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GENDER GAPS IN EDUCATION

Abstract

This chapter reviews the growing body of research in economics which concentrates on the education gender gap and its evolution, over time and across countries. The survey first focuses on gender differentials in the historical period that roughly goes from 1850 to the 1940s and documents the deep determinants of the early phase of female education expansion, including pre-industrial conditions, religion, and family and kinship patterns. Next, the survey describes the stylized facts of contemporaneous gender gaps in education, from the 1950s to the present day, accounting for several alternative measures of attainment and achievement and for geographic and temporal differentiations. The determinants of the gaps are then summarized, while keeping a strong emphasis on an historical perspective and disentangling factors related to the labor market, family formation, psychological elements, and societal cultural norms. A discussion follows of the implications of the education gender gap for multiple realms, from economic growth to family life, taking into account the potential for reverse causation. Special attention is devoted to the persistency of gender gaps in the STEM and economics fields.

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Keywords: education, Gender, gaps

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Gender Gaps in Education

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ABSTRACT: This chapter reviews the growing body of research in economics which concentrates on the education gender gap and its evolution, over time and across countries. The survey first focuses on gender differentials in the historical period that roughly goes from 1850 to the 1940s and documents the deep determinants of the early phase of female education expansion, including pre-industrial conditions, religion, and family and kinship patterns. Next, the survey describes the stylized facts of contemporaneous gender gaps in education, from the 1950s to the present day, accounting for several alternative measures of attainment and achievement and for geographic and temporal differentiations. The determinants of the gaps are then summarized, while keeping a strong emphasis on an historical perspective and disentangling factors related to the labor market, family formation, psychological elements, and societal cultural norms. A discussion follows of the implications of the education gender gap for multiple realms, from economic growth to family life, taking into account the potential for reverse causation. Special attention is devoted to the persistency of gender gaps in the STEM and economics fields.

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Introduction

Gender-based inequalities are a universal and pervasive characteristic of all societies, today and in history. One of the most crucial dimensions in which gender differences manifest themselves is in human capital accumulation and its acquisition through education. In turn, gender gaps in education are among the main factors that determine gender disparities in a broad set of socioeconomic realms, including work, family, and public life.

Despite the persistence of discriminations, women's education has gone through substantial expansion since the 19th century, with a gradual closing, or even reversal, of the gender gap in recent times. This progress – one of the most puzzling stylized facts of modern economic growth – has received huge attention in the economics literature. This chapter makes the point on these remarkable achievements and collects the main contributions – within the field of economics – on the causes and effects of gender differences in education, with a strong emphasis on a historical perspective. Since human capital accumulation is highly persistent through time, understanding the mechanisms that have created the pre-conditions for gender gaps to emerge is a crucial input to devise policy interventions capable of eradicating them today.

The literature has relied on a wide set of measures of the education gender gap, ranging from individual indicators to composite indices. A common approach is to use relative measures, such as female to male ratios, but absolute differences are also employed. Depending on the historical period under examination, the focus shifts from basic indicators of literacy and numeracy to measures of attainment, captured in terms of years of schooling and of enrollment and completion rates, that can in turn be computed for different age groups. Achievement indicators based on grades and test scores are also appraised. As the survey proceeds, the various measures will be gradually introduced and defined.

Two warnings are in order. First, for reason of space, the review is not meant to be exhaustive, but it is instead selective. Special attention is devoted, on the one hand, to seminal contributions that have started streams of research and, on the other, to cutting-edge, recent explorations that are likely to advance the state of the art further ahead. Since, at least for specific topics, effective survey articles have recently become available, they will be referenced to as a way to summarize the corresponding literatures. The second warning concerns parallel research within the fields of history, education, sociology, and psychology, that has also greatly contributed to the analysis of the education gender gap. Even though the importance of these complementary perspectives is acknowledged, they are covered only tangentially, as they remain beyond the scope of this review, which focuses on economics (surveys for, e.g., sociology and psychology are provided by Voyer and Voyer 2014 and Buchmann et al. 2008, respectively).

The chapter is organized as follows. Section 1 focuses on the education gender gap in the historical period that roughly goes from 1850 to World War II (WW2). It describes and documents the main stylized facts and trends in gender differences in literacy, enrollment, and numeracy rates for the available countries. A separate sub-section summarizes the growing body of evidence focusing on their deep determinants, including the legacy of pre-industrial characteristics, cultural and religious

value systems, and family organization and structures. Section 2 turns to contemporaneous gender gaps in education, from WW2 to the present day. Again the section starts with a description of the stylized facts, taking into account several alternative measures of the gap involving both attainment and achievement and, for attainment, alternative levels, from primary school to high school, and then higher education, up to post-graduate programs. The analysis also distinguishes between geographic regions, sub-periods, and groups in the population (e.g., blacks and whites). As for Section 1, a separate sub-section investigates the determinants of the gaps, with an effort to disentangle separate dimensions, including labor market factors, marriage patterns, cultural, biological, and psychological aspects, technological innovation, family background, and policy interventions. Since human capital accumulation is persistent through time and transmitted across generations in a path-dependent fashion, it is acknowledged that the same forces that determined the pre-WW2 gender gaps can still be at play. A dedicated sub-section devotes special attention to the lasting gaps in the science, technology, engineering, and mathematics (STEM) and economics fields. Section 3 discusses the implications of the education gender gap for multiple realms, from economic growth to fertility decisions and family structure, taking into account the potential for reverse causation and again adopting a historical perspective, since the processes being involved can last decades or even centuries. Section 4 concludes with a brief discussion of what the literature still misses to understand and what is left to do at the policy level in order to equalize women's position to that of men's.

1. The education gender gap in history

The steep rise in female education and the continuing decline in the education gender gap have begun by the second half of the 19th century in Western Europe and the United States (US), the leading and more developed countries at the time, and are still ongoing in today's developing ones. This phenomenon has been extensively studied in economics, and especially in its branches of economic history and cliometrics, and also in neighboring disciplines such as historical demography. This section presents a review of the literature, by narrowing the focus on those contributions which refer to the pre-WW2 period.

1.1. Facts

For the most part of human history, women have been undereducated relative to men. In the past indeed female education was mostly restricted or even neglected: when, between the 16th and the 18th century, literacy and reading skills began to improve among males across early modern Europe, education was a privilege reserved only for girls and women belonging to the nobility, small elites, the regular church, professional minorities, and market-oriented classes, such as merchants or bankers. The content and quality of education also varied widely between genders: when educated, girls were mostly instructed only in basic reading, writing, and arithmetic, with much more emphasis being devoted to specific women's subjects such as needlework, sewing, and household duties. It was only with the rise of modern economic growth, over the past two centuries, that there has been a widespread expansion of mass schooling, initiated by early-industrialized nations in Western Europe and the US (Morrisson and Murtin 2009). Yet, the initial extension of education opportunities benefited mostly boys. Only since the 19th century there has been a progress in women's formal

education, with a convergence to the men's counterpart starting with the beginning of the 20th century, as modernization and economic development proceeded.

Early estimates of literacy and education statistics, disaggregated by gender, are scarcely available in the historical literature prior to 1820. For the period running roughly from 1820 to WW2, the global evolution of the gender gap in education can be summarized as follows, taking into account the few available standard measures of human capital. Starting with literacy, i.e., the fraction of literate individuals in the population, near equality across genders was reached by mid-19th century in France, Prussia (Cipolla 1969), and the US (Perlmann and Shirley 1991), and by 1900 in Great Britain (West 1978), Ireland, Northern France, and most parts of today's Austria, the Czech Republic, Slovenia, and Latvia (Hippe and Perrin 2017). Gender parity – defined by the United Nations Educational Scientific and Cultural Organization (UNESCO) using the Gender Parity Index (GPI), i.e., the ratio of female to male values, where 1 represents perfect equality – gradually decreased moving toward the Southern Mediterranean countries, such as Spain, Portugal, and the South of Italy, and was confined to very low values in Eastern Europe and the Balkans.

Turning to enrollments, in the European context gender parity was nearly reached by the second mid-19th century, at the primary level, in Great Britain, Belgium, and Prussia, followed by the Netherlands and Italy, while many other countries, such as Spain, lagged behind (Bertocchi and Bozzano 2016). Italy actually showed a peculiar pattern in the GPI in enrollments, mostly due to the wide regional divide which characterized the country in many dimensions, including human capital formation: between 1861 and 1911, while higher and increasing gender equality, both in enrollments and literacy, was documented in the North, very low and stagnating levels were found instead in the Center-South of the country, a path-dependent pattern mostly inherited from pre-unification states and their differing educational policies prior to 1861 (Bozzano and Cappelli 2019; Cappelli and Vasta 2019; Ciccarelli and Weisdorf 2018). By contrast, in Ireland, gender differences in attendance were even reversed by the 1880s and those in enrollments followed suit by 1901 (Blum et al. 2017). On the other side of the Atlantic, in the US, mass schooling expanded since the early 1800s in a balanced way for males and females, both in terms of enrollment ratios and years of schooling. Later on, between 1870 and 1950, women superseded men among high school graduates (Goldin 2005).

Extending on Barro and Lee (2013), who report statistics on human capital formation for the period 1950-2010, Lee and Lee (2016) compile a gender-disaggregated dataset on enrollment rates and educational attainment for 111 countries from 1820 to 1945, at five-year intervals. These long-term data allow to look at wider areas of the world: in the period 1820-1950, the gender gap in enrollment rates significantly declined, in a faster way between 1900 and 1950 (Lee and Lee 2016). In 1820, in the early-developed countries (today's advanced economies), the average enrollment rate at the primary level was 37% for boys and 21% for girls, with an implied GPI of 0.59. By 1950, primary enrollment rates had increased to 92.4% and 90.3%, respectively, and the GPI had approached equality (0.97). Instead, for the rest of world, between 1820 and 1900 primary schooling still remained largely neglected. It begun to expand only after 1870-80 in Eastern Europe and Latin America, which performed well also in terms of GPI, and even later in the rest of the developing world, where the GPI reached values above 0.5 only by 1950.

Likewise, average educational attainment and the human capital stock sharply increased over the period (Lee and Lee 2016): throughout the world, average years of schooling for females increased from 0.42 in 1870 to 2.88 in 1950, while for males they went from 0.55 to 3.54. Differences between women and men were much wider in developing countries. Nonetheless, on the whole in the period 1820-1950, the main critical difference among genders was in terms of access to education, because whenever both genders were effectively enrolled at and attending school, the gender gap in average years of schooling became quite negligible.

A further account of gender differences in human capital formation is given by numeracy estimates, which can sometimes be retrieved, in the historical records, even when gender-disaggregated standard measures of literacy and schooling are lacking. In order to compute them, the most commonly employed method is the age-heaping method, which consists in estimating the systematic misreporting of age derived from censuses. An index of gender equality can then be derived by comparing the numeracy rates of men and women. In comparative perspective, basic numeracy skills spread in the early Middle Ages in Western Europe and the German-speaking lands of central Europe, which reached high numeracy rates by 1600, long before the rise of mass schooling and industrialization. Gender gaps were already identifiable, but they were too diverse among countries to permit to delineate a common trend (A'Hearn et al. 2009). Rare accounts on Flanders and the Netherlands demonstrate that already by the 16th century there was almost no gender gap in numeracy or, under certain circumstances, women even outperformed men (de Moor and van Zanden 2008, 2010b). Similarly, gender gaps in age heaping were negligible in Spain over the period 1877-1930, in spite of remarkable differences in literacy rates (Beltran Tapia et al. 2018). Finally, evidence on Italy in 1871 shows that even though a systematic gender gap in age heaping existed, it widened with age, by cohort, and by geographic area. Moreover, women were more likely to heap their age than the lowest-skilled men (A'Hearn et al. 2016).

Referring to more recent years, estimates of gender equality in numeracy are available for 28 Latin America countries over the period 1880-1940 (Baten and Manzel 2009) and for 14 Asian countries over the period 1900-1960 (Friesen et al. 2012). Although gender equality in numeracy increased in both areas together with economic development, Argentina, Uruguay, Suriname, and Guyana performed very well over the long run, followed by Central American countries. Conversely, none of the Asian countries being considered ever showed gender parity over the longer period, except for Hong Kong, the Philippines, and Pakistan for certain decades. In particular, the Philippines and Sri Lanka started from very large levels of gender inequality in 1900 but nearly closed the gap in subsequent years. By contrast, Afghanistan and Iran even worsened their gender gap over the period, reaching the lowest scores among all countries in the sample.

1.2. Determinants

After presenting the available historical stylized facts, it is natural to ask which were their determinants, in order to understand the processes that produced the gender gaps in education that arose in modern times. Even though a consensus has not yet been reached, this question has been at the center of a very recent literature, which is still in its infancy, that has looked at girls' education in

historical perspective. To date, this literature has been expanding its coverage in terms of time span, but it is still limited to few countries, mainly located in Western Europe.

The identification of the causal mechanisms driving the education gender gap is inherently problematic, because the rise in education for women and girls might be both a cause and a consequence of modernization forces such as changes in economic growth, fertility, culture, and institutions through time. The resulting potential reverse causation between women empowerment and economic development is addressed by Duflo (2012).

Among the few contributions that have focused on the drivers of the education gender gap in the pre-WW2-period, a common approach is the attempt to conceive human capital accumulation, and the associated gender gap, as "inherently historical" (Goldin 2016) and therefore determined by and embedded into history, culture, and value systems as inherited from the past. In other words, to acknowledge the persistence through time of the legacy of certain gender norms and incentives is crucial to the understanding of the issues at hand.

The lasting inequalities in education among genders do emerge at the very beginning of the expansion of education in the early modern pre-industrial era, as societies progressively enhanced access to and the supply of educational opportunities, in order to respond to demand-driven factors such as religious and intellectual forces as well as professional, commercial, and administrative needs. According to the historical narratives, the chances for a girl of being educated in the medieval and early modern period were a function of a wide set of factors such as economic incentives and characteristics, e.g., wealth and job opportunities, but also religious denomination and values, family structure, and kinship relations, as well as female agency and empowerment per se. Even though these complex factors are intimately intertwined, for ease of exposition an effort will be made to examine them separately in the following sub-sections.

1.2.1. Trade and economic development

A first group of contributions focuses on the role of commercial and professional demand for education in the late Middle Ages and early modern era in promoting female education. Indeed, in this period a broad process of expansion of human capital accumulation affected different areas of the European continent, such as Italy, the Low Countries, and the North Sea region, in response to the amplification of international exchange and trade, city growth, and intense economic development. These processes promoted the progress of mercantile practices, such as banking and payment tools as well as mercantile bookkeeping techniques. In the context of a generalized increase in the demand for literacy and numeracy, female education also emerged as a by-product, since in merchant communities women were frequently in charge of business operations and therefore needed to be educated. The link between trade and the creation of new opportunities for women is amply documented across Europe (Richardson 1997; Uitz 1990; Wiesner 2000). As a result, medieval and early modern commercial centers were characterized by relatively high female literacy rates (Hoftijzer 2001; Spufford 1995) and numeracy rates (de Moor and van Zanden 2008). It has been documented that these early gains in female education, reached in the distant past, were able to change the role of women in the corresponding societies in a persistent fashion, thus perpetuating their

original influence through the intergenerational transmission of human capital and gender roles: for instance, more equal educational attainment for girls is still observed in the second half of the 19th century in those Italian provinces that hosted a trade center in the Middle Ages (Bertocchi and Bozzano 2016).

1.2.2. Religion

A second relevant potential push factor, or else a retarding force to female education, has been religion, with the associated incentives or disincentives, depending on the denomination. The functional importance, for specific religions, of achieving literacy in order to read religious writings is one of the mechanisms highlighted in the literature: indeed during the 16th century, first in Protestant areas and then, albeit to a lesser extent, in Catholic ones, learning how to read has been increasingly included as part of religious instruction. In the same regions, religious authorities have progressively encouraged the development of girls' schools and formal teaching opportunities for girls (Houston 1983; Wiesner 2000). In the context of 19th century Prussia, Protestantism has been established as one of the religions which had a greatest impact on girls' education, precisely because of its more pronounced stress on the individual study of the Bible both for boys and girls, while Catholicism in the same context had generally relied more heavily on oral communication of religious dicta (sermons) (Becker and Woessmann 2008; Bertocchi 2011). The same finding is confirmed for Africa in the colonial period, where the location and activities of Protestant versus Catholic missionaries have exerted different long-run effects on the educational attainment of females, consistently with the conclusion that the Protestant church placed more importance on the education of women's than the Catholic one (Nunn 2014). To be noticed is that both Protestantism and trade did play an important role in enhancing female education historically. Furthermore, in vast areas of historic Europe, in particular Northern Europe, the spread of Protestantism and the expansion of commercial networks often coincided (Spufford 1995), making potentially hard to unbundle their distinct influences.

Going beyond the role of certain religious groups and organizations as important suppliers of education, the differential treatment of boys and girls with regard to human capital formation can also be viewed as the result of the intrinsic explicit and implicit female subordination to men perpetrated into religious texts (e.g., the Bible), as well as other forms of religious teachings. In this perspective, specific religious denominations have been among the most relevant retarding and constraining forces affecting female education, not only in the past but up to the present day. In China, for example, Confucian ideology has historically ascribed to women an oppressed and discriminated social status (resulting, for instance, in girls' foot-binding practices), which in turn has not allowed them to be educated as well as men until the last 60 years, notwithstanding the millennial and rich educational history which characterizes the country (Liu and Carpenter 2005). The same discriminating influence on female education is also found in countries where Hinduism and Islam are prevalent (Frieser et al. 2012), with effects lasting up to the present day (Cooray and Potrafke 2011; Dollar and Gatti 1999; Norton and Tomal 2009).

Gender inequitable beliefs are generally associated with all those dominant religions that are based on a deep patriarchal and hierarchical structure – including the Judeo-Christian, Hindu, and Muslim

traditions – and therefore impose specific behavioral prescriptions for men and women resulting in persistent gender models and stereotypes (Kok 2017).

1.2.3. Family and kinship

The next driver of the education gender gap assessed in the literature relates to family and kinship patterns and their implicit elements of patriarchy. The family is a fundamental economic and demographic unit within which all decisions on education and childbearing, as well as consumption and saving, are taken: the different rules governing family and kinship formation are therefore among the most studied mechanisms at the core of the differential trends in both female empowerment and economic development, in the short and long run.

As early as the 1960s, a flourishing strand of the literature has concentrated on the so-called European Marriage Pattern (EMP), a family model diffused at least since the 16th century in Northern Europe, West of a line running from Trieste to St. Petersburg, and mostly conceived as pre-dating industrialization (Hajnal 1965, 1982; Laslett 1977, 1983). The EMP was characterized by nuclear residential patterns, relatively late female marriage age, and widespread permanent female celibacy. These features were eventually complemented by a low age gap between spouses (Laslett 1977). Given these distinctive features and the implied practice of consensual marriage, this mating model led to cultural values based on equality between the sexes within the household. Hence, women were encouraged to acquire human capital and work outside the household. The resulting "girl power" is believed to have contributed to economic growth (Carmichael et al. 2016; de Moor and van Zanden 2010a; Foreman-Peck 2011), even though this conclusion has been challenged (Dennison and Ogilvie 2014). Moreover, because of its strong correlation with human capital accumulation – and therefore higher opportunities to enter the labor market – late female age at marriage has been often considered a good indicator of the degree of subordination of women in society, i.e., of female agency (Baten et al. 2017; Bertocchi and Bozzano 2019; de Pleijt et al. 2019; van Zanden et al. 2017). Less educated – early marrying – women eventually exerted a negative influence on the human capital accumulation of their offspring, thus inducing a detrimental effect on the human capital potential of the population as a whole, as revealed by data on numeracy for late medieval and modern Europe (Baten and de Pleijt 2018).

Similar considerations arise from a further influential line of research which has concentrated on the legacy of the family systems prevailing in the Middle Ages for subsequent economic and human development (Todd 1985, 1990), and more specifically for gender relations and empowerment (Carmichael and Rijpma 2017), up to the present day (Duranton et al. 2009). Indeed historical family patterns were characterized by different residential habits (nuclear versus complex families) and inheritance rules (partition versus primogeniture), which influenced gender power and the position of women within the household and in the society. In line with the EMP literature, a higher degree of gender equality in education is associated with nuclear residential habits and equal partition of inheritance (Bertocchi and Bozzano 2015), with an even stronger effect under late age at marriage (Bertocchi and Bozzano 2019). Along the same line of reasoning, female agency is highly correlated with a further feature of family and kinship structure, i.e., the degree of feminism in the patrilinearity-bilaterality-matrilinearity continuum, which is in turn connected with higher human capital

investment and economic development (Le Bris 2016; Todd 1987). Still, the explicit link with the education gender gap lacks any formal empirical test to date.

In an alternative framework based on historical census micro-data referring to Europe in the period 1700-1918, patriarchal characteristics of alternative historical familial settings are identified and combined in order to calculate a patriarchy index (PI) (Szołtysek and Poniat 2018; Szołtysek et al. 2017). This measure is composed by four main dimensions: male domination over women, old-age domination over the younger, patrilocality, and son preference. The PI is then employed to analyze its connection with human capital accumulation for different societies in the past. Overall, previous findings are mostly confirmed: in most patriarchal societies parents underinvest in the education of daughters, who then acquire very limited access to education, while their employment opportunities are further constrained by the indirect effect of early marriage (Gruber and Szołtysek 2016). A patriarchy-numeracy correlation is also effectively at work in these societies: higher PI values tend to be associated with lower levels of numeracy, particularly among women (Szołtysek et al. 2019).

A mainly theoretical strand of the literature stresses the role of sociologically and anthropologically grounded mechanisms that can originate gender heterogeneity in education. Kinship and family patterns might result in gender differentiated parental preferences for the optimal level of children's education, because of different arrangements about the post-marital residence of the offspring and the presence of intergenerational co-residence: under patrilocal exogamy and extended kinship configurations, daughters are more likely to leave their natal homes upon marriage and therefore female education is minimized (Rammohan and Robertson 2012); conversely, in communities that practice the custom of bride price, daughters' education is favored and increased (Ashraf et al. 2019). Prevailing gender stereotypes can also shape the evolution of women's human capital as a result of the interplay of families' decisions on the quality of the offspring as a coordination game: since the final objective is to maximize total income of each future household, parents will invest in the education of daughters taking into account the marriage market. Therefore, gaps in female-to-male investments in education arise since it is optimal for each family to discriminate daughters if all the other families do the same (Lagerlof 2003). In a similar framework, endogenous cultural norms about gender roles co-evolve with gender disparities in education, leading to low development traps and inferior economic performance. Indeed, when the gender gap is internalized, it creates a vicious cycle: the resulting decreased participation of women in the labor market will strengthen inegalitarian gender beliefs and the initial gender gap is reinforced since boys will receive more education than girls (Hiller 2014).

2. Contemporaneous gender gaps in education

2.1. Facts

This section collects basic stylized facts about the education gender gap starting from the post-WW2 period, taking into account different measures, geographical areas, and sub-periods. It starts by presenting global trends and then focuses separately on Organization for Economic Co-operation and Development (OECD) countries and developing countries.

2.1.1. Global trends

Despite the fact that gender-based inequalities have tended to close in recent years, sharp differences still exist across levels of education and across countries. A majority of regions have reached gender parity in primary education, but disparities persist at higher levels (United Nations 2015). The United Nations Gender Inequality Index, aimed at capturing women's empowerment, includes a component that reflects education gender gaps, measured by comparing the ratio of females aged 25 years and older with at least some secondary education with the corresponding ratio for males. For the world as a whole, as of 2010-2017, such ratios are equal to 62.5 for females and 70.9 for males, while they are closer, at 84.6 and 87.3 respectively, among OECD countries, and considerably further away, at 25.0 and 34.3, among least developed countries. However, participation rates in primary and secondary education, taking into account the relevant age brackets, have reached near-equality for girls and boys, while in tertiary education a reversed bias is emerging in favor of women, who are enrolling at faster rates than men (World Bank 2012).

Over the period 1980-2014, world trends of the GPI at the secondary level, i.e., the female to male ratio of gross secondary enrollment rates, reveal an increase for all regions in the world. If data are disaggregated by region, with reference to the International Monetary Fund (IMF) classification, the ratio is above 1 in the Americas and the Caribbean for most of the period, close to 1 in Europe, approaching 1 in Asia and the Pacific at least by the end of the period, and still below 1 in sub-Saharan Africa, the Middle East and Central Asia. Disaggregating countries by income level (again following the IMF designation), all groups display convergence in the ratio toward 1, with low-income developing countries making substantial progress but still lagging behind, again more visibly so for lower income countries within sub-Saharan Africa, the Middle East, and Central Asia (Stotsky et al. 2016).

2.1.2. OECD countries

Narrowing the focus on OECD countries, the historic progress in young women's education is documented using data by Barro and Lee (2013) covering the period from 1896 to 1980 (OECD 2015a). Over the century, the average number of years of schooling among the working-age population in OECD countries increased from 6 to 12 years for men and from 5 to 13 years for women, with substantial equality reached by 1970, and a reversal of the gap emerging since then. With the introduction of compulsory education, usually up to age 14 to 16, secondary education has become nearly universal, with more young women (87%) than young men (81%) graduating from an upper secondary program by 2000.

At the tertiary level, OECD data show that the fraction of women attaining a degree has surpassed that of men's, to reach 34% and 30%, respectively, by 2012. Indeed, the expansion of tertiary education has largely benefited women, to the point that among individuals aged 55 to 64 a perfect balance has been reached on average across OECD countries, with the same fraction (27%) of tertiary educated for men and women. Among younger individuals, aged 25 to 34, the share of tertiary educated women is even higher than that of men (50% and 38% respectively, in 2017). With reference to advanced research programs, women are also increasing their participation. In 2010, over most

OECD countries, the proportion of advanced degrees awarded to women had reached 40% to 50%. In 2017, among individuals aged 25 to 34 who attained a master's degree, women represented the majority in 33 countries, while this was true only in 11 countries at the doctoral level (OECD 2018).

Program for International Student Assessment (PISA) scores reveal further information about educational achievement. Ever since the tests were first administered in 2000, girls have outperformed boys in reading while boys did better – albeit by a lesser degree – in mathematics, with science performance being equalized. The PISA questionnaires also capture consistent shifts in youth's expectations regarding their future education and occupation, with 15-year-old girls currently showing more ambitious prospects than boys of the same age. Boys are more likely than girls to fail to attain a baseline level of proficiency in reading, math, and science (14% against 9%), while high-performing girls still underachieve in math compared to high-performing boys. Rather than in innate biological differences, the reasons for these patterns of performance are to be found in students' attitudes towards learning, their behavior in school, their use of leisure time, and their self-confidence (OECD 2015b).

The experience of the US has led researchers' attention to the reversal phenomenon in secondary and tertiary education. Throughout most of the 20th century, at the high school level the gender gap in graduation rates has persistently favored girls: it narrowed between 1920 and 1970, but widened ever since (Goldin and Katz 2008). It is therefore at the college level that a reversal is observed. The ratio of male-to-female undergraduates in the US was close to 1 from 1900 to 1930, and then started to grow, to continue growing until 1947. Later on, the constant increase in female enrollments relative to male gradually reduced the ratio. In 1960, there were 1.55 males for every female. By 1980, parity was achieved, and then turned into an advantage in favor of women. By 2003, there were 1.30 females for every male undergraduate (Charles and Luoh 2003; Goldin et al. 2006).

Because of its peculiar racial mix due the legacy of slavery, the US has also been at the center of research on the influence of race on the gender gap in education. Since black females are much more likely to attend college than black males, the college-level gender gap among black youth is actually even larger than the black-white racial gap (Aucejo and James 2017). An excessive gender gap for black youth is also present in high school completion rates (Autor et al. 2019).

2.1.3. Developing countries

Turning to developing regions, along with the expansion of mass education gender disparity has narrowed substantially, and sometimes reversed, at all levels of education, sometimes with even faster progress than in OECD countries (Becker at al. 2010a). In 2015, on average, the GPI was equal to 0.98 in primary and secondary education and 1.01 in tertiary education, despite vast cross-country variation. Primary education has witnessed the most significant improvement, especially in Southern Asia, where the index was lowest in 1990 but reached 1.03 in 2015. Gender inequality at the primary level has also been reduced sizably in North Africa, sub-Saharan Africa, and Western Asia. At the secondary level, gender parity was widespread by 2015, but girls were still behind in Oceania, sub-Saharan Africa, and Western Asia, while they outperformed boys in Latin America and the Caribbean. In the same year, women were still underrepresented also in tertiary education, especially in sub-

Saharan Africa and Southern Asia, but evidence of a reversal was instead present in Eastern Asia, Northern Africa, Latin America, and the Caribbean (United Nations 2015).

Yet, in the face of generalized improvement, in severely disadvantaged populations girls remain the last to enroll and the first to drop out (World Bank 2012). At the same time, Demographic and Health Surveys data covering a sample of 38 developing countries over the periods 1990-1999 and 2000-2006 reveal that, in most countries, girls who have ever attended school have equal or significantly better schooling progress than boys in a similar position, pointing to a female advantage conditional on ever attending school (Grant and Behrman 2010).

2.2. Determinants

After presenting the stylized facts concerning the education gender gap in the post-WW2 period, this section proceeds by looking at its potential causes. As for other contemporary gender gaps such as those in political participation and economic opportunities, the gap in education is intimately linked to gender norms that originated in response to specific historical circumstances, but were then transmitted across generations and tend to persist even after the originating historical conditions and incentives have changed (Alesina et al. 2013; Bozzano 2017; for an extended review see Giuliano 2018). Hence, the same drivers of the pre-WW2 gender gaps may still be at play in the post-war period. Even though several of the underlying processes are closely interrelated, the following review will attempt at disentangling the most relevant ones.

2.2.1. Labor markets factors

An early literature, mostly focused on the US, has emphasized drivers coming from labor markets, where improved opportunities for women – through higher participation and earnings – gradually determined an increase in their educational attainment. By the end of the 1960s, women's expectations of their future labor force participation prospects went through a rapid change, relative to previous generations, that pushed their demand for college education. This change in expectations started to manifest itself even earlier on women's educational achievement, through improved test scores and high school performance (Goldin 1995; Goldin et al. 2006). From the 1980s to the 2000s, the role of post-secondary expectations, in particular those for attending graduate or professional schools, is confirmed as a major driver of the increase in girls' high school grade point average, relative to boys (Fortin et al. 2015). Moreover, since 1980, conditional on being a college-educated woman, the probability of working in a cognitive/high-wage occupation has risen, in contrast with the experience of college-educated men, due to a greater increase in the demand for social skills in such occupations relative to others. Evidence from the psychology and neuroscience literatures confirms that women have a comparative advantage in tasks requiring social and interpersonal skills (Cortes et al. 2018).

Biological differences between men and women in terms of brawn versus brains, with men being physically stronger than women on average, have also been invoked in order to explain the education gap reversal in other contexts, such as long-run growth theory (Galor and Weil 1996) and empirical analyses of developing countries (Pitt et al. 2012).

2.2.2. Family formation

It is hard to separate labor markets factors from factors involving other interrelated social processes. Indeed, as women were changing their expectations about career prospects, and consequently adapting their educational choices, they were also marrying and having children later (Goldin 1995). As already seen in the previous section, marriage and family patterns are a crucial driver of schooling decisions and, ultimately, of the education gap reversal in more recent times. One reason why women may be induced to invest in education more than men do is that men are increasingly in short supply in the marriage market (Iyigun and Walsh 2007). Another explanation stems from the fact that divorce is more harmful to women, due to their lower income, so that women may use schooling as an insurance device against the risk of unwanted divorce (Chiappori and Weiss 2007). The joint determination of pre-marital schooling and marriage patterns may also lead to an equilibrium where women invest more than men when the labor market return to schooling rises, home production demands less time, and the traditional norms of labor division weaken (Chiappori et al. 2009). Indeed, the impact of relative earnings and labor market performances is enhanced when rising divorce probabilities, that increase returns to schooling for females and decrease them for males, are accounted for (Ge and Yang 2013).

The impact of the family in shaping norms and biases regarding the role of women in society can also manifest itself through changes in the way the sons of working mothers view working women as potential wives. Males' more positive attitudes to the idea of having a working wife may render more attractive for girls to invest in market-work human capital, thus activating a learning process leading to cultural change (Fernandez 2013; Fernandez et al. 2004). Assuming the existence of a quantity-quality trade-off in the decision to raise children (Galor and Weil 2000), another explanation for the reversal of the gender education gap comes from a decline in the variation in family size, in a context where parents' preferences are biased in favor of sons. At an early stage of development, low returns to human capital induce parents with female firstborn to have more children, so that girls tend to be raised in larger families and hence receive less education. As development raises the returns to human capital, the bias in favor of sons declines, variations in family size falls, and the correlation between family size and the number of daughters is weakened, leading to an improvement in females' educational outcomes (Hazan and Zoabi 2015).

The influence of family systems can be particularly strong in the developing world, where affordable mass education is not the standard and cultural norms transmitted through the family are especially resilient to change. Indicators that capture the relative strength of women within a marriage, such as age at first marriage, the age difference between husband and wife, the ability of women to inherit, and the patterns of co-residence, are correlated with gender equality in education (van der Vleuten 2016). More generally, many developing countries have cultural norms that exacerbate favoritism toward males and, interacting with the development process itself, generate gender gaps favoring males, not only in education but also health, personal autonomy, and other realms (Jayachandran 2015).

2.2.3. Culture versus nurture

A specific research line has focused on the determinants of the gender gap in schooling achievement, and in particular in math scores. Using PISA data, a cross-country association has been uncovered between measures of women's emancipation and the gender gap in math scores, which tend to favor boys. In fact, the performance of girls is closer to – or even better than that of – boys in those countries where social and economic conditions are more favorable to women (Guiso et al. 2008). In Muslim countries, despite women's low status, there is actually little or no gender gap in math, but this can be explained by the prevalence of same-sex classes, that may boost girls' self-esteem (Fryer and Levitt 2010). Over US data, gender disparities also show significant cross-state variations, again with larger gaps in more gender-unequal states (Pope and Sydnor 2010). Even among high achievers, in the US girls are underrepresented, with a widening of the math gap over the high school years (Ellison and Swanson 2018), while a cross-country comparison shows that female underrepresentation is more severe in more unequal countries (Breda et al. 2018). Other analyses based on the performance of second-generation immigrants confirm the influence of country-of-ancestry gendered social norms on girls' math test scores, relative to those of boys (Rodriguez-Planas and Nollenberger 2018), while a comparison between former East and West Germany also shows that the relatively better performances for girls in the East can be attributed to cultural attitudes shaping their attitudes, confidence, and competitiveness (Lippmann and Senik 2018). Generally speaking, since nature-driven, innate abilities – being determined by genetic and hormonal factors – are plausibly invariant across regions, the gaps can therefore be interpreted as coming from cultural and social norms. A potential mechanism shaping such norms can be found in the process of socialization within the family, and in particular in parents' preferences for boys (Dossi et al. 2019). Furthermore, traditional opinions held by women regarding the role of women in the labor market are shown to be developed in youth and to result in reductions in their human capital investment (Vella 1994), while young women's decisions to invest in higher education are affected by the labor market outcomes of older women living in the same region: where career opportunities for women with young children are wider and more women reach top positions, the incentives for younger women are stronger (Casarico et al. 2015). Even the contribution of a biological factor such as prenatal testosterone, measured by comparing in-utero exposure for twins – with girls with a twin brother scoring lower in math compared to girls with a twin sister – is believed to manifest itself through environmental factors related to adherence to traditional gender norms, rather than through biology itself (Gielen and Zwiers 2018).

2.2.4. Psychological elements

Drawing on the psychology and social-psychology literatures, a stream of economics research surveyed by Bertrand (2010) provides micro-foundations for why women may choose different educational paths than men, by stressing the importance of gender differences in risk preferences, attitudes toward competition and negotiation, and other variations in personality traits. For instance, the gender gap in achievement in math tests, which are perceived as particularly competitive and anxiety-inducing for girls, can be explained by the fact that women respond particularly poorly to competitive pressures (Niederle and Vesterlund 2010). An explanation offered for the reversal of the gender gap in attainment relies instead on the fact that boys tend to have a higher incidence of behavioral problems in high school, because of their later puberty and maturation. One consequence

is that postponing when students have to choose between vocational and academic tracks leads to an increase in the share of girls choosing the latter and continuing into tertiary education. This differential response is related to the fact that, while boys and girls are at a similar stage of cognitive and psychological development at age 10-11, by age 14 girls are beyond puberty while boys are still going through a problematic stage (Pekkarinen 2008). College attendance rates are also affected by the gender gap in non-cognitive behavioral factors, since boys have a higher incidence of school disciplinary problems and spend fewer hours doing homework (Jacob 2002).

The accumulation of human capital by girls can also be affected by negative stereotypes held by teachers. A typical example of such stereotypical beliefs is that boys outperform girls in math and science, so that girls are encouraged to pursue traditionally female and less demanding tracks. Empirical tests of this hypothesis have employed measures of gender bias expressed through grading (Lavy 2008; Lavy and Sand 2018), self-reporting (Alan et al. 2018), and the Implicit Association Test (Carlana 2019), a test devised by social psychologists (Greenwald et al. 1998). Most studies (but Lavy 2008 is an exception) uncover evidence of negative stereotypes against girls, particularly with reference to math test scores, with potential long-run implications for occupational choices and earnings at adulthood, through self-selection of girls away from choosing college degrees in the hard sciences.

2.2.5. Technological innovation

Technological innovation, in its various forms, can affect women's decisions to accumulate human capital. The decline in the price of household durables, which freed women from household work, raising their value in the labor market and their incentive to become more educated, is one example (Greenwood et al. 2016). Medical innovation provides several other examples. The availability of oral contraceptives increased the likelihood that college-educated women chose to make further investment in their career, by attending post-graduate programs such as medical or law school (Goldin and Katz 2002). Health improvements, and their relative stronger pace for females, are a further driver of the increase in female schooling. In the US, between 1930 and 1960, medical improvements in maternal health and the introduction of infant formula enabled women to reconcile work and motherhood, letting their educational attainment increase together with the rise in their labor force participation and the decline in their fertility (Albanesi and Olivetti 2016). Variation in life expectancy gains triggered by the epidemiological transition (i.e., the post-WW2 period of rapid decline in mortality, due to medical innovations, from previously fatal infectious diseases) also had a gendered impact, with women benefitting more than men because of their more favorable biological responses to vaccination. This resulted in differential increases in female and male educational attainment and contributed to the closing of the education gender gap (Klasing and Milionis 2017).

2.2.6. Family background

In US based studies, family socioeconomic status – another important determinant of schooling decisions – has been found to exert a much stronger influence on high school completion decisions for males compared to females. Moreover, since black boys are more likely to belong to disadvantaged families than white boys, this sensitivity can explain why the gender gap is larger for

the former compared to the latter (Autor et al. 2019). Gender gaps in college attendance also vary substantially across the parental income distribution, with childhood disadvantage being especially harmful for boys, so that men raised in low-income families do especially poorly relative to women in adulthood (Chetty et al. 2016). The differential responses for black males and females to family background persist at the college level, with black boys being more responsive to family background than are black girls (Aucejo and James 2017).

In developing countries, progress in female education is associated with increases in household incomes, more powerfully so when they happen simultaneously with increases in the returns to educational investment in girls and with the removal of institutional constraints to educating them (e.g., reductions in schooling fees and in the distance from schools) (World Bank 2012).

2.2.7. Policies

Heath and Jayachandran (2018) provide a review of the literature on the gender-focused policies directed at affecting the education gap, mostly in the context of randomized controlled experiments conducted in low-income countries. Examples of successful policies are the provision of closer and more convenient school infrastructure, the elimination of school fees for primary schools, and the distribution of conditional – cash or in-kind (e.g., bicycles) – transfers. More general policies aimed at improving female welfare may also have positive spillovers onto education. Examples are the granting of land inheritance rights to women, the assignment of quotas to increase female political representation, and bans on early marriage. Furthermore, Evans and Yuan (2019) scrutinize policy interventions not principally targeted to girls and find that they deliver gains for girls that are comparable to girl-targeted interventions, while offering to policymakers the advantage of a broader menu of options that have already been tested. Del Boca et al. (2019) summarize studies on the gendered impact of early childcare.

Although women have outpaced men in educational attainment, on average – even in OECD countries – gender gaps in employment, entrepreneurship, and politics do persist. Government priorities in designing public intervention have therefore been shifting, with growing attention to issues such as gender pay gaps and violence against women. A report of the policies enacted by public authorities, for example aimed at reducing pay gaps and at encouraging women to choose more lucrative STEM fields of study, is provided by the OECD (2017).

2.3. Gender gaps in STEM and economics

The evidence so far collected points to a pervasive reduction of gender inequalities in education. Yet, visible discriminatory gaps against women persist, in secondary and especially tertiary education, in the choice of the fields of study, with life-long consequences for their occupational careers and earning profiles. In particular, at the college level, women are underrepresented in the STEM fields, that typically lead to higher employability and wages. Even though a clear gendered pattern only emerges in higher education, girls' lower representation is actually already present as early as in secondary education, when subject selection becomes available, and even earlier on when gender

gaps in mathematical ability start to materialize. Besides, girls' lower participation in STEM is also associated with worse progression and lower learning achievement once they actually choose them.

UNESCO (2017) reports stylized facts at the global level, showing that in 2014-2016 male students are the majority of those enrolled in engineering (73%) and information and communication technology (72%), while female students are the majority in education (71%), health and welfare (68%), arts and humanities (62%), and social sciences (61%). Women also prevail, albeit to a lesser extent, in business, administration, and law as well as in natural sciences, mathematics, and statistics (55%). In other words, only 30% of the female student population in higher education is in STEM fields. Furthermore, the attrition rate in STEM is particularly high for women, as they are more likely than men to leave these fields during their studies, in their transition to work, and along their career paths. For the US, there is stronger evidence of gender convergence in college major choice over the last 40 years, but women still choose college majors associated with lower potential wages than men (Sloane et al. 2019).

An explanation for the above patterns has been searched along several directions, including individual-level biological and psychological factors, as well as factors at the family, peer, school, and society level. While the influence of biology for learning and academic ability has been found nil, psychological factors driving the self-selection of girls out of STEM have emerged as central determinants, which are in turn influenced by the socialization process and by gender stereotypes communicating the perception that STEM studies and careers are male domains. Family factors, through parents' beliefs and expectations, also play an important role in shaping girls' attitudes towards STEM. Likewise, peer influence is highly relevant for girls' motivation, interest, and confidence. School-level factors, from the presence of female teachers that may activate a role model process, to the organization of curricula to make them more attractive to girls, can also effectively promote girls' engagement. Lastly, at the society level, cultural and social norms in the realm of gender equality, the introduction of measures to promote the latter, for instance through quotas, as well as the way media transmit gender stereotypes are all recognized influential factors (UNESCO 2017).

A finer distinction between fields is proposed by Kahn and Ginther (2018), who argue that women's underrepresentation is actually concentrated in the math-intensive science fields. In their survey article, they introduce the taxonomy of LPS (life science, psychology, and social sciences, excluding economics) and GEMP (geoscience, economics, engineering, math and computer science, and physical science), where LPS and GEMP are differentiated by mathematical requirements. With a focus on the US, their analysis concentrates on the environmental factors that influence women's choices, including gendered stereotypes, culture, role models, competition, risk aversion, and interests, starting from childhood and then progressing through high school and eventually college. They argue that early biological differences are not conclusive drivers of gender gaps in mathematical ability at early ages, and that the gaps widen by middle and high school, under the influence of psychological and cultural factors that manifest themselves both at home and at school through, for instance, negative gender stereotypes proposed by family, teachers, and peers. The conclusion is that the roots of women's STEM underrepresentation have to be found in childhood.

While the gender gaps in STEM fields have been widely acknowledged and researched, the presence of significant gaps in the field of economics is relatively less recognized (despite early accounts, as Dynan and Rouse 1997). Yet, not only they are large but, in the US, the fraction of economics majors who are female is lower than in chemistry, mathematics, and statistics. Furthermore, in engineering, which is still more male-dominated than economics, the fraction of majors who are female has increased in the past decades, while in economics there has been no progress (Avilova and Goldin 2018). Unsurprisingly, these dismal trends are reflected in the extremely low representation of women in the economics profession (Bayer and Rouse 2016; Lundberg and Stearns 2019). To be noticed is that economics studies are sometimes (as in UNESCO 2017) grouped together with the social sciences, or else with business economics, while they differentiate themselves from both because of their heavily mathematical content. Care must therefore be used when attempting at drawing international comparisons.

Allgood et al. (2015) review the investigations into the determinants of the gender difference in the choice of economics majors and rule out a number of factors which the literature has tested, such as (lack of) faculty role models, mathematics aptitude, and differences in mathematics training and sensitivity to grades. Their conclusion is that the economics gender gap remains an unsolved puzzle. A recent study based on UK university admissions data investigates whether universities discriminate against female applicants along the admission process, possibly because women are perceived as less competent in the discipline, or out of fear that they are less likely to accept an offer due to the low ranking of economics in their preferences. This hypothesis, as the previously mentioned ones, is also ruled out (Tonin and Wahba 2015). However, mechanisms that may work do emerge from evidence collected from specific US universities. A field experiment finds a positive influence of female role models, i.e., successful women who majored in economics at the same university to whom students were exposed in introductory classes, on female students' enrollment in further economics classes (Porter and Serra 2019). Another field experiment shows that a mentoring and nudging treatment increased female students' probability of majoring in economics (Li 2018). In a third case, institutional data reveal that persistence in studying economics, for female students, is particularly affected by the attractiveness of introductory economics courses and relative economics course grades (Ahlstrom and Asarta 2019).

3. Implications of the education gender gap

The processes so far described can often last decades or even centuries, and as a consequence they manifest their influence not only in the short but also in the long run. Hence, a review of the implications of the education gender gap inherently encompasses an historical approach. Over this ample perspective, the increase in women's education has been caused by the interplay of the variety of factors previously described but, at the same time, such increase has influenced many of the same factors, determining a potential for reverse causation and endogeneity. In reviewing the likely theoretical and empirical effects of the education gender gap and its evolution, it is therefore crucial to establish whether the increase in women's education can be viewed as plausibly exogenous. While the literature is very large, several effective survey articles on specific streams are already available and will then be referenced to, with the references therein, in the following discussion.

3.1. Growth and development

Whether the gender gap in education harms or boosts economic performance is controversial. Minasyan et al. (2019) provide a review of the literature that addressed the link between the education gender gap and economic growth and present a meta-regression analysis mostly based on cross-country post-WW2 growth regressions, i.e., on the first generation of the empirical literature on growth (Barro and Lee 1994). After highlighting the empirical challenges of establishing a causal link, the survey concludes that the evidence supports the existence of a moderate positive effect of the education gender gap on growth.

By looking at how the misallocation of talent affected US economic growth, it has been established that declining obstacles to accumulating human capital, particularly for women, have been important drivers of growth. These obstacles reflected discrimination in favor of boys, both at school and within the family, in the development of certain skills, as well as restrictions on the admission of girls to higher education institutions (Hsieh et al. 2019). A meta-analysis conducted by Weichselbaumer and Winter-Ebmer (2005) reports that the increase in women's education is a central driver of the decline of the gender pay gap between the 1960s and the 1990s.

Even within low income countries, women empowerment and development – where the latter encompasses economic growth but goes beyond it – are closely related: if development can play a major role in closing gender inequalities, empowering women may benefit development, and indeed education is a primary dimension of empowerment. Duflo (2012) reviews the literature on the empowerment-development nexus focusing on randomized experiments, which are specifically designed to overcome the bias stemming from the existing bidirectional nexus and to establish causal effects. A wealth of evidence leads to the conclusion that the interrelationships are not necessarily self-sustaining, so that continuous policy commitment to improving access to education for girls remains a necessity.

3.2. Fertility and well-being

Following Galor and Weil (1996, 1999, 2000) and the so-called Unified Growth Theory (UGT) approach, a stream of contributions has modeled the process of gender specific accumulation of human capital within an historically grounded framework that allows to understand the interplay between long-run economic development and the demographic transition from high to low birth rates. Even though they share the common belief that women's empowerment plays a specific role in triggering the switch between the Malthusian era and sustained growth (de la Croix and Donckt 2010), its occurrence is attributed to slightly different mechanisms. On the one hand, triggered by technological progress and the associated higher returns to skills, women invest more in education: this increases their bargaining power within the household, their chances to access the labor market, and in turn their opportunity costs of having children, which results in a decline in fertility (Diebolt and Perrin 2013). This mechanism can also explain the transition from a patriarchal, male-breadwinner organization of society to a modern, dual-earner model, a further transformation which characterized Western countries in their process of development (Diebolt and Perrin 2019). An alternative mechanism integrates components of the EMP: it is the postponement of marriage, chosen

by women in order to acquire higher levels of human capital, that produces a reduction in fertility. Together with an increase in child survival, this process activates a quality-quantity trade-off in parenting, thus justifying a larger investment in children' human capital that ultimately raises income levels (Foreman-Peck 2011).

Within the cliometrics literature, the hypothesis that female education can trigger the fertility transition and a sustained economic growth regime has been tested empirically on Western European countries in the 19th century. Evidence from France shows a negative correlation between female education and fertility (Diebolt et al. 2015), but also highlights other factors affecting fertility, such as religiosity, the cultural diffusion of ideals, and family structure (de la Croix and Perrin 2018; Diebolt et al. 2017; Murphy 2015). Studies on Prussia confirm that female education may have triggered a reduction in fertility for the next generation (Becker et al. 2013) and suggest that marriage postponement may have been one of the causes of the fertility decline, because of prolonged investment in education by women (Cinnirella and Hornung 2016). Overall, this evidence strongly suggests that investment in education, and more specifically female education, represented a dominating force in the decline in fertility in the 19th century.

A second generation of empirical studies on economic growth has tested the role of the education gender gap and the child quantity-quality trade-off in the context of UGT, in the effort to account for the evolution of economic growth and the demographic transition in the last two centuries. The existence of the education-fertility trade-off is widely documented over different samples of countries in the world (Becker et al. 2010b; Murtin 2013; for a comprehensive review see Cinnirella 2019). A strong negative relationship between fertility and gender parity in literacy emerges in 1900 (Hippe and Perrin 2017) as well as in the long run, in particular in those countries with lower educational attainment (Barro and Lee 2015).

With a focus on the contemporaneous experience of developing countries, Heath and Jayachandran (2018) collect empirical evidence on the effects of the increase in female education on fertility, as well as several measures of the well-being of women and children. The relationship between education and fertility emerges as a strong one, through several of the potential channels that have been explored in the above mentioned historical literature: for instance, more education can reduce the desired number of children, as education can expose women to more liberal norms and/or increase their opportunity cost of reducing labor force participation. Furthermore, delayed marriage as a result of staying longer in school also plays a role. Children's outcomes can also be affected: a higher level of the mother's education reduces child mortality and improves the children's education level. The woman's bargaining position within the household is also positively affected by her level of education, as well as her beliefs in gender equality and political knowledge. Further evidence also points to a relationship between women's education and their own health, in several dimensions including maternal mortality and risk of HIV infection.

3.3. Family structure

Female age at marriage, a crucial factor in the analysis of family formation, has already been mentioned in the previous sub-section as one of the channels linking female education and fertility.

A broader literature has examined other elements of family structure. A set of dynamic macroeconomic models formalizes such gender differences as endogenously determined by intra-household bargaining – within marriage – on consumption, number of children, and investment in children's education (Echevarria and Merlo 1999) or – before marriage – accounting for pre-marital differences in education investment and the implied heterogeneities in gender power (Iyigun and Walsh 2007). These models similarly predict that, as wives become more educated, the number of children is reduced.

With attention to Western countries, the impact of the reversal of the education gender gap on family life is reviewed by Van Bavel et al. (2018), taking into account multiple aspects such as union formation, assortative mating, and union stability. Despite the resilience of the breadwinner-homemaker model of marriage, the evidence points to a narrowing of gender differences in mate preferences. Furthermore, both for men and women, there has been a decline in the aversion to female status-dominant relationships, while couples in which wives are more educated are now more stable than in the past. Another literature has looked at educational differences between husbands and wives as one of the determinants of intra-household decision-making responsibility over economic and financial choices. One conclusion is that the probability that the wife is responsible increases as the wife's education level becomes closer, or even higher, than that of her husband's (Bertocchi et al. 2014).

Relatedly, Blau and Winkler (2018) review long-term trends regarding family structure, labor market participation, and time allocation to household production, with a special emphasis on the educational gradient, that is, the differential experiences of women at the top and bottom of the educational distribution. They report how the decline of marriage and the rise of unmarried births have manifested themselves more strongly among the less educated, while women's labor force participation rates have risen more markedly among those with more education. At the same time, less educated mothers, being constrained by less flexibility in the workplace, tend to spend less time with their children, with multiplicative negative effects on their human capital.

4. Conclusions

This review has offered a comprehensive but selective overview of the growing body of contributions in economics which tries to shed light on the gender gap in education in a wide variety of time horizons and regions across the world. Much progress has been done in identifying and understanding its determinants and implications. However, some puzzles still remain unresolved. First, despite the closing, or even the reversal, of education gender gaps worldwide, in the developing world large discrepancies still exist in access to schooling for girls and in basic literacy among adult women. Second, even in rich countries, girls are still at disadvantage given their apparent self-selection out of the more lucrative fields of study in STEM and economics. Lastly, it is not yet entirely understood why girls' remarkable progress in education has not so far fully propagated to other realms where women are still discriminated, from their performance in the labor markets, to their position within the household, and their accomplishment in the political arena. Further research is needed in this direction.

To allow further progress, the United Nations Sustainable Development Goals have restated the role of gender equality in education among global priorities: Goals 4 and 5 explicitly target to "ensure that girls and boys, women and men not only gain access to and complete education cycles, but are empowered equally in and through education" (UNESCO 2016). However, the policies enacted up to the present have not been fully effective, because of the nature of barriers and constraints, partly addressed in this review, such as traditional cultural practices and gender stereotypical beliefs. Being female human capital so crucial for economic growth, development, and well-being, as highlighted by the literature, dismantling such obstacles should be one of the central goals of future policy intervention.

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