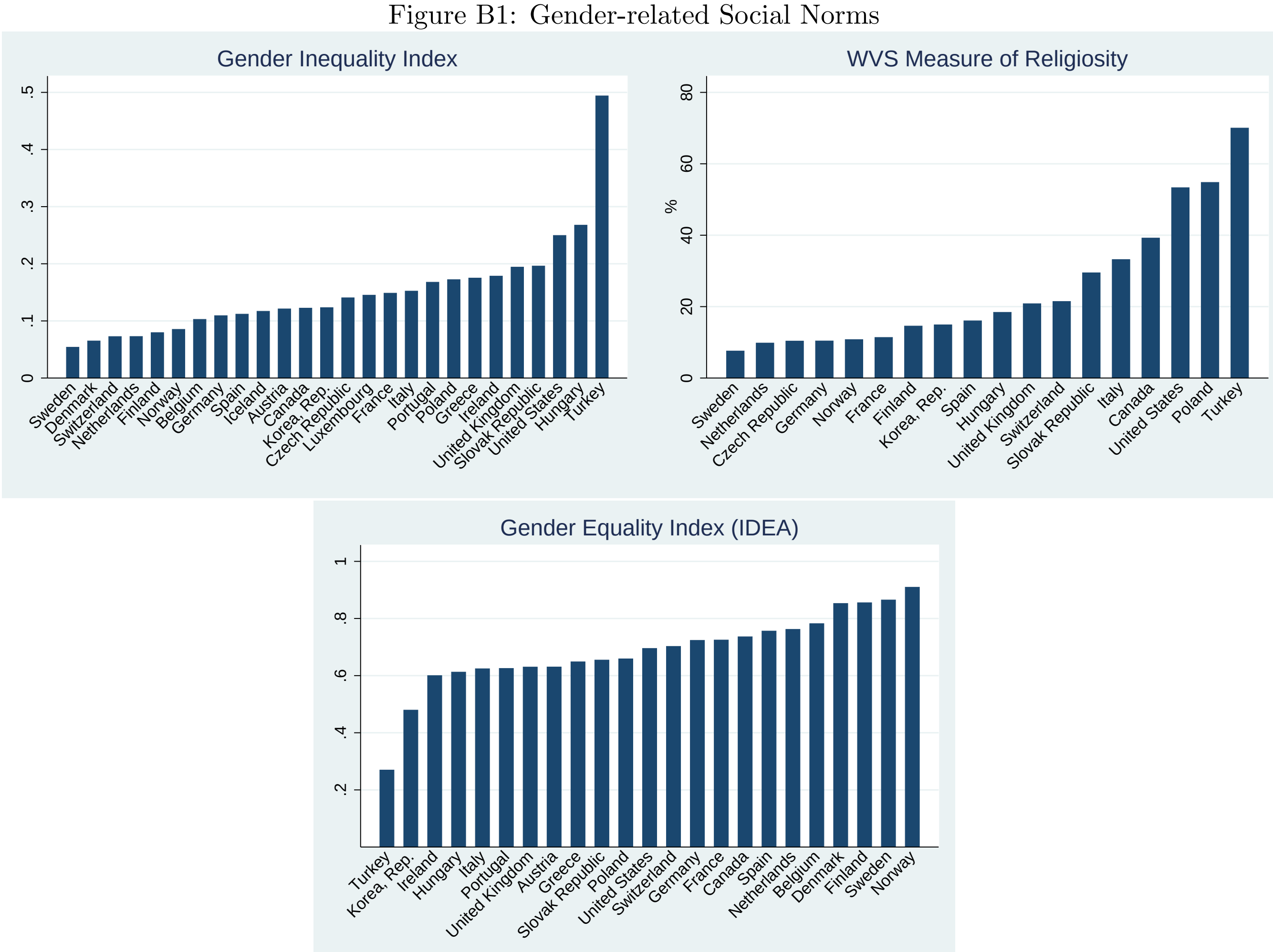
Figure A1: Trend in Proportion of Female Graduates



"Not known or unspecified" (NKOU) is not displayed in the graph

Appendix B: Gender-related Social Norms Variables

Figure B1: Gender-related Social Norms



Country averages for 1998-2012

Appendix C: PISA Assessment of Math Affinities

Table C1: Math Anxiety PISA Questions

Question	Boys	Girls	Girls - Boys
I often worry that it will be difficult for me in mathematics classes	56.37	62.94	7.45
I get very tense when I have to do mathematics homework	28.05	31.99	3.94
I get very nervous doing mathematics problems	28.47	32.24	3.77
I feel helpless when doing a mathematics problem	29.25	34.99	5.74
I worry that I will get poor (grades) in mathematics	57.79	64.41	6.61

Table C2: Math Self-Concept PISA Questions

Question	Boys	Girls	Boys - Girls
I am just not good at mathematics (strongly disagree or disagree)	63.26	52.27	11.11
I get good grades in mathematics	60.20	54.60	5.64
I learn mathematics quickly	58.69	22.92	40.10
I have always believed that mathematics is one of my best subjects	43.56	15.86	29.76
In my mathematics class, I understand even the most difficult work	42.76	15.22	29.03

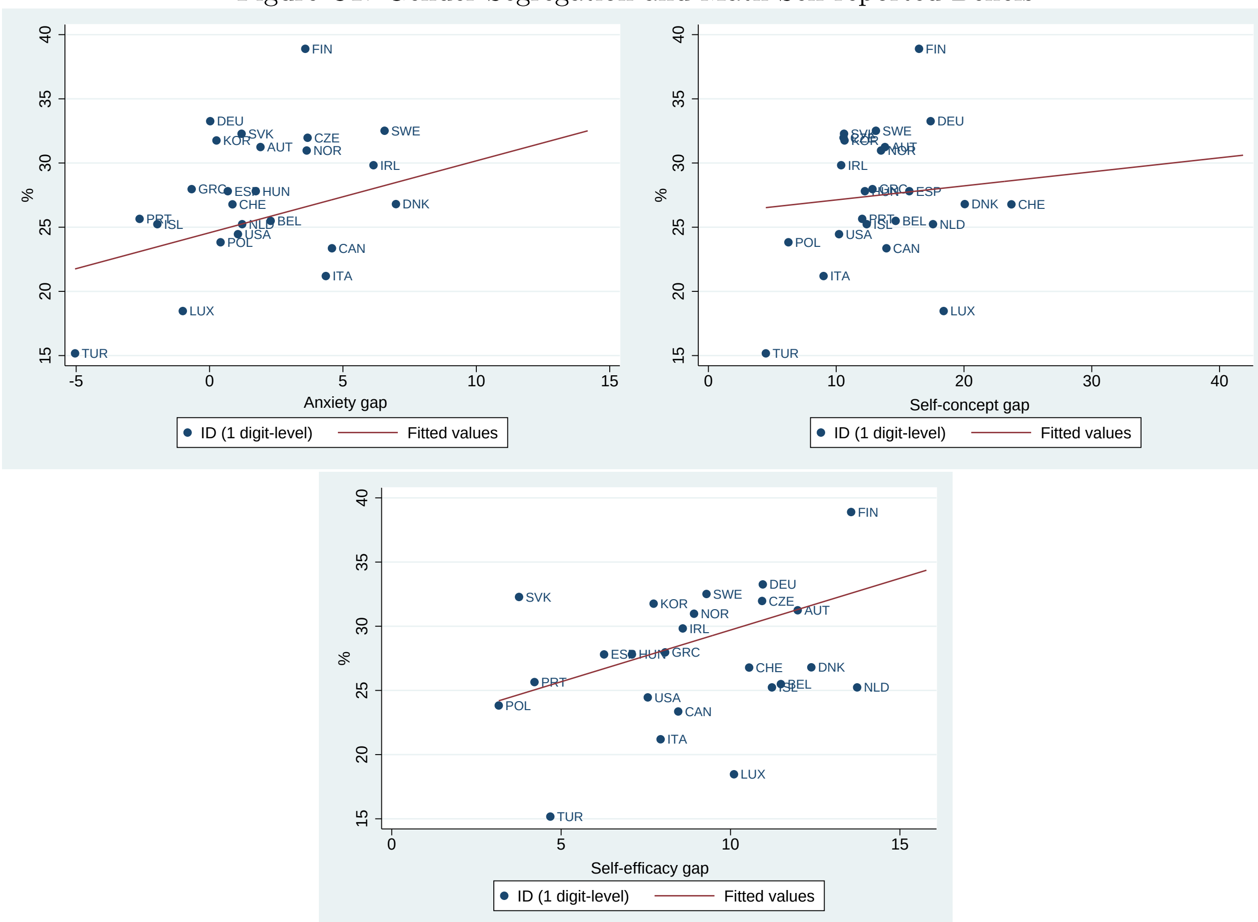
Table C3: Math Self-Efficacy PISA Questions

Question	Boys	Girls	Boys - Girls
Using a train timetable to work out how long it would take			
to get from one place to another	82.99	77.67	5.31
Calculating how much cheaper a TV would be after a 30% discount	84.32	75.98	8.35
Calculating how many square metres of tiles you need to cover a floor	75.77	61.43	14.34
Understanding graphs presented in newspapers	81.15	76.27	4.88
Solving an equation like 3x+5=17	83.8	85.2	-1.40
Finding the actual distance between two places on a map with a 1:10 000 scale	67.44	48.36	19.08
Solving an equation like 2(x+3)=(x+3)(x-3)	70.79	71.65	-.86
Calculating the petrol-consumption rate of a car	68.25	44.82	23.43

Table C4: Cross-correlation table

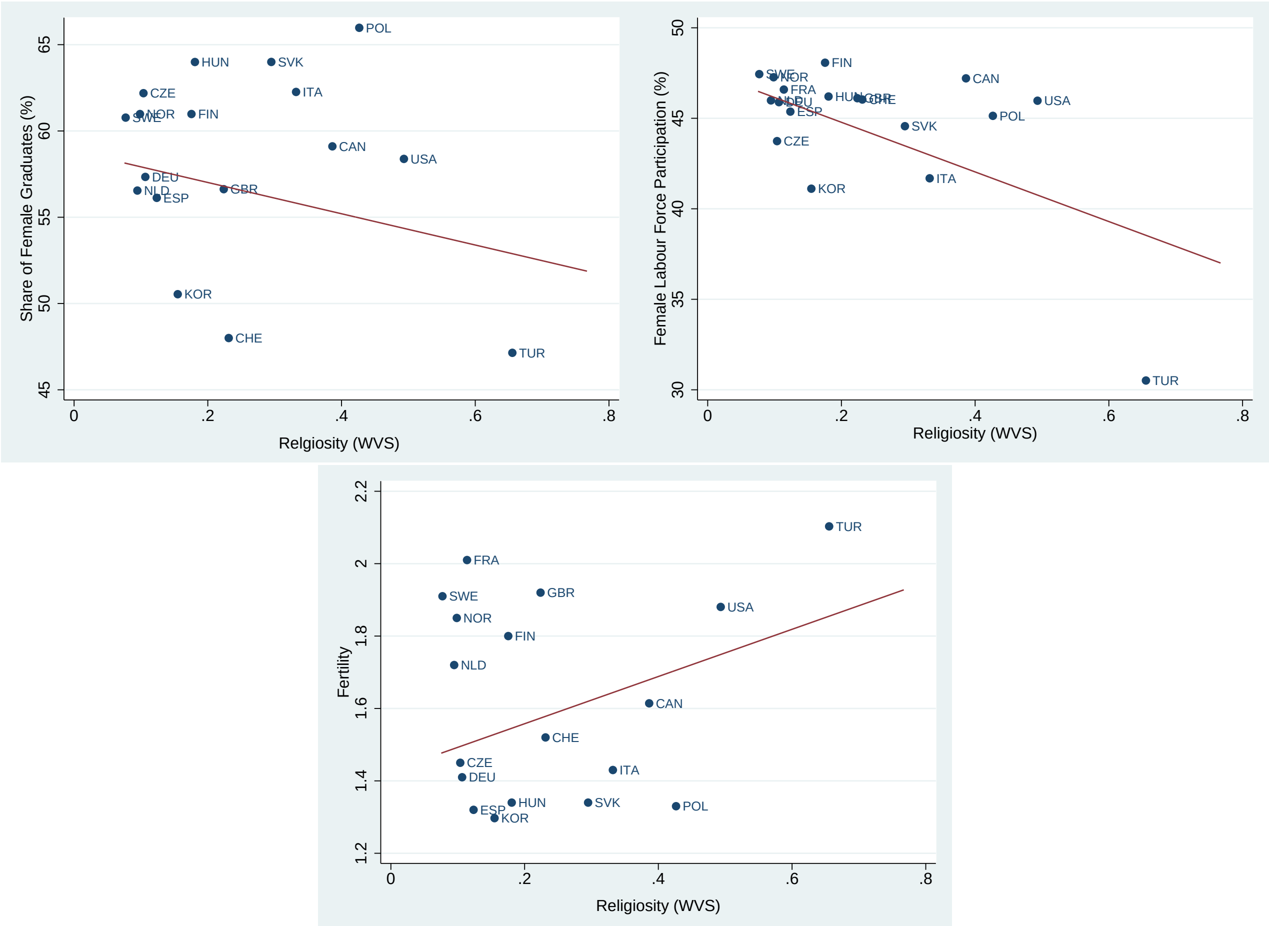
Variables	Anxiety gap	Self-concept gap
Self-concept gap	0.816	
Self-efficacy gap	0.388	0.383

Figure C1: Gender Segregation and Math Self-reported Beliefs



Dissimilarity index at 1 digit-level and gender gaps in math beliefs in 2012

Figure C2: Women in the LM and HE and Religiosity



Female participation in the labour market and higher education, fertility and religiosity in 2012