Essays on Education, Gender Equality, Fertility and Child Labor

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Abstract

This dissertation consists of three essays on the interaction of education, gender equality, fertility rate and child labor. The first essay makes a thorough documentation of facts and empirically verifies the robustness of the relationship between fertility and female to male schooling ratio. The second essay develops a mechanism to explain the correlation of fertility with gender equality in education. The last essay theoretically examines child labor restriction policy outcomes, mainly gender gap in education, in an environment where societal gender role is a key driver of household division of labor.

In the third chapter, we verify the robustness of the correlation between fertility and female to male mean years of schooling ratio. A cross− country comparison of fertility and gender gap in education shows that countries with lower female to male mean years of schooling ratio have significantly higher fertility and those countries with education gender parity tend to have lower fertility. Given this motivating fact, the purpose of this chapter is to thoroughly document and empirically verify this observed negative association using a large cross− section of countries and latest available data. To this end, first, we document empirical facts and conduct a descriptive analysis to show the correlation of fertility and gender gap in education. Second, we specify an empirical model to verify the degree of robustness of the merely observed relationship between the two variables of interest, fertility and gender gap in education, while accounting for confounding factors including income level, overall average level of education and by controlling for fixed effects. The results from our estimation show a robust negative association between fertility and female to male mean years of schooling ratio.

The fourth chapter designs a mechanism to explain the link between fertility and gender gap in education. Here, we employ an altruistic overlapping generations model with parental gender preference bias in education investment and gender differential in the rate of returns to schooling as key components. In this model, child education and fertility are endogenous and the agents care both about the quantity and quality of their children. These qualities depend partly on the current education expenditure by parents and partly by other factors beyond the control of the household including gender specific returns to schooling. Thus, if parents attach high(low) preference to

the quality of girls compared to boys, they will invest more(less) on their education. The results from the model show how high parental gender preference bias in education leads to an increase in fertility, depresses education levels and widens the gender gap in education. Similar outcomes occur when gender differential in returns closes due to an increase in females' return to schooling. The quantity− quality tradeoff triggered by parental gender preference bias is an important explanation for this relationship in the model. Given these results, in the second part of this chapter, we perform a quantitative exercise by pinning down the model parameters using moments from two economies: Benin and Pakistan. We conduct a counter− factual experiment using the benchmark economies of the two− countries. The result from the experiment shows that a decline in the preference bias of parents against a girl's education or increase in a girl's returns to schooling reduces fertility and narrows the gender gap in education which corroborates the role of parental gender preference bias in education investment as implied by the model.

The final chapter theoretically investigates the potential consequences of child labor bans on the education of girls and boys in an environment where gender norms are key in governing the division of household labor. Child labor practices or lack thereof have important implications for outcomes such as gender gap in education, education levels and fertility. Especially, in economies where household labor division is influenced by societal gender role, the child labor experiences of girls and boys are more likely to vary. Using an altruistic overlapping generations model with child labor following an existing study but by adding two new features, gender heterogeneity and a home production sector undertaken by female members of the household, we examine how a child labor restriction policy affects mainly gender gap in education. Since child labor bans do not take into account unpaid domestic child work, there arises a potential for an unequal impact of such a policy on girls who are more likely to engage in domestic production compared to boys who engage in child labor. The mechanism through which the child labor restriction policies affect these outcomes is through differences in the fall of the opportunity cost of education for boys and girls. When home production time of girls is high enough due to the relative share of home produced consumption and the role of girls in its production, the education of boys increases faster than that of girls as the former face relatively lower opportunity cost of education following a ban on child labor. Consistent with previous findings, in general, the results of the model show that child labor regulation increases education and reduces fertility. However, our results also show that there are cases in which gender gap in education widens following a child labor restriction policy despite both girls and boys experiencing a rise in their education levels.

Before embarking on these essays, we will provide a brief background for each essay and a summary of relevant literature in the first and second chapters respectively.

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Dedication

To my parents

Sileshi Tilahun Wubete & Ayal Asmare Ewunete

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Chapter 1

Introduction

This chapter and the one that immediately follows it are devoted to covering the backgrounds of the dissertation essays and summarizing the relevant literature on the interactions of gender equality in education, fertility and child labor respectively. In the third chapter, we conduct an empirical verification of the correlation between gender gap in education and fertility. And in the fourth chapter, we establish a mechanism that explains the correlation of gender gap in education and fertility. The final chapter theoretically investigates the potential consequences of child labor restriction policies, especially, on gender gap in education in an environment where gender role is a key driver of household division of labor− by following a related study.

1.1 Background of the Study on Gender Gap in Education and Fertility

The last five decades have witnessed contrasting developments in education and birth rate: a significant rise in both overall average schooling and female to male education ratio in one hand and a drastic fall in the number of children per woman on the other. During this period, if one looks at a cross− section of countries in terms of fertility and female to male education attainment ratio at any point in time, there appears to be an inverse relationship between these two variables. Countries with high female to male schooling ratio have lower fertility and those countries with larger education gender disparity tend to have higher fertility. For example, in 1980, countries whose female to male mean years of schooling ratio is at the bottom 10% of the distribution of 109 countries in the data do have an average fertility of 6.79. On the contrary, those countries at the top 10% of the same distribution do have about 3.71 children per woman[1]. Similar inverse relationships between fertility and female to male schooling ratio can be found in other periods too.

Following this development of the rise in education and fall in fertility, many studies have been conducted to explain how these two are related. One major framework of analysis in this regard is the *quantity −quality* tradeoff approach developed by Becker (1960) and refined in Becker & Lewis (1973). According to these studies, education makes children more expensive. Hence, parents want few of them but with high quality or many children with low level of education. This competition between the quantity of children and their quality as measured by education expenditure is what is expressed as the quantity− quality tradeoff. Other factors in the literature that explain the inverse link between education and fertility include increase in marriage age, rise in the opportunity cost of child raising time in the form of forgone income and increase in the knowledge, availability and utilization of contraception.

Even though there is ample theoretical literature on the investigation of the number and education of children, empirical work using cross−country data with gender gap in education is limited. The existing studies in this area are micro level experimental or quasi experimental[2]. Even those papers that use cross− country fertility and education data either focus on general education or female education with less emphasis on gender disparity in education and its association with fertility[3]. Moreover, their results on the relationship between fertility and education are mixed. Given this background, the third chapter of this dissertation conducts a thorough empirical documentation and verifies the robustness of the relationship between fertility and female to male schooling ratio using panel data with large cross−section of countries and a period spanning from 1980 to 2010.

Does the merely observed negative association between female to male schooling ratio and fertility withstand empirical verification? Given the motivating facts about the observed negative correlation between fertility rate and female to male schooling ratio, we employ a large cross− section of countries with the latest available data on education to check if the negative association between these two variables consistently

[1]The data for fertility is from world development indicators, World Bank (2019) and data for education attainment from Barro & Lee (2013). The latest available education attainment data for adults (25−64) is for 2010.

[2]Hanushek (1992) shows how a child's education achievement is negatively affected by the number of siblings using micro−data.

[3]Fort et al. (2016) in their assessment of the causal effect of female education on fertility following schooling reforms in England and Continental Europe find a negative relationship between education and fertility in the former while their result doesn't show a relationship for the latter. Similarly, Li et al. (2017) using census data from Asia and Latin America find evidence of a negative association between the education attainment and the number of siblings of a child. Martin (1995) also documents the relationship between women's education and fertility in about two dozen countries. The results show that while there exists a reduction in fertility with a rise in women's education, in some low income countries, female education is found to enhance fertility.

and robustly holds after controlling for confounding factors. To accomplish this, first, we provide a descriptive analysis of the relationship between the two variables. Second, and more importantly, we run an estimation to verify the robustness of this relationship by accounting for factors including overall average schooling, income and by controlling for country specific characteristics and time effects. However, no causality analysis is intended here. Using both gender gap in education and overall average education as opposed to either female education alone or general education alone in other studies, this chapter sheds light on the empirical side of quantity− quality tradeoff especially by emphasizing on the link between gender equality in education and fertility. The relatively larger size of the cross− section and the inclusion of recent education attainment data together with various specifications of the empirical model also enrich the contribution this chapter makes to the existing literature.

1.2 Background of the Study on Parental Gender Preference Bias in Human Capital Investment, Gender Gap in Education and Fertility

What explains the correlation between gender equality in education and fertility? The main purpose of chapter four is to address this question. One could point out that one or a combination of factors such as gender discrimination, gender role, gender differential in the rate of return to education investment as a source of the observed gender disparity in education and subsequently affecting fertility behavior.

In some cases, parents favor boys more in terms of excelling in education than girls. If they do not have control over the sex composition of their children, this pro −boy bias in education expenditure means that they spend less on nearly half of their children which has far reaching implications for fertility decisions. Many studies have endeavored to shed light on what causes such gender gaps in education. One way of analysis is to closely examine the pattern of expenditure of households with similar characteristics but one having an additional daughter another having a son. Studies using this type of approach to investigate the existence of pro−boy bias in intra−household resources allocation include Kingdon (2005) and Zimmermann (2012) who argue that, in India, the unequal education outcome in terms of gender is due to pro− boy bias in intra−household resource allocation either through zero expenditure on the education of girls−extensive margin or conditional on enrollment the amount of education expenditure favors boys to girls− intensive margin. In addition to intra−household allocation, other forms of cultural norms also dictate how far girls go in their education path compared to boys in a society. The influence of culture on female education, female labor supply and fertility decision as key factor has been pointed out by Fernández & Fogli (2009). Other institutional factors which are beyond the realm of the household such as labor market gender discrimination can also contribute to gender disparity in education. Given the influence of culture on household decision making and the observed gender disparity in education outcomes, we take parental pro−boy bias in education investment and gender differential in the rate of return to schooling as potential explanations for the link between gender gap in education and fertility behavior. In order to address the question posed above, we employ an altruistic overlapping generations model where parents gain utility both from the quantity and quality of their children. At the same time, parents in the model show a gender preference bias in terms of education expenditure.

To this end, this study uses an approach similar to that of De La Croix & Doepke (2003) where the quantity −quality tradeoff is an important mechanism in explaining the negative relationship between the number and education of children− in an altruistic environment. The current study extends their model by introducing gender heterogeneity both at adult and children level, and more importantly, parental gender preference bias in education investment and gender differential in the rate of returns to schooling are taken, here, as key explanations of the association between gender gap in education and fertility. To check whether this model explains observed differences in gender gap in education and fertility, we pin down the parameters in the model using two real world economies: Benin and Pakistan which have similar income level in 2010[4]. By conducting a counter−factual experiment using the calibrated model with these two economies, we are able to show how far parental gender preference bias in education investment or gender differential in the rate of returns to schooling explains changes in fertility and gender gap in education vis−a−vis the benchmark. Thus, the introduction of gender heterogeneity in an altruistic model with parental gender preference bias in education and gender differential in the returns to schooling which serve as a mechanism linking gender equality in education and fertility is the main contribution of this chapter of the dissertation.

1.3 Background of the Study on Child Labor, Gender Equality in Education and Fertility

In 2016, about one in ten children are engaged in child labor worldwide according to ILO (2017). Such child labor practices or lack thereof have important implications for various outcomes such as the education levels of children, gender gap in education and fertility rate among other things. Since beliefs and attitudes continue to shape the role of women and men in many societies, child labor may help perpetuate traditional gender roles by introducing daughters and sons differently to various sets of activities

[4]If the pair of countries chosen are from developed economies where fertility is low and there is gender parity in education, there will be less room for counter− factual exercise. Yet, other pairs of low or middle income economies can also be used for the exercise

which is more likely to affect gender gap in education when policies prohibiting child labor are introduced. Despite centuries old concern and rich literature on child labor, there has been less emphasis in the systematic analysis of its gender differential impact, say, both in the types of tasks boys and girls engage in and the subsequent policy restriction outcomes such as gender parity in education[5].

Child labor, in most cases has been used to refer only to those children who work outside a household setting be it in the formal or in some cases informal sectors (such as agriculture), paid or unpaid but the products usually make it to the market according to ILO (2017). Since both the definitions and counter− measures of child labor are mainly applicable on child works that take place outside own home in which boys are more active, there arises a potential for leaving the works of girls at home out and resulting in an unequal impact of child labor banning policies− gender wise. This happens as females have disproportionately higher role in the domestic work such as household chores due to traditional gender role attitudes[6]. Among the underlying factors for gender−based labor division between household and market work and also type and place of occupation are cultural norms [7].

Even though, there have been numerous studies in the past that empirically or/and theoretically investigate child labor, there is limited study that sheds light on the interactions among gender, child labor and fertility systematically. Usually, child labor policy investigations focus on general economic and demographic outcomes with less emphasis on the gender aspect. For example, Doepke (2004) examines how the introduction of child labor restriction policies account for variations in the speed of demographic transition across countries by changing the opportunity cost of education. Ban on child labor means, schooling time becomes the only alternative to idleness which is not the case in the presence of child labor. This reduces the cost of sending an additional child to school. The author finds that when child labor is restricted, education rises and fertility declines rapidly. However, this and other similar investigations on the impact of child labor restriction policies on fertility and education do not examine gender differential impacts which are crucial in settings where gender norms and attitudes govern the division of household labor. Indeed, girls are disproportionately represented in unpaid household work which is not directly targeted by child labor banning policy measures due to its very nature. The fifth chapter of the dissertation contributes to the existing literature by shedding light on how in the prevalence of gender role child labor restriction policies will not affect boys and girls equally or otherwise in terms of education− using similar framework to Doepke (2004).

[5] Nardinelli (1980) provides an important insight regarding child labor in Great Britain during the Industrial Revolution. The author brings forth concerns and debates about the working condition of younger children in the textile industry, the Factory Acts of 1833, and its impacts on child labor.

[6] Charmes (2019) documents the disproportionate role women play in unpaid care work− time spent caring for a family member, community, or on oneself.

[7] Lachance-Grzela & Bouchard (2010) provide a thorough discussion of research findings on household division of labor and the role of traditional gender norms.

1.4 Main Contribution

By focusing on gender equality in education as opposed to either female education alone or general education alone in other studies, the third chapter of this dissertation contributes by shedding light on the correlation of the number of children with gender equality in education. The relatively larger size of the cross− section and the inclusion of recent education attainment data together with various specifications of the empirical model also enrich the contribution this chapter makes to the existing literature. In order to accomplish our goal in this chapter, we do two tasks: first, we thoroughly document the empirical regularities surrounding the relationship between female to male schooling ratio and fertility. Second, and more importantly, we empirically verify the robustness of their correlation by accounting for per capita income, overall average schooling and fixed effects.

The fourth chapter makes a sound contribution to the existing literature by designing an altruistic overlapping generations model with parental gender preference bias in human capital investment and gender differential in the rate of returns to schooling in order to explain the correlation between gender gap in education and fertility. This chapter builds on the existing literature. It extends the models used in De La Croix & Doepke (2003) where they investigate the link between initial human capital distribution and fertility differential using an altruistic model and Doepke & Tertilt (2016) in which they discuss son preference in bequests as a factor affecting growth with exogenous fertility. But unlike in these two papers, in this study the agents are heterogeneous gender wise −departure from the former. Fertility is endogenous−departure from the latter. The current study explains the correlation between gender equality in education and fertility by introducing parental gender preference bias in education and gender differentials in returns to schooling. The parental gender preference bias is the key driver of gender gap in education and generates the quantity− quality tradeoff in the fourth chapter of this dissertation.

The last chapter of this dissertation contributes to the existing literature by investigating the potential consequences of child labor bans, mainly, on gender gap in education in an environment with gender−based division of household labor. The majority of existing studies on child labor restriction policy and its impact on education and fertility do not focus on gender differences in child labor sphere. For instance, Doepke (2004) examines how child labor restriction policies affect education and fertility. However, this and other similar investigations on the impact of child labor restriction policies on fertility and education do not examine gender differential impacts which are important in settings where gender norms and attitudes govern the household division of labor. In the fifth chapter of this dissertation, we develop an overlapping generations model following that of Doepke (2004) which we extend by including a gender dimension and home production sector[8]. Thereby, we are able to examine the consequences of child

[8]Home production sector is not a new introduction in this study. Other papers such as Ngai &

labor restriction policies mainly on gender gap in education.

1.5 Organization of the Dissertation

The remaining parts of this dissertation are organized as follows: chapter two summarizes the relevant literature. The third chapter presents a thorough documentation and empirical verification of female to male schooling ratio and fertility. Chapter four develops a mechanism in order to explain the association between gender gap in education and fertility. And the last chapter is devoted to systematically examining the potential consequences of child labor restriction policies mainly on gender equality in education in an environment where gender role is a key driver of household division of labor.

Petrongolo (2017) do have this sector in their analysis.

Chapter 2

Related Literature Review

This chapter summarizes the literature related to the interaction of education, fertility, gender equality and child labor since two or more of these variables run through the three essays as part of the central theme −fertility and gender equality in education. The first section reviews the literature on the link between fertility and education: quantity− quality tradeoff. The second part of the literature review covers studies on gender bias in education investment. The last part of the literature is devoted to reviewing studies related to the interaction of child labor, gender equality in education and fertility.

2.1 Quantity−Quality Tradeoff

There is a considerable literature accumulated over the years analyzing fertility rate with an economic lens as a re−emergence of Malthus (1798)'s theory of population growth and resource utilization. One of the strands of literature relates education and fertility with a focus on the quantity −quality tradeoff which translates into either having high quality children with fewer quantity or having low quality and high quantity of children. This tradeoff occurs due to the associated costs of child raising be it in monetary or in non−monetary terms[1]. The quality is usually approximated by the amount of expenditure per child mainly for purposes such as education.

An earlier investigation of fertility rate with an economic framework, in its modern sense, appears in Becker (1960). Among the key factors the author points out in his study are: first, fertility is endogenous to the family. Parents can control the number of children they want to have through contraception when this knowledge and technology are available or through abortion in other cases. Second, children are considered as consumer durable goods since they are sources of satisfaction to their parents. As it is

[1] Doepke (2015) reviews the development of the child quantity − quality framework.

the case for other consumer durables, parental preferences(tastes), quality of children and income of parents are important determinants of the demand for children. The third key point he makes is that since children are normal − durable consumer goods, as income increases, so does the expenditure per child which translates into high quality of children. The quantity of children has also to increase in response to income but, he argues, the income elasticity of quantity is lower than that of quality though both are positive. A similar investigation of family size appears in other studies. Leibenstein (1957) examines how low level of development and family size are related. In his study, children are considered as sources of utility in three dimensions: direct utility by merely having them, utility from children as sources of income and old age insurance for parents. The author argues that the level of economic development also plays a role on whether children are assets or liabilities− for example, asset in rural economy, liability in urban settings.

Another study by Becker & Lewis (1973) clearly models the inverse link between the quality and quantity of children. Their argument is that the shadow price of having more children, given a high quality, is expensive. And, having high quality, given large number of children, makes also children expensive. Hence, parents have to choose between having fewer children with high quality or more children with low quality. This expensiveness of children does not come only in direct monetary terms according to the authors. Parents' childcaring time is also an important ingredient in this explanation. Since child raising is a time intensive task, the more children a family has, the more time is required to take care of them − in total. In a related study, Becker & Tomes (1976) extend this model with child differential in endowments in the form of inherited ability. The authors point out that since highly endowed children in terms of ability require less time to acquire a certain level of human capital and gain high rate of return compared to the less endowed, parents will prefer to invest on the high ability children. They depart in their analysis from the previous study in that the income elasticity of the quantity of children which, in this case, is not only smaller than that of quality, but also there is a possibility for it to be negative.

A similar study by Easterlin (1975) analyzes determinants of fertility. In addition to the similar factors pointed out by earlier studies as affecting demand for children like household income, the monetary costs and parents' tastes for a child, the author adds two more determinants of fertility: the potential output of children and the cost of fertility regulation. The first corresponds to the number of children if no deliberate control is done− natural fertility. This factor is more applicable in modern settings as the author points out. The second factor, the cost of fertility regulation, comes in the form of forgone subjective satisfaction due to choosing not to have a child, monetary and time costs associated with the utilization of contraceptive methods.

Although one finds a great deal of discussion and examination related to the child quantity− quality tradeoff in these studies, they use different mechanism that brings about this tradeoff. A key assumption in these discussions is that parents are altruistic towards their children the degree of which is manifested by the expenditure of resources per child be it monetary or time cost. Becker & Barro (1988) introduce a dynastic utility framework where they analyze the importance of inter−generational considerations for fertility. As far as parental altruism to children is concerned, their result shows a positive relationship between fertility and the degree of altruism to children. There are many more studies that employ the altruistic approach to investigate the relationship between fertility and education outcomes.

De La Croix & Doepke (2003) also examine one such a channel using an altruistic set up where the initial distribution of human capital results in differentials in fertility due to varying opportunity cost of childcaring time between those with high human capital−the rich and the ones with low level of human capital−the poor. High initial human capital implies higher wage rate per unit of effective labor supply. This enables rich parents to earn and spend more money per child. However, their childcaring time is more expensive than the poor as they have to tradeoff higher income per child per unit of time. The authors show that this influences the parents to have fewer children but spend more resources on each of them. The reverse is true for the poor households. In a recent study, Doepke & Tertilt (2016) also examine an altruistic model with son preference in bequests and its relation to growth. However, fertility is exogenous in their model.

Even though there is vast theoretical literature on the investigation of the tradeoff between education and the number of children, empirical work using cross−country data with gender gap in education is rare. Most of the existing studies in this area are micro− level experimental or quasi experimental[2]. Even in those papers that use cross−country fertility and education data, the focus is either on general education or female education alone with less emphasis on gender disparity in education and its association with fertility. For instance, Fort et al. (2016) in their assessment of the causal effect of female education on fertility following schooling reforms in England and Continental Europe find a negative relationship between education and fertility in the former while their result doesn't show a relationship for the latter. Similarly, Li et al. (2017) using census data from Asia and Latin America find evidence of a negative association between the education attainment and the number of siblings of a child.[3]. Moreover, the results on the relationship between fertility and education are mixed. However, it should be noted that despite the fact that our empirical analysis shares with these studies the underlying child quantity−quality tradeoff, we don't follow their methodology both in the nature of data we emphasis on−which is gender equality in education and the purpose of our analysis− correlation verification. Given this background, the

[2]For instance, Hanushek (1992) shows how a child's education achievement is negatively affected by the number of siblings using micro−data.

[3]Martin (1995) also documents the relationship between women's education and fertility in about two dozen countries. The results show that while there exists a reduction in fertility with a rise in women's education, in some low income countries, it is found to enhance fertility.

third chapter of this dissertation contributes to the literature by conducting a thorough empirical documentation and verifying the robustness of the relationship between fertility and female to male schooling ratio using panel data with large cross−section of countries and a period spanning from 1980 to 2010.

So far, the main focus of the literature review has been mainly on studies related to the correlation of fertility with children's education. However, in these studies, there is less emphasis on gender equality in education resource allocation and its implication for fertility behavior.

2.2 Gender Bias in Education Investment

Next, we turn to cultural aspects which directly or indirectly influence family decisions regarding fertility, education of children and bias against girls. This is important because as mentioned in chapter one, parental bias against the education of girls is one of the mechanisms in the fourth chapter's theoretical investigation used to explain the relationship between fertility and gender gap in education. Does pro− boy bias in education exist?

Studies with the aim of investigating gender bias in intra−household resources allocation include Kingdon (2005) who finds that, in India, the unequal education outcome between the genders is due to pro− boy bias in intra−household resource allocation in the form of zero or less expenditure on the education of girls compared to boys of equivalent age and family characteristics. The author identifies two mechanisms through which this takes place. One is zero expenditure on education of girls which is bias at the extensive margin. Parents send boys to school and incur positive education expenditure while girls receive no resource for schooling. The second mechanism is through unequal investment in education of girls and boys in which case, conditional on enrollment, the amount of education expenditure favors boys to girls− intensive margin. The finding is that given two households with similar characteristics except that in one family a daughter is added and in another a son is added to the family, the household with an additional girl is more likely to incur less or zero education expenditure compared to a household with a boy. This is especially true for rural areas according to the finding. A related study by Zimmermann (2012) using Indian data also compares education expenditure of households with a girl to another similar household of a similar age boy. Consistent with the previous study, the author finds pro− boy bias in both the extensive and the intensive margins. The result shows that discrimination against girls works mainly through the intensive margin which implies that even if both girls and boys enroll to schools, girls receive less education expenditure compared to boys. And this pro−boy bias increases as one goes from primary to junior high school (with age). Unlike the previous study whose result is significant for rural areas of India, the latter finds the pro− boy bias to be significant at the national level as well[4]. Besides such pro− boy biases in the intra−household allocation, there are studies which provide a wider view on how culture affects female education and fertility decisions among other outcomes. Having insight into the influence of culture on the education and fertility decision is important for the current study as parental preference bias against the education of girls is influenced by attitudes and beliefs that are part and parcel of a culture.

In line with this purpose in mind, Fernández & Fogli (2009) investigate how past female labor force participation and total fertility from the country of ancestry, which are used as proxies for culture, affect important economic outcomes such as female labor supply and fertility. They measure this cultural factor using data on a group of women born in the U.S. from first generation immigrant parents. The authors find that ancestral cultural influences as approximated by past female labor force participation and total fertility have positive and significant relation with individual work and fertility outcomes. Since such cultural attributes by influencing gender role affect fertility and work, one can argue that this will have an effect on how parents view the education of girls and boys in such households. As the earlier two studies using Indian data corroborate, norms also affect whether to send a girl to school or not. And once in school, whether girls receive the same level of education resource or not is affected by gender related societal beliefs. Thus, the fourth chapter's focus on parental preference bias against the education of girls to explain the correlation between gender gap in education and fertility shares the "culture matters for household decision making "aspects from these and other similar studies. Beyond parental gender preference bias in education investment, other institutional factors like gender differences in return to education in the labor market can also contribute to the prevailing gender gap in education and fertility correlation.

So, how does this dissertation fit into the existing literature in light of the child quantity− quality tradeoff? The next two chapters contribute to the above literature in two ways. First, using country−level panel data, in the third chapter, we thoroughly document the empirical regularities surrounding the relationship between female to male schooling ratio and fertility and empirically verify the robustness of their correlation. While doing this, we account for confounding factors including average income, overall average schooling and we also control for fixed effects. Unlike previous empirical studies which focus either on general education or female education to measure causality or correlation between one of these variables and fertility, the third chapter of this dissertation emphasizes on gender equality in education and verifies its correlation with fertility. Gender gap in education is more likely to affect intra−household bargaining, consensus on contraceptive use, age off marriage and other fertility related household

[4]However, these two papers do not focus on the relationship of fertility and education. They are important in supplying literature on the key component in the analysis of gender gap in education and fertility employed in chapter four− that of parental gender bias against girls in the sphere of education investment exists and it is key in explaining difference in the education outcomes of girls and boys.

characteristics. These factors justify the inclusion of female to male schooling ratio in our fertility analysis.

Second, we develop an altruistic overlapping generations model with parental gender preference bias in human capital investment. The main contribution in the fourth chapter is this devising of a theoretical model to identify the link between fertility and gender gap in education with parents attaching different weight to the education of their daughters as compared to their sons. We extend the models used in De La Croix & Doepke (2003) and Doepke & Tertilt (2016). But unlike in these two papers, in chapter four of this dissertation the agents are heterogeneous gender wise −departure from the former. Fertility is endogenous−departure from the latter. The current study introduces parental gender bias in education which is a key driver of gender gap in education and generates the quantity− quality tradeoff in the fourth chapter of this dissertation. A second factor, gender differential in the rate of returns to schooling is also accounted for in the model.

The remaining part of the current chapter reviews the literature related to the final essay− chapter five which theoretically examines the interactions of education, gender equality, fertility and child labor by closely following a previous study.

2.3 Child Labor, Education, Fertility and Gender Equality

This part of the literature summarizes works on the interaction of child labor, fertility and gender equality in education. First, we refine the concepts surrounding child labor by covering widely used definitions. Then, we review papers that link child labor, education and fertility. The third part, here, deals with summarizing of studies related to gender and household division of labor− both economic and other closely related social science studies.

2.3.1 Child labor concepts and definitions

What does child labor mean? For the purpose of this study, as it is the case in other studies including Doepke (2004), child labor means the part of work by children for which they are paid for. The second category of child work in this study is unpaid domestic work. In practice, there are child works such as on family farm or family business which qualify as child labor, but children are not directly paid for although they can boost the household's income if the product is marketable or increase the household's own consumption otherwise. The definition of child labor by the International Labor Organization (ILO) excludes unpaid domestic work. It defines child labor as any work by a child that is mentally, physically, socially or morally dangerous and harmful to children between the ages of five and fourteen which includes employment in the market and some non− market activities like agricultural produce for own use ILO (2017). Household chores such as food preparation and cleaning undertaken by children do not count as child labor or economic activity in the sense of the UN's system of national accounts UN (2008). Since the main focus in the fifth chapter of this dissertation is to examine how child labor ban affects mainly gender gap in education, any child work related activity that crowds out schooling time is accounted for. We categorize child work in the model into two: child labor for which there is direct or indirect payment for work including family business and farm which are considered economic activities by the UNSNA and the second category is unpaid domestic work which includes cooking, dish washing, taking care of a household member, water fetching and the like. By introducing a home production sector to represent the unpaid domestic work, we will examine how this within homework by children, mostly by girls, in own household setting contributes to gender gap in education when child labor bans are issued.

A clear distinction between what is meant by home production and what activities qualify as child labor in the current study are outlined follows. Work by children in family farm (business), where most child work takes place, are counted as child labor and excluded from the household work. This is in line with approaches in the literature. For instance, Basu & Tzannatos (2003) present three categories of child work: household work, agricultural and non−agricultural. Only in the latter two categories is a child work considered child labor. Whereas, household work, in which girls disproportionately do more work according to the authors, is not counted as child labor. They also point out that ILO "ignores the unpaid and not-for-market work that is done in the household, such as household chores". The "household production"in chapter five is similar to what these authors present as "household work ". It may include activities such as cooking, serving meals, dish washing, house cleaning, water fetching and related domestic chores. In Ngai & Petrongolo (2017) the home production includes childcare, cleaning, food preparation and other services that have close substitute in the market (following the Bureau of Economic Analysis)[5]. Neither family farm nor family businesses are mentioned as part of the household sector in their study. ILO too, clearly states the exclusion of household chores from standard child labor measurement and the fact that girls shoulder disproportionate responsibility in these activities ILO (2017). Thus, the household production in chapter five is used in a similar sense as "housework"in Basu & Tzannatos (2003), "household chores"in ILO (2017) and "household production "in Ngai & Petrongolo (2017) but doesn't include agricultural activities in which about two-thirds of child labor takes place.

[5]While care for other members of the family can be included in the home production of services where mothers and daughters jointly work, childcare is undertaken by the mother alone in the current study. This is done purposely to avoid young children caring for other children. However, it does not create any problem if it is treated with other family member care activities

2.3.2 Child labor, education and fertility

Economic concerns about child labor as a problem to be alleviated are more than a century old [6]. The arguments against child labor include the wage depressing effect of rampant child labor and the forgone productivity due to lack of schooling during childhood as it is crowded out by child labor. However, despite all the arguments, tens of millions of children are still participating in child labor according ILO (2017). Since both unpaid domestic work and child labor are intertwined with a household's welfare, measures against child labor are more likely to affect other related outcomes such as fertility and education[7]. Many studies have focused on identifying the consequence of child labor restriction policies. One string of this literature is that which links child labor restriction policies with education and fertility.

For instance, Doepke (2004) examines how differences in the introduction of child labor restriction policies account for variations in education and fertility outcomes. This happens as child labor policy reforms affect the opportunity cost of education. A ban on child labor reduces the cost of sending an additional child to school. The author finds that when child labor is restricted, education rises and fertility declines rapidly. However, this and other similar investigations on the impact of child labor restriction policies on fertility and education do not examine gender differential effects which are important in settings where gender norms and attitudes govern the household division of labor. In such cases, girls and boys will not have the same experience both in child labor and in the outcomes of its outlawing.

Though scattered and lacking theoretical mechanism, the different experiences of girls and boys in child labor appear in various studies. Against this backdrop, the purpose of the last chapter of this dissertation is to construct a mechanism to account for unpaid domestic work and its impact on the outcomes of child labor restriction policies, especially on gender gap in education − using similar framework as in Doepke (2004) but with gender role and a home production sector.

2.3.3 Gender role and the household division of labor

Year after year, ILO's child labor reports show higher child labor incidence rate of boys compared to girls. However, this is due to the exclusion of unpaid works in own household which girls are excessively engaged in. Boys are much more likely to be in

[6]Nardinelli (1980) provides an important insight regarding child labor in Great Britain during the Industrial Revolution. The author brings forth concerns and debates about the working condition of younger children in the textile industry, the Factory Acts of 1833, and its impacts on child labor.

[7]Edmonds & Schady (2012) show how poverty is central in influencing parents' decision whether to send their children to employment or to school. On the other hand, Basu et al. (2010) show that there can be an inverted U−shaped relationship between child labor and household wealth such as land holdings, especially. In both cases, the families value children's work

employment outside their own household or in tasks that qualify as economic activity which are visible for authorities to measure and enforce laws such as farms and family businesses compared to the invisible work undertaken within the home domain[8]. The fact that the involvement of girls in unpaid child work has been left out means policy measures that aim to prohibit child labor cannot address this particular portion of child work both due to lack of measurement and enforcement. Thus, treating gender differences in light of child labor ban outcomes is paramount importance. This disproportionate role of girls in unpaid household chores has been pointed out by many studies including Nieuwenhuys (1996) who notes that girls undertake more unpaid domestic work. Many investigations have attempted to examine the potential causes of this disparity in place and type of tasks boys and girls engage in.

One line of approach is that traditional gender attitudes play key role in the way household labor is divided between husband and wife and daughters and sons Lachance-Grzela & Bouchard (2010). The crucial role of gender ideology in determining which gender works what and where is also pointed out by Davis et al. (2007) in which they argue that such beliefs regarding how women and men are expected to behave may include an extremely non− egalitarian arrangement: male breadwinners from paid work and female homemakers compared to the egalitarian practices where both genders equally share home and outside responsibilities. Family norms are also manifested in the division of household labor among girls and boys. Cunningham (2001) shows that adult gender role attitudes influence children's attitude on what an ideal household division of labor is. Thus, it is more likely that girls and boys are exposed to various sets of child works due to norms and attitudes related to gender role. To account this variation in the experience of child labor between boys and girls we develop a model with home production sector entirely run by female members of the household.

Given this background, the fifth chapter examines the consequences of child labor ban mainly on gender gap in education. The model in this part is closely related to Doepke (2004) in that both link child labor policies, education and fertility using altruistic model. However, the current study is different at least in two ways. First, the model considers gender heterogeneity as a key component both at adult couple and childhood level− daughters and sons. Second, there is a home production sector run by female members of the household. This latter element of the model is vital to capture the underestimated role of girls in child work and helps explain how child labor banning policy will be unequally felt by girls and boys in an environment where the former are more active in unpaid home production and the latter in child labor outside home which is more visible to authorities. The key assumption in this regard is that child labor restriction policies do not directly affect unpaid domestic work by children.

In the next chapter, we focus on documenting and empirically examining the correlation between female to male education attainment ratio and fertility.

[8]Fares & Raju (2007) point out the disproportionate role of girls in unpaid own domestic work whereas, boys are more engaged in economic activities.

Chapter 3

Gender Gap in Education and Fertility: An Empirical Approach

3.1 Introduction

A glance at a cross− country distribution of fertility rate and gender gap in education shows that countries with lower female to male mean years of schooling ratio have significantly higher fertility and those countries with education gender parity tend to have lower fertility. For example, in 1980, countries whose female to male mean years of schooling ratio is at the bottom 10% of the distribution of 109 countries in the data have an average fertility of 6.79. On the contrary, the average number of children per woman for those countries at the top 10% of the same distribution is about 3.71. Similar inverse relationships between fertility and female to male schooling ratio can be found in other periods too. How strong is this negative association between these two variables? The main purpose of the current chapter is to shed light on this question by conducting a thorough documentation of related facts and empirically verifying the robustness of the observed correlation between fertility and female to male mean years of schooling ratio.

Following the developments of the rise in education and fall in fertility in many countries during the past several decades, many studies have endeavored to explain how these two are related. One major framework of analysis in this regard is the child quantity and child quality(education) tradeoff approach pioneered by Becker (1960) and enriched in Becker & Lewis (1973). Following these works, many researchers adopted this approach to analyze various dimensions of the nexus between fertility and education. Though there is vast theoretical literature on the investigation of the child quantity− quality tradeoff, empirical work using cross−country data with emphasis on gender gap in education is rare. As pointed out in chapter two, most of the existing empirical studies in this area are micro−level experimental or quasi experimental ones. Even those studies that use cross− country fertility and education data either focus on general education or female education with less emphasis on gender disparity in education and its association with fertility. Moreover, their results on the relationship between fertility and education are mixed. However, it should be noted that despite the fact that our empirical analysis shares with these studies the underlying child quantity−quality tradeoff, we don't follow their methodology. They use general or female education alone while the current study focuses on gender equality in education. Besides, the purpose of this chapter is robustness check of the correlation between fertility and gender equality in education as opposed to causality analysis in other studies.

Against this backdrop, this chapter contributes to the literature by analyzing the correlation of fertility with gender gap in education while accounting for overall average schooling as opposed to the education of one gender or overall average education alone employed by other papers. We control for confounding factors including average income and country specific and time effects. Thus, there are about three ways that this study enriches the existing fertility −education analysis: first, unlike the previous studies which use either female education or average education alone, in the current chapter, we bring these two in the analysis of fertility by emphasizing on gender gap in education. Second, the data we employ has large cross−section of countries(109) and covers longer period (1980 −2010). Third, this study uses the latest available education data in the Barro & Lee (2013) dataset. While a causality analysis is not the aim of this study, these new features in the data and the way the variables are combined will be important strides to make a sound robustness check on the correlation of the two variables− fertility and gender gap in education.

The first task in this chapter is to make a thorough documentation of the correlation of fertility and gender gap in education by taking into account income level differences and also variations in average years of schooling levels. The consideration of the latter two variables is crucial as they can affect both fertility and the gender gap in education. This will serve as a first step in our undertaking to address the question posed above− how strong is the correlation between fertility and female to male schooling ratio? To control for the effect of income on gender gap in education and fertility, we categorize countries into income groups as defined by the World Bank and examine the association of fertility with female to male schooling ratio [1]. Second, we specify an empirical model to verify the degree of robustness of the relationship between the two variables of interest: fertility and gender gap in education while accounting for confounding factors. The estimation results from the empirical model show that female to male schooling ratio and fertility are negatively correlated. And this negative association is statistically

[1]Using the World Bank (2011)'s classification, we reduce the four income groups into two main categories: low income and lower middle income in one category, and upper middle income and high income in another category. The per capita income thresholds used for classification in their respective periods are given in TableC.1

significant. The strength of the correlation holds even after controlling for income, time and country fixed effects and overall average schooling.

3.2 Fertility and Gender Gap in Education: Documentation of Facts

A key motivating fact for this study is the observed negative correlation between fertility and female to male education attainment ratio. As it is presented in Figure 3.1, there is an inverse relationship between fertility and female to male mean years of schooling ratio in a cross country data. Depicting female to male schooling ratio on the horizontal axis and fertility on the vertical axis reveals that countries with lower female to male schooling ratio, in 1980, lie at the top left of the figure while those countries with gender parity in education lie on the bottom right of the graph− have lower fertility.

The same relationship between fertility and gender gap in education is also evident in the year 2010 as well. Here, again, countries with high gender disparity in education are distributed around the top left of the graph and the vice− versa. These graphs are plotted by using data for 109 countries in both periods: 1980 and 2010. One key departure in 2010 compared to 1980 is that there are many more countries in the lower right corner of the distribution which implies higher female to male schooling ratio and lower fertility compared to the distribution in 1980− however the relationship of these two variables overtime is not a focus of investigation, here.

To further check whether this relationship shown in Figure 3.1 prevails or not after accounting for income differences, we use the World Bank's country classification based on income level as low income, lower middle income, upper middle income and higher income. Here, we put the countries into two main categories: the low and lower middle income groups in one category and the upper middle and higher income groups into another category. As shown in Figures 3.2 and 3.3, the negative relationship between fertility and female to male schooling ratio prevails even after sorting countries by income level differences both in 1980 and 2010. The general picture is that, given average income, countries with lower female to male schooling ratio have higher fertility rate compared to countries with more education parity between men and women.

In addition to income and female to male mean years of schooling ratio, overall average schooling also affects fertility. Given two countries, say, one with female and male average schooling of 3 and 4 years respectively and another with female and male average schooling of 9 and 12 years respectively, we get the same female to male mean years of schooling ratio. However, we expect different level of fertility for these two countries.

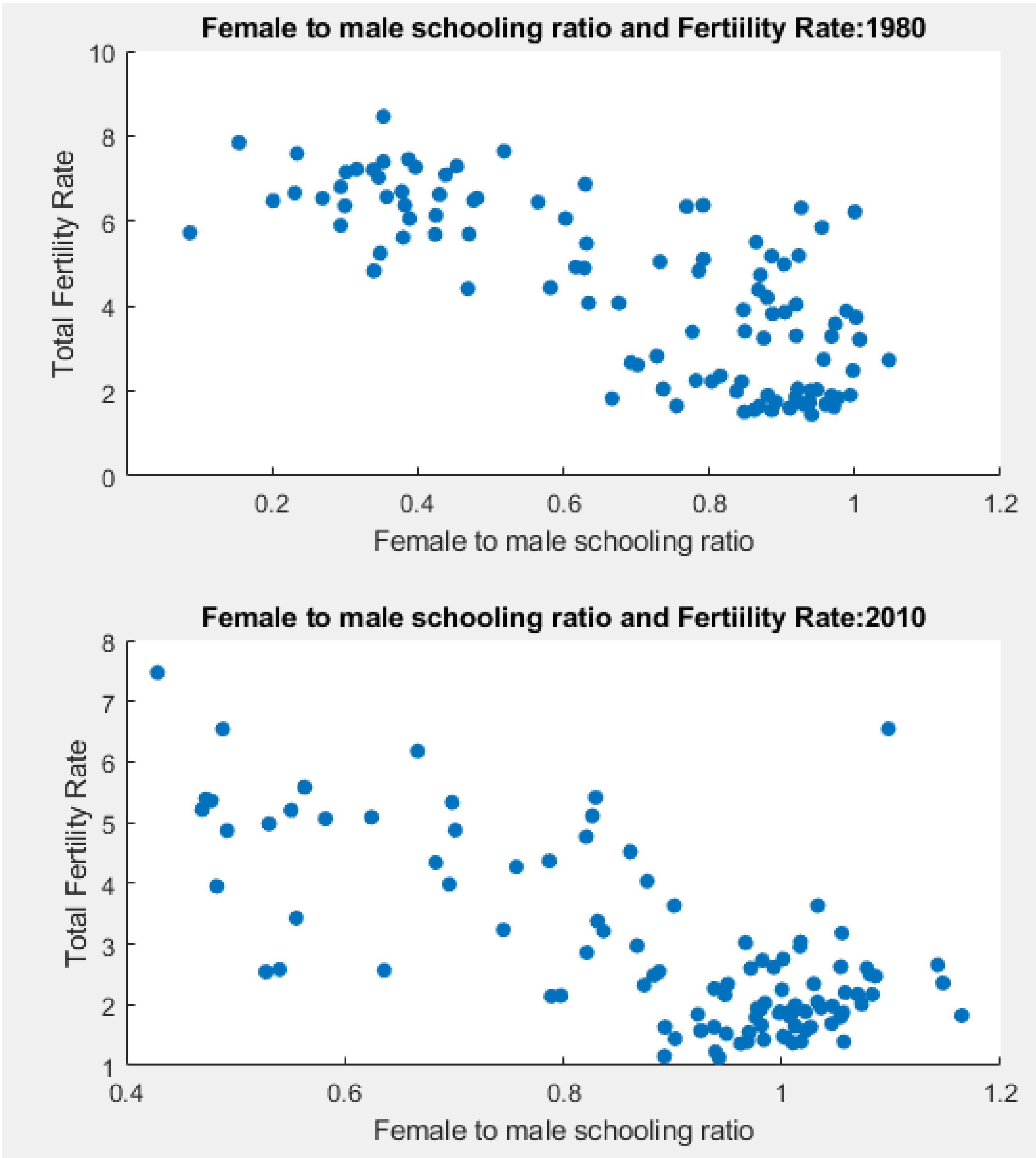

Figure 3.1: Cross−country fertility rate and gender gap in schooling for 1980 and 2010.
The female to male schooling ratio is calculated by dividing female mean years of schooling to male mean years of schooling, both aged 25−64 .
Source: Own calculation using total fertility data from World Bank (2019) and the education figures − Barro & Lee (2013).

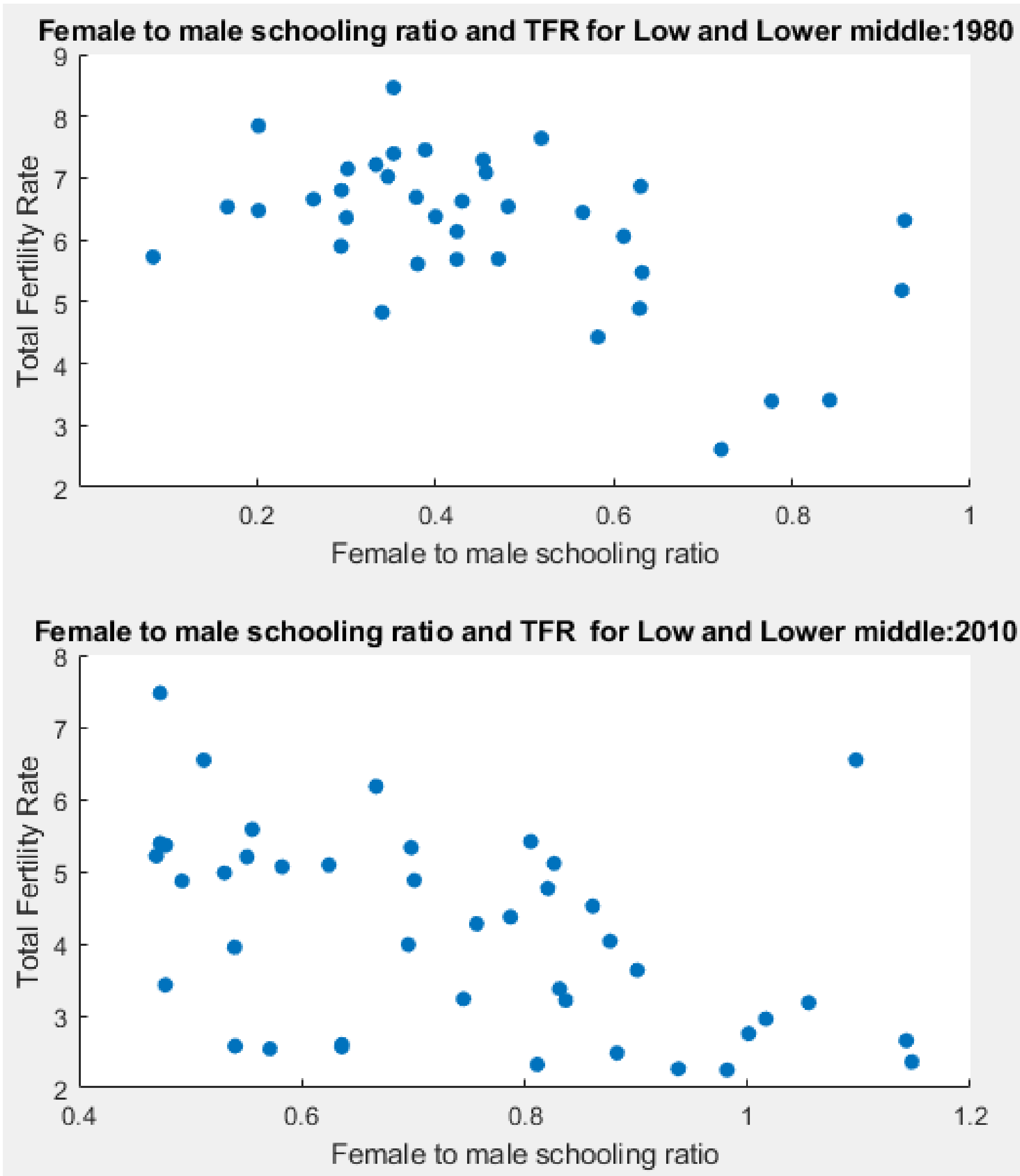

Figure 3.2: Fertility rate and gender gap in schooling: low and lower middle income group.
Source: Own calculation using total fertility data from World Bank (2019) and the education figures – Barro & Lee (2013). Income classification source: World Bank (2011)

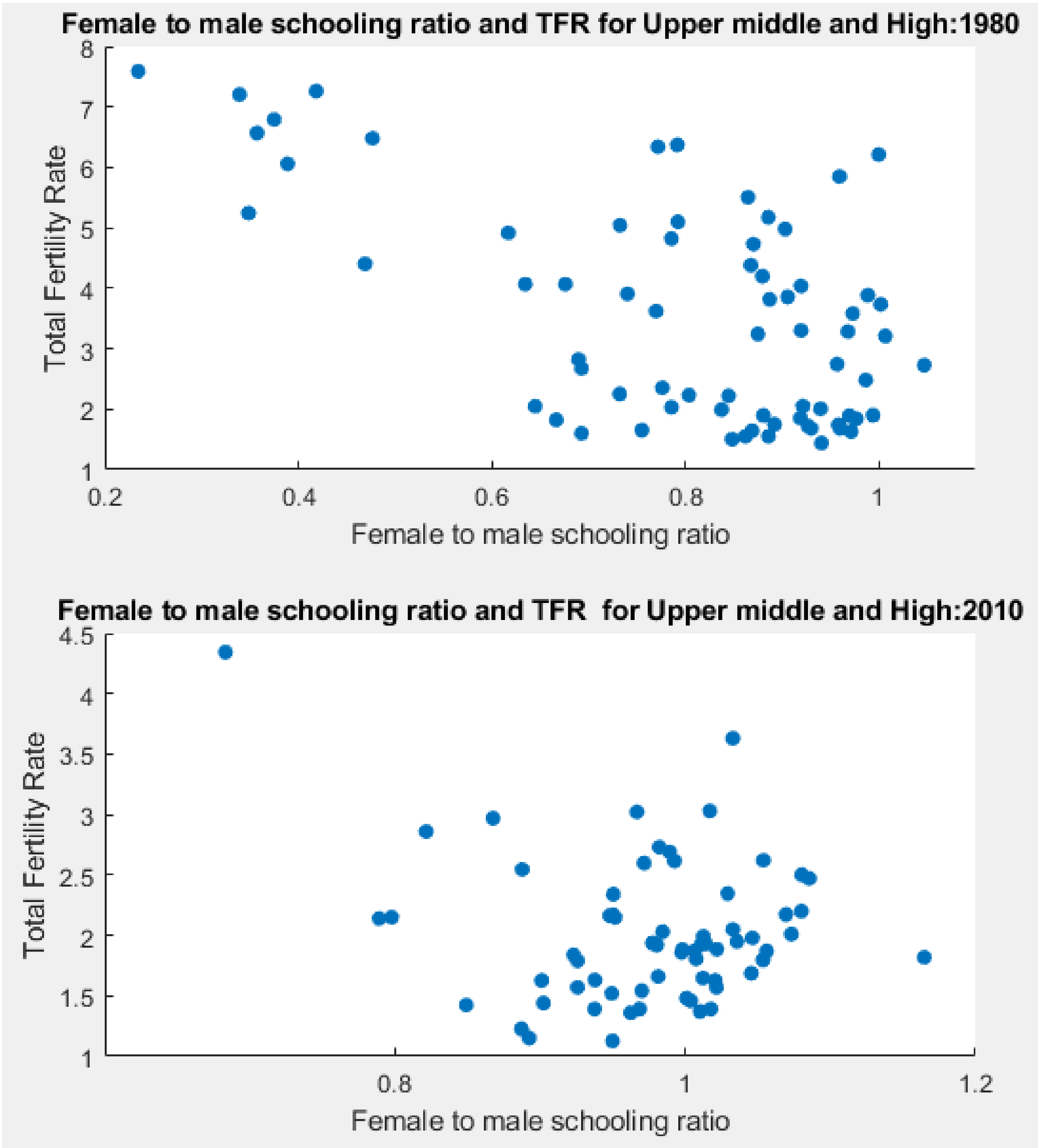

Figure 3.3: Fertility rate and gender gap in schooling: Upper middle and high income group.
Source: Own calculation using total fertility data from World Bank (2019) and the education figures – Barro & Lee (2013). Income classification source: World Bank (2011)

Table 3.1: Fertility, gender gap in education and education levels for selected countries: 1980

Country	Avg. Years of Schooling		Female/Male	Fertility
	Female	Male		
Finland	7.79	8.02	0.97	1.63
Sweden	10.10	10.52	0.96	1.68
Norway	8.87	9.57	0.93	1.72
France	6.24	6.79	0.92	1.85
Spain	5.66	6.70	0.84	2.22
Greece	6.35	7.90	0.80	2.23
Portugal	3.87	4.95	0.78	2.25
Republic of Korea	6.43	8.83	0.73	2.82
Malaysia	3.70	5.83	0.63	4.07
Indonesia	2.44	4.19	0.58	4.43
India	1.00	2.94	0.34	4.83
Bangladesh	0.93	3.10	0.30	6.36
Cote dIvoire	0.49	2.09	0.23	7.59

Source: Own calculation using total fertility data from World Bank (2019) and the education figures – Barro & Lee (2013).

In line with this, we make a further check on the relationship between fertility and gender gap in education with differences in average years of schooling in place as presented in Table 3.1. This last way is intended to show that even if two countries have relatively similar average education attainment but one with higher gender equality in education and another with more inequality, they may experience different fertility outcome. Countries can have higher average years of schooling, but if the female to male mean years of schooling ratio is low, fertility will be relatively higher in that country if one considers the associated implications such as intra− household bargaining power, comparative advantage in childcaring time between spouses, effective application of contraceptive methods and so forth. Since intra−household bargaining is crucial for family decisions, relative spousal education is more likely to play a key role in determining fertility outcomes.

Overall, Table 3.1 conveys similar message as Figures 3.1, 3.2 and 3.3: female to male mean years of schooling ratio and fertility are inversely related. It can be seen that after accounting for income and overall average education levels, this relationship holds. However, what we have seen thus far is a mere correlation between gender equality in education and fertility. This neither shows how robust the relationship between these two variables is nor explains what the explicit mechanism that links them is.

The remainder of this section is devoted to empirical investigation of the link between fertility and gender equality in education using country level longitudinal data. Moreover, average income, average years of schooling, country heterogeneity and time effects are accounted for when analyzing the relationship. The estimation is conducted to verify the consistency and robustness of this negative association between fertility and female to male schooling ratio as shown in the figures and the table. To this end, we employ a balanced panel data of 109 countries for the period 1980 to 2010 with alternative empirical specifications. Our aim, here, is to check the robustness of the correlation between our two variables of interest, gender equality in education and fertility, not a causality analysis. In the model, fertility is regressed on female to male schooling ratio, average income level, and average years of schooling. The empirical specification accounts also for time invariant country level factors and also controls for time fixed effects.

3.3 Data and Estimation

3.3.1 Data source and variable definition

This study uses mainly two data sources. Data for total fertility rate and per capita gross domestic product/GDP from 1980 to 2010 for 109 countries come from World Bank (2019). The reasons for starting the analysis period in 1980 are two. First, even though the World Bank's World Development Indicators data set starts from 1960, many countries do not have data on real GDP per capita for the earlier period. So, here, the decision is whether to have fewer countries for longer time series or more countries for fairly longer period. We chose the latter approach. Second, pre−1980 data for gender gap in education and fertility, taken on average, do not seem to provide a different relationship compared to the period we cover. Overall, fertility before 1980 for many countries is high and flat while female to male education ratio is low and flat. And as far as the last period 2010 is concerned, it is the last year for which education data is available for the $25-64$ age group in the data set we use. This education attainment data is obtained from the Barro & Lee (2013). It includes data for adult female (25-64) and adult male average education attainment. The data set contains figures in every five−year interval. The subsequent female to male mean years of schooling ratio is calculated from this by dividing female mean years of education attainment to that of male mean years of education attainment in the same age group, 25−64.

The variables in the empirical model include fertility rate, gender gap in education, Real GDP per capita and average years of schooling. Total fertility rate (TFR) is defined

Table 3.2: Summary statistics of the variables in the empirical model.

Variables	Mean	St.Dev	Min	Max
Fertility	3.56	1.82	0.96	8.46
Female to male mean years of schooling ratio	0.80	0.25	0.09	2.13
Female mean years of schooling	6.13	3.51	0.11	13.67
Male mean years of schooling	7.03	3.02	0.63	13.8
Overall average schooling	6.58	3.23	0.41	13.58
GDP per capita(2010 USD)	12,741.86	17,957.69	137.60	116,232.80

as the average number of children a woman is expected to bear in her reproductive years. The other important variable is gender gap in education which is measured using female to male schooling ratio (FMSR). The gender gap is calculated by 1 minus female to male years of schooling ratio. Where the FMSR is calculated as the ratio of female mean years of schooling (FMYS) to the male mean years of schooling (MMYS). As this ratio approaches to one from the left, it corresponds to a decline in education gender gap. To account for overall education, we use the simple average of female mean years of schooling and male mean years of schooling which is denoted by MYS in equation (3.1). Real GDP per capita (GDPC), used here, is measured in 2010 US \$[2]. The total observation we have is 763 which is found from 7 time points multiplied by 109 countries. This is because from 1980 to 2010, with five−year interval, there are seven time points. The five−year spacing is due to the nature of the education attainment data set by Barro & Lee (2013). Given these variables, the summary statistics in Table 3.2 gives the overall picture for the period considered and the countries included.

Table 3.2 shows the mean and dispersion of fertility, female to male schooling ratio, income, and average schooling given the 109 countries from 1980 to 2010. The overall mean of female to male schooling ratio is about 0.80− meaning for every one year of education an adult male has, a female's level of education is 0.80 year whereas the standard deviation is 0.25[3]. As for fertility, the mean is about 3.56 and the standard deviation 1.82. There is a significant variation across countries in all the variables as it

[2]There is a new GDP per capita data using 2015 as a base year. But, it was released in September, 2021 after this analysis was almost complete. In terms of impact on the estimation, we believe that it will not affect the essence of this result. Another point related to the GDP per capita is that the unit used in the regression is in $1000's$ of USD.

[3]The average gender gap in education in this case is $1 - 0.80 = 0.20$

is evident in the ranges reported in this table.

3.3.2 Empirical verification

This part of chapter three is devoted to the empirical verification of the relationship between fertility rate and gender gap in education highlighted by the figures and tables earlier. The empirical specification takes the following form.

Fertility rate (TFR) is the dependent variable. The explanatory variables include female to male schooling ratio (FMSR), overall average education (MYS) and GDP per capita (GDPC). We also run an estimation with a log$-$ linear version of the model to see if the correlation between fertility and gender equality in education is robust to various specifications. Moreover, country and time fixed effects are controlled for as there are regional factors that may uniquely influence the fertility behavior of a country besides gender gap in education, overall average education and income.

$$TFR_{it} = \beta_0 + \beta_1 FMSR_{it} + \beta_2 GDPC_{it} + \beta_3 MYS_{it} + \alpha_i + \delta_t + u_{it} \qquad (3.1)$$

Where the error term, $u_{it} \sim IID(0, \sigma_u^2)$. The subscript i denotes country i [4]. And t denotes year. The terms α_i and δ_t are country and time fixed effects respectively. The regression has $109 - 1$ country dummies and $7 - 1$ time dummies.

Results of the estimation of equation (3.1) are provided in Table 3.3 where each column contains various version of the above specification[5].

Table 3.3 shows that fertility and female to male schooling ratio are negatively correlated. And this result is statistically significant $-$ after controlling for income, overall average years of schooling, country fixed effects, and year fixed effects. The result is consistent with the correlation observed in the raw data shown with figures and tables in the earlier subsections. An increase in female to male schooling ratio is associated with a fall in fertility across all specifications. Columns (1) and (2) are different in that the latter includes GDP per capita while columns (3) and (4) replicate the previous two columns but in the latter two, we control for year fixed effects. Overall mean years of schooling also has a negative and statistically significant coefficient in this estimation. This can be explained using the substitution effect. As average years of schooling rises, the opportunity cost of child raising time also increases. This leads to a negative association between fertility and overall average schooling years.

[4]The list of countries in the data is provided in Table C.3

[5]A log$-$ linear version of this estimation is provided in Table C.2. The specification, here takes the form:

$$ln(TFR_{it}) = \beta_0 + \beta_1 FMSR_{it} + \beta_2 (lnGDPC_{it}) + \beta_3 (lnMYS_{it}) + \alpha_i + \delta_t + u_{it}$$

Table 3.3: Estimation results : Linear model

	Dependent Variable: Fertility			
VARIABLES	(1)	(2)	(3)	(4)
Female to male schooling ratio	-1.947***	-1.710***	-1.701***	-1.230***
	(0.628)	(0.592)	(0.576)	(0.447)
Overall average schooling	-0.336***	-0.391***	-0.185***	-0.151***
	(0.0307)	(0.0307)	(0.0444)	(0.0391)
GDP per capita		0.0357***		0.0449***
		(0.00546)		(0.00650)
Country FE	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes
Constant	7.342***	7.059***	6.558***	5.590***
	(0.351)	(0.336)	(0.512)	(0.425)
Observations	763	763	763	763
R-squared	0.943	0.952	0.947	0.959

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The correlation between income and fertility is positive and statistically significant − consistent with literature that income effect raises fertility. When income rises, parents can easily meet the material needs of their children such as clothing, room, education material, nutrition and so on. But, the coefficient is small considering the fact that the unit of income measurement in the data is in thousands of USD[6]. The sign of the coefficient of income is the way it is due to the presence of education both in relative and absolute terms. Rich countries have lower fertility compared to lower income countries which is more likely to be due to high education and partly due to high female to male schooling ratio offsetting the positive push by income level. Thus, it should not be a surprise that income has a positive effect after controlling for the education variables. When it comes the log−linear specification (provided in Table C.2), female to male schooling ratio and log− overall average schooling do have negative statistically significant coefficients whereas, the sign of income is reversed.

However, the endeavor so far in this section doesn't show how the female to male mean years of schooling ratio and fertility are negatively related− the exercise was simple correlation verification. Having verified a robust negative relationship, next, we turn towards developing a model that explicitly charts the channel of the link between gender gap in education and fertility.

Chapter four presents such a model. The theoretical framework's main goal in the next chapter is to develop a sound explanation that links fertility and gender gap in education. Parental gender preference bias in education investment is the best candidate in the model as a factor explaining this relationship between fertility and gender gap in education verified in this chapter. Gender differential in the rate of return to schooling is also accounted for in the model.

3.4 Summary

Using a large− cross section of countries and the latest available education data, in this chapter, we are able to show the negative correlation between fertility and female to male schooling ratio. And this relationship is statistically significant under various specifications of the empirical model. Control variables include average income and overall average education. These two are also statistically− significantly correlated with fertility− the former positively and the latter negatively in the linear model. This is consistent with previous findings that the income effect enhances fertility as affording to the material needs of children becomes easier when income rises. However, the education aspect brings the substitution effect− as individuals rise in their education levels, their time becomes dearer and dearer. The final level of fertility in a country, of

[6]We denominated the real GDP per capita in 1000s of USD due higher decimal number for the coefficient of income when using the data as it is.

course among other things, will be determined by which of these two effects dominates, given the effect of female to male schooling ratio on fertility in place.

Though this study is not the first in estimating the correlation between fertility and education, by using both gender gap in education and overall average education in fertility analysis as opposed to either female education alone or general education alone in other studies, it contributes by shedding light on the correlation of fertility and gender equality in education. The relatively larger size of the cross− section and the inclusion of recent education attainment data together with various specifications of the empirical model also enrich the contribution this chapter makes to the existing literature.

Using the current chapter as a springboard, the next two chapters of this dissertation contribute by designing models to explain the link between gender gap in education and fertility and by investigating the potential consequences of child labor policy in an environment where household division of labor is driven by gender societal norms. The analysis proceeds in that order.

Chapter 4

Parental Gender Preference Bias in Human Capital Investment, Gender Gap in Education and Fertility

4.1 Introduction

What are the mechanisms through which gender gap in education and fertility are related? The main purpose of this chapter is to address this question. We use parental gender preference bias against human capital investment in girls and gender differential in the rate of return to schooling as potential explanations for the correlation of gender equality in education with fertility behavior of households. The parental preference bias is one important source of gender gap in education as pointed out in the literature− households either sending only boys to school or sending both girls and boys but spending less on the education of girls (extensive and intensive margins of pro− boy bias in household resource allocation) [1].

In section 2 of this chapter, we develop an altruistic over−lapping generations model with the parental preference bias in education investment against girls as a key component in explaining the observed gender gap in education and as a factor that brings about the quality−quantity tradeoff. This is accomplished using an altruistic model similar to that of De La Croix & Doepke (2003) in which they examine how differences in the initial distribution of human capital lead to fertility differential between the poor and the rich. In their model, both the number and education of children are endogenous but no gender heterogeneity. In the current study, however, the focus is on investigating how parental gender preference bias in education investment of girls affects gender gap in education which in turn is related to fertility decisions. Hence,

[1]See Kingdon (2005) and Zimmermann (2012) for pro− boy bias in intra−household allocation .

the introduction of gender heterogeneity and with it parental gender preference bias in education is a key extension by the current study. In another paper Doepke & Tertilt (2016) examine a growth model with relation to son preference in bequests and exogenous fertility. In contrast, the current study clearly links endogenous fertility and gender gap in education with preference bias against the education of girls.

Thus, if parents attach high or low preference to the quality of girls compared to boys, they will invest more or less on the education of girls. However, parents do not have control on the sex composition of their children. If we assume that there is an equal chance for a female and a male to be born, preference bias against the education of girls affects family size due to less spending on the education of nearly half of the children resulting in lower average education expenditure per child. Hence, they will tend to have larger quantity of children. But, if the household doesn't have a bias in education investment against any of the genders, it has to equally spend on the education of girls and boys. This makes having an additional child more expensive in terms of education cost. Therefore, in the latter case, parents will decide to have fewer children. The model also accounts for factors which are not controlled by the family such as gender differences in the rate of return to schooling that may be influenced by labor market institutions. If the rate of return to schooling for one of the genders is lower, then, parents will spend less on that particular gender's education which leads to higher fertility: quantity− quality tradeoff, keeping the gender preference bias constant. However, what parents can control is the amount of education expenditure on their children through which manifests their preference to the quality of their children. Thus, both parental gender preference bias against the education of girls and gender differential in the rates of return to schooling are the two important components of the model used to explain the association of fertility with gender equality in education.

Given this model environment, first, we derive closed form solutions for the household's problem which includes own current and future consumption, savings, the number of children and education of girls and boys. And from the closed form values for the education of boys and girls, we are able to derive the gender gap in education as per the model. Second, we conduct quantitative exercise by applying the results from the model to two real world economies: Benin and Pakistan which have similar income level in 2010. We pin down the model parameters by targeting moments for fertility and mean years of education of girls and mean years of education of boys for the year 2010 in these two economies[2]. Third, after generating the baseline economies, we conduct a counter− factual experiment. By fine− tuning the calibrated values, we examine how fertility and gender gap in education respond to changes in preference bias against

[2] Any other pair of countries from similar income level can also serve this purpose. However, the choice of these two economies which have relatively higher fertility is important to generate the quantity− quality tradeoff in the quantitative section. Since developed economies are more likely to have high gender equality in education and lower fertility, there is less room for maneuvering in a counter−factual exercise. And the usage of the year 2010 is because that is when the latest data on education attainment for the 25−64 age group exists in the Barro & Lee (2013) data set.

the education of girls and how these same variables respond to changes in the rate of return to the education of girls. The results from this experiment are compared to the benchmark values of fertility, gender gap in education and levels of education for girls and boys in order to gauge the effect of changes in gender preference bias in education and also rate of return to schooling.

The results from the model show that a decline in parental gender preference bias against girls decreases fertility and rises education levels for both genders. However, since the education of girls rises faster, gender gap in education narrows. The increase in the return for girls' education, keeping boys' schooling return in place, also results in the same outcome as the decline in the parental preference bias. The counter−factual experiment corroborates the results of the model.

The remainder of this chapter is organized as follows. In section 4.2, we develop an altruistic model with parental gender preference bias in education investment and gender differential in the rate of return to schooling. Section 4.3 is devoted to computational experiment. In section 4.4, we present a discussion of the results from the model and counter−factual experiments. Section 4.5 concludes.

4.2 Model

The main framework we employ is an overlapping generations model with three periods: childhood, adulthood and old age. Decisions are made during adulthood and only adults work. Current and future consumption, saving, time allocation between labor supply and childcaring time, family size/fertility, education of children are all decision variables which are made by a couple at time t. For simplicity, we assume that only mothers devote a fraction of their time for childcaring. And in our model, fertility is endogenous but no control on what sex a child is[3].

The model is altruistic in that parents care about, hence derive utility from, the quantity as well as the quality of their children. It is in the quality aspect that they become either pro− girl or pro−boy as it will be manifested in their education investment. If parents attach equal weight to the quality of their daughters and sons, the analysis will result in the same finding as some of the studies we mentioned in the literature. In this model, couple is the unit of analysis. They both have a unit of time each. The mother spends a fraction of this time for a childcare. Since this study doesn't focus on intra− household bargaining, it doesn't matter which spouse cares for children. The results of the model will not be affected if the couple equally share childcaring time;

[3]However, in a world where parents perform sex preferential abortion, they will want to give birth to children with a gender whom they want to invest on−this is not the case in this model. The ideal sex composition of children a household desires may also affect the number of children as parents continue to have a child until the preferred gender's child−number is met. However, in the current model, parents only have preference bias on the quality of their children and no sex preference in birth.

one of them does it or unequally share it. The fact that we chose the mother to spend a fraction of her time for childcare is for two reasons. One it is consistent with literature[4]. Second, to make the model simple− compared to the case in which both of the spouses spending time on childcaring.

4.2.1 The household's problem

Next, we formulate the household's utility function, state the resource constraints it faces, formulate children's future earning and derive the closed form solutions for the variables of interest− fertility, education levels and gender gap in education among other outcomes like consumption and saving. The utility formulation, by construction, fulfills all the properties of standard utility function− twice differentiable.

The utility of an adult couple at time t depends on their current consumption, the discounted utility from next period's consumption, the quantity and quality of their children. The latter two capture the altruistic nature of the model. The quality of children enters adult couple's utility in the form of future welfare of children as measured by their wages. These wages in turn depend on parental education expenditure at time t. It is at this point where the adult couple can discriminate against a certain gender. If they prefer higher quality sons compared to girls, it implies that they attach lower weight to the utility they gain from the welfare of a daughter.

4.2.2 Preference

Utility of an adult couple at time t is given by equation (4.1).

$$u_t = ln(c_t) + \beta ln(c_{t+1}) + \gamma ln(n_t) + \gamma_f ln(w^f_{t+1}) + ln(w^m_{t+1}) \tag{4.1}$$

Where c_t and c_{t+1} in (4.1) stand for current and future consumption for the current adults respectively. And n_t denotes the number of children at time t. $\gamma > 0$ is altruism parameter to quantity of children, n. The parameter β is future consumption discount factor where $0 < \beta < 1$. In addition to the number of children, the parents care about the future welfare(quality) of their children too, as denoted by w^f_{t+1} and w^m_{t+1} which represent next period wage level of daughters and sons respectively[5]. The remaining parameter, $\gamma_f \geq 0$ is parental preference weight to the quality of girls compared to the parental preference to the quality of boys which is normalized to 1. As pointed out earlier, there are cases where parents discriminate against girls−education wise. Hence, we assume that the condition $\gamma_f \leq 1$ is satisfied in this model. If this condition holds

[4] Charmes (2019) documents the disproportionate role women play in unpaid care work− time spent caring for a family member.

[5] In this dissertation, the super/sub scripts f and m denote 'female'and 'male'respectively.

with equality, there is no parental gender bias in education investment. The mechanism through which parents affect w^f_{t+1} and w^m_{t+1} is through current education investment on their children. They can invest equally on both girls and boys or they preferentially treat their children based on gender. In the latter case, gender gap in education arises. To be consistent with the observed gender gap in education as presented in chapter three, the parental preference bias in the model is directed against the education of girls.

4.2.3 Constraints

When maximizing its utility, the household faces resource constraints. The couple's income at time t is allocated for current consumption, saving and schooling cost for children. The parents work only when they are adults and consume from their savings at old age. Each adult has one unit of time endowment. This time endowment is apportioned between labor market and childcaring for a mother and supplied to the market in the case of the father. Given, the above income and expenditure profile of the household, its budget constraint is given in 4.2.

$$c_t + s_t + (p^f e^g_t + (1-p^f)e^b_t)n_t\Psi = w^m_t + w^f_t(1-\phi n_t) \tag{4.2}$$

Where, s_t is the household's saving at time t. The gross return on saving is given by $R_{t+1} > 1$. In the third term of the left hand side of (4.2), p^f is the probability with which a couple gets a baby girl and e^g_t is the schooling time for girls. Similarly, $(1-p^f)$ is the probability with which a couple gets a baby boy and e^b_t denotes the schooling time for boys[6]. The parameter Ψ denotes education cost per child per unit of time. Therefore, Ψe^g_t and Ψe^b_t are total education cost per girl and total education cost per boy in period t, respectively. Parents can choose different length of education period for girls and boys. With that they demonstrate their preference bias against the education of a particular gender or lack thereof it. The terms w^m_t and w^f_t are adult male and female wage rates respectively − which determine the household's aggregate income[7]. And the parameter ϕ, in the second term of the right−hand side expression, is a fraction of a mother's time required for each child's care. If a couple has n_t children at time t, the mother's available time for market production is given by $1-\phi n_t$. Thus, high female wage rate implies that the opportunity cost of raising an additional child is higher − the mother has to substitute market work time for childcaring. On the other hand, higher wage of a mother and(or)father implies high income to spend on each child's education and afford for more children− income effect.

[6]In this dissertation, the super scripts g and b denote 'girl'and 'boy'respectively.

[7]Since long−run analysis is not a focus here, the wage levels of adults, w^m_t and w^f_t, are treated as exogenous.

4.2.4 The future welfare of children

As shown in equation 4.1, parents care about the quality and the quantity of their children. The quality is a function of children's future wage income. These wages in turn depend on their current schooling levels. Other factors affecting children's future income, in the model, include exogenous gender specific productivity denoted by parameters, α_f for a girl and α_m for a boy in equations 4.3 and 4.4. We also consider gender differences in the rate of return to schooling. In addition to the parental preference bias to the quality of girls, this latter exogenous factor also partly explains the gender gap in education and its relationship with fertility. We denote the rate of return to schooling σ_f for a girl and σ_m for a boy. The wage function for the next generation is given as follows: $w_{t+1}^f = w(e_t^g)$ for a girl and $w_{t+1}^m = w(e_t^b)$. More specifically, the future wages of girls and boys are written as[8]:

$$w_{t+1}^f = \alpha_f (e_t^g)^{\sigma_f} \tag{4.3}$$

$$w_{t+1}^m = \alpha_m (e_t^b)^{\sigma_m} \tag{4.4}$$

The σ_f and σ_m parameters govern the return to education investment. Combined with parental gender bias parameter, γ_f, these two exogenous gender differentials in the rates of return to schooling give an important relationship and implication for fertility and gender gap in education. If the return to education of girls is equal or higher than that of boys, lower investment on girls' education shows strong pro−boy bias. However, the only factor parents have control over is the education expenditures captured by e_t^g for a girl and e_t^b for a boy. It is here that parents can show whether they have equal preference for the quality girls and boys or not. If they are biased against girls, then, they attach less weight to the utility coming from the future income of girls and hence spend less on their education at the current period. Hence, the lower schooling attainment of girls observed in the empirical part, chapter three, can be explained primarily by using parental gender preference bias against the education of girls together with gender differentials in the rate of returns to schooling.

4.2.5 Closed form solutions

Given the household's preference, its resource constraints and children's future earning equations, we derive the closed form solutions for all the decision variables in the model: consumption (current and future), saving, fertility and the education of boys

[8]An alternative wage formulation and the subsequent solutions for the household's problem are provided in AppendixA.2. This option is used to show how exogenous gender specific productivity levels, α_f and α_m affect important choice variables which is not the case in the main setup. Moreover, this latter formulation shows how robust the model's results are irrespective of the specification.

and girls. From the latter two, we are able to derive the gender gap in education in the model which we relate to fertility and examine the quantity− quality tradeoff. These results are derived using equations (4.1), (4.2), (4.3) and (4.4). The detailed derivation is provided in Appendix A.1. The following are the closed form solutions for consumption and saving where R_{t+1} is the gross return on saving.

$$c_t = \frac{w_t^m + w_t^f}{1+\beta+\gamma} \qquad \rightarrow \text{Current consumption.} \tag{4.5}$$

$$s_t = \beta c_t = \beta \frac{w_t^m + w_t^f}{1+\beta+\gamma} \qquad \rightarrow \text{Saving.} \tag{4.6}$$

$$c_{t+1} = R_{t+1} s_t = \beta R_{t+1} c_t = \beta R_{t+1} \frac{w_t^m + w_t^f}{1+\beta+\gamma} \qquad \rightarrow \text{Future consumption} \tag{4.7}$$

As equation (4.5) shows, current consumption is increasing in the amount of the couple's labor income−consistent with the literature. The higher their patience as captured by the future consumption discount factor, the more they will save and the higher will be their future consumption. Moreover, for the current adults, the direct negative effects of high education expenditure as represented by the weights attached to children's future welfare on consumption and saving is offsetted by their indirect positive impact through reduced fertility. In other words, the effect of high/low expenditure on education of girls is balanced by fine tuning the quantity of children before it reaches the household's consumption.

Since the focus in this chapter is on the relationship between fertility and gender gap in education as they are affected mainly by parental gender preference bias against the education of girls and gender differential in the rate of return to schooling provide a detailed account of the following three equations: fertility, education of girls and education of boys and their subsequent derivatives.

$$n_t = \frac{(w_t^m + w_t^f)}{(1+\beta+\gamma)} \frac{[\gamma - (\gamma_f \sigma_f + \sigma_m)]}{w_t^f \phi} \qquad \rightarrow \text{Fertility} \tag{4.8}$$

$$e_t^g = \frac{\sigma_f \gamma_f w_t^f \phi}{[\gamma - (\gamma_f \sigma_f + \sigma_m)] p^f \Psi} \qquad \rightarrow \text{Education of girls} \tag{4.9}$$

$$e_t^b = \frac{\sigma_m w_t^f \phi}{[\gamma - (\gamma_f \sigma_f + \sigma_m)](1 - p^f) \Psi} \qquad \rightarrow \text{Education of boys} \tag{4.10}$$

For equations (4.8), (4.9),& (4.10) to hold, the non − negativity constraint, $\gamma - (\gamma_f \sigma_f + \sigma_m) > 0$ must be satisfied.

From equations (4.8) , (4.9),& (4.10)it can be seen that given parental preference to the quality of boys, which is normalized to unity, fertility falls and education rises with a decline in preference bias for the quality of girls ($\uparrow \gamma_f$). However, the education of girls responds more than that of boys to a change in gender preference bias. This is due to both the direct effect through increased investment on girls' education and indirect effect through increased per capita education expenditure resulting in having fewer children. The education of boys is affected through the indirect channel only. This is evident in that the parental preference to the quality of girls, γ_f, appears both in the numerator and denominator of (4.9) and for boys, (4.10), it only affects through the denominator which makes its impact only partial for the latter.

The main task in this part of the model is to outline a clear mechanism relating fertility and gender equality in education. Parental gender preference bias in education is used as key source of gender gap in education. To derive the central focus of this model− relation between gender gap in education and fertility, using the above results, we make this relationship clearer, by dividing equation (4.9) by equation (4.10) which is the equivalent of the female to male schooling ratio/FMSR discussed in the empirical section and we later relate this result with fertility in equation(4.8).

The model's female to male schooling ratio can be expressed as: -

$$FMSR \approx \frac{e_t^g}{e_t^b} = \frac{\left(\frac{\sigma_f \gamma_f w_t^f \phi}{[\gamma - (\gamma_f \sigma_f + \sigma_m)] p^f \Psi}\right)}{\left(\frac{\sigma_m w_t^f \phi}{[\gamma - (\gamma_f \sigma_f + \sigma_m)](1 - p^f)\Psi}\right)} = \frac{(1 - p^f)\sigma_f \gamma_f}{p^f \sigma_m} \tag{4.11}$$

Equation(4.11) reveals three important facts about the gender gap in education in this model. First, other things being equal, if parents are biased against the education of girls (lower γ_f), gender gap in education is higher. Second, similarly, if the return to the schooling of a girl is relatively lower, gender gap will be larger. Finally, if the proportion of girls in the household is lower, given the parental preference to the quality of girls, the relative education of girls will be higher as boys make up a larger proportion of children and the total education cost of the latter matters the most. Thus, the higher the proportion of girls in a family (higher p^f), the larger will be the gender gap in education. However, sex composition in the model is treated as exogenous however parental preference to the quality of girls may shift up, down or remains constant relative to the preference to the quality of boys.

And from equations (4.8) and (4.11)− we generate the quantity− quality tradeoff in this model which can be shown as follows:-

$$n_t = \frac{(w_t^m + w_t^f)}{(1 + \beta + \gamma)} \frac{[\gamma - (\frac{e_t^g (p^f)}{e_t^b (1 - p^f)} + 1)\sigma_m]}{w_t^f \phi} \tag{4.12}$$

From equation (4.12), it can be clearly seen in the second term of the square bracket that holding other factors constant, a rise in the parental preference to the quality of daughters($\uparrow \gamma_f$) relative to that of boys which is normalized to 1, increases the female to male schooling ratio, $\uparrow \frac{e_t^g}{e_t^b}$, which in turn leads to a decline in the number of kids, $n_t \downarrow \Rightarrow$ quantity $-$ quality tradeoff in our model. This happens due to per child education spending becoming more expensive when parents reduce bias against girls. When it comes to the impact of the exogenous gender specific rate of returns to schooling on gender gap in education and fertility, the channel is is not as clear as the parental gender preference bias is. One way is an in increase in either of the returns (σ_f or σ_m) to schooling reduces fertility but gender gap narrows if the return to girls schooling increases by a higher proportion than that of boys or the return to the schooling of boys falls by a larger proportion compared to the return for the schooling of girls. Thus, the connection between changes in return to schooling and gender gap in education is not straight forward unlike that of fertility. This happens because higher return to schooling of either gender means, it is good for parents to spend on the education of children now to guarantee an improved welfare in the future. Since the parents are altruistic, an increase in the return to education of a child incentivizes them to provide more for their education but in order to accomplish this the couple will prefer to have fewer quantity of children.

We can also show how exogenous factors like initial income and the fraction of childcaring time affect fertility, education levels and gender gap in education. Higher income, in the form of adult male and female wages, rises fertility and education$-$ income effect. At the same time, a higher female income makes every unit of time spent to take care of an additional child more expensive/higher opportunity cost which brings about the substitution effect. In the short$-$run, a fall in preference bias for the quality of girls reduces fertility since high preference for education makes children more expensive. Thus, parents have to tradeoff between the number and education level of their children. This quantity$-$ quality nexus is similar to the existing literature on child quantity$-$quality tradeoff. However, the preferential gender bias aspect is peculiar to this model.

In section 3 of this chapter, we conduct a thorough computational exercise so as to check the model's quantitative importance in explaining observed differences in fertility rate, gender gap in education, and education levels. Two sample economies are chosen: Benin and Pakistan. Any other pair of countries with relatively higher fertility and with gender inequality in education can also be used in this exercise to shed light on how the model works in explaining the observed differences in our variables of interest. The model parameters are pinned down by targeting the moments in these countries for the year 2010. Then the respective baseline economies are generated for these two countries with which we conduct a counter$-$factual experiment to see how changes, mainly, in parental preference bias for the quality of girls and also changes in gender specific rate of return to education investment affect fertility, education level and subsequently the gender gap in education. This way, we are able to check how these economies would have looked like absent the disparities in parental gender preference bias in education investment for girls and also if we remove the gender difference in the rate of return to schooling.

4.3 Quantitative Analysis

The purpose this section is to show the quantitative importance of the model. Especially, the impact of parental gender preference bias on fertility, education levels and gender gap in education. How far can this parental gender preference bias in education as shown in the results of the model in equations (4.8 − (4.12) explain observed differences in fertility, education levels and gender gap in education? We use moments for these variables from the two real world economies: Benin and Pakistan in order to pin down the parameters in the model. We chose these two because they have similar per capita income in 2010− GDP per capita equals $989 for Benin and $1239 for Pakistan according to World Bank (2019)), but they differ in fertility rate and average schooling years for females and males. Hence, the parameters calibrated in each economy have to reflect these differences in the two economies. Data for these moments comes from the World Bank (2019) for fertility and latest data available for average means of schooling comes from Barro & Lee (2013)− the latest period education attainment data for adult males and females are available is 2010. After pinning down the parameters in the model, we generate the benchmark economy for each country. Then, using these benchmark economies we conduct a counter −factual experiment in order to be able to see how parental gender bias in education investment affects fertility, gender gap in education and education levels. This is done by fine−tuning the preference to the quality of girls (gender bias) parameter, γ_f, in comparison with the value for a boy which is normalized to 1. In the experiment, we also examine the degree to which exogenous differences in the rate of return to schooling affect fertility, gender gap in education and education levels of girls and boys. This too is done by fine−tuning the rate of return to the schooling of girls, σ_f, in comparison with the value of that of boys in the benchmark.

4.3.1 Quantitative analysis: Parameter choice

Not all of the parameters are pinned down within the model. Some of them are adopted from existing literature at the same time they are reasonably assumed to be the same in both economies while the remaining parameters are calibrated by matching country specific moments such as fertility and education levels.

Those model parameters assumed to be the same for both countries include child-caring time cost, ϕ, and future consumption discount factor, β, and preference to the quality of boys, the latter is normalized to 1 in the model. The adult male wage, w_t^m, is also normalized to 1 in both economies. The child raising time cost has been estimated to be about 15% of a parent's time as used in De La Croix & Doepke (2003). If kids stay with their parents for 15 years out of the 25 years which is equivalent to one period in the model, then the per child time cost in the model is, $\phi = 0.15 \times 15/25 = 0.09$. The annual consumption discount factor, β, is 0.98 which is adopted from real business cycle literature. And it is set to be 0.98^{25} in the calibration. Since the preference to the quality of boys is normalized to 1, we will be able to calibrate the preference to the quality of girls, γ_f, and check how far behind it is compared to that of boys. Similarly, since the wage of adult male is normalized to 1, relative female wage is calculated from gender wage gap data for each country. During the counter− factual experiment, we change the parental preference bias to the quality of girls, γ_f, while that of boys is kept at its current value,1. This will be used to elaborate the importance of gender preference bias in education investment in affecting the variables of interest: gender gap in education, fertility and education levels thereby being able to see how fertility and gender gap in education relate in the model. And finally, we set the probability with which a couple gets a baby girl to be 0.5 in which case there is an equal chance for parent to have a female or a male baby.

The remaining five parameters are calibrated within the model. These are the preference to the quality of girls, γ_f, preference to the quantity of children, γ, the education cost parameter, Ψ, and the return to education investment parameter for a girl, σ_f, and for a boy, σ_m. The latter two are estimated using the wage equations in (4.3) and (4.4) and time series data on income and education in the two economies. Here, we construct average female wage and average male wage from each economy's per capita income.

Thus, in order to be able to estimate for the returns to schooling for each gender, we construct weighted average income for females and males and regress it on their education levels. The period used for this estimation is 2000 to 2010. The reason for using this period are two−fold: first, the rest of the model parameters are calibrated using moments on fertility and education from 2010. Thus, values for the returns to schooling parameters have to reflect the closest period. Second, gender wage gap and labor share of income data are not available in earlier periods for the selected economies. Given these facts, we confine our estimation of the return parameters to the period 2000−2010.

The weighted average income is constructed by apportioning the national average income based on each gender's employment share, average working hours and by taking into account the gender wage gap. Moreover, since income is shared between labor and capital, we also account for the share of labor income in each country. The data on GDP per capita and for employment share of women and men with respect to their population group is from World Bank (2019). And the gender wage ratios are adopted from earlier estimates. There is about 43% wage gap for Benin according to ITUC

(2018) − hence, the female to male wage ratio is about 0.57. Similarly, there is a 31% gender wage gap in Pakistan according to Sabir & Aftab (2007). In the following equations, the employment share of 15+ women is denoted by (a) and that of men (b) as % of their respective total population. And we also denote females actual working hours by h_f and male working hours as h_m. The labor share of national income is denoted as ω_B for Benin and ω_P for Pakistan. Given data on all these, we can approximate both genders' weighted average income in each country as follows and then estimate the return to schooling parameters for both gender in the two economies.

Benin:

$$
\begin{aligned}
(\frac{a}{2}h_f w_t^f + \frac{b}{2}h_m w_t^m) &= \omega_B \text{GDP per capita} \\
\Rightarrow (\frac{a}{2}h_f 0.57 w_t^m + \frac{b}{2}h_m w_t^m) &= \omega_B \text{GDP per capita}
\end{aligned}
$$

Where $w_t^f = 0.57 w_t^m$ in Benin.

Pakistan:

$$
\begin{aligned}
(\frac{a}{2}h_f w_t^f + \frac{b}{2}h_m w_t^m) &= \omega_P \text{ GDP per capita} \\
\Rightarrow (\frac{a}{2}h_f 0.69 w_t^m + \frac{b}{2}h_m w) &= \omega_P \text{ GDP per capita}
\end{aligned}
$$

Where $w_t^f = 0.69 w_t^m$ in Pakistan.

In Pakistan, the mean weekly hours actually worked by prime age female is 35.1 while it is 52.4 for a male according to ILO (2020). For Benin, data on mean weekly hours worked exists for 2018. And the figures are 47.5 for females and 48.2 for males. These weekly working hours are converted into annual by multiplying them by 52 as the GDP per capita is on an annual basis. Data for ω_B and ω_P which represent the income share of labor in Benin and Pakistan (as a % of GDP) come fromUN (2020). Since we use the 2000 to 2010 data to estimate for the returns to schooling parameters for both females and males, we applied the labor share of income values for each year. However, there is no labor share of income data for years before 2004 in which case we used the closest year's value(that of 2004). Having constructed the wages of females and males, we regressed them on their respective education levels[9].

[9]Since education data in the Barro & Lee (2013) data set is in every five−year, we interpolate for the missing years.

Table 4.1: Estimates from the wage equations

	Benin	Pakistan
α_f	0.14	0.14
α_m	0.10	0.07
σ_f	0.46	0.63
σ_m	0.80	0.99

Where, α_f and $\alpha_m > 0$ represent exogenous productivity levels. And σ_f and $\sigma_m > 0$ govern the return to education investment for girls and boys respectively.

The estimation results of the wage equations in the two countries are given in Table(4.1)[10].

Now, out of five unknown parameters, the values for the returns to education for girls and boys in each country have been identified. Only three unknown parameters remain: weight to the quantity of children, γ, preference to the quality of girls, γ_f, and the education cost parameter per student per unit of time, Ψ. These are calibrated by matching moments in each country for fertility, girls education and boys education for the year 2010.

4.3.2 Target moments

To calculate the value of the three parameters we use the three equations: (4.8) , (4.9),& (4.10). Now, we match moments for these three equations to solve for the three unknown parameters. Thus, the weight to the quantity of children, γ, preference to the quality of girls, γ_f, and the education cost parameter, Ψ, are pinned down by targeting the moments in each country. Since, we have normalized the parental preference to the quality of boys to 1, we expect the value of $\gamma_f \leq 1$ given the observed gender gap in education.

Table 4.2 presents the target moments for each economy. These moments are all for the year 2010 as this is the last period when education data is available in the Barro &

[10]The purpose of this regression is not causality identification rather a simple coefficient estimation.

Table 4.2: Targeted moments

Variable	Value for 2010		Source
	Benin	Pakistan	
TFR	5.36	3.95	World Bank (2019)
FMYS	2.26	2.96	Barro & Lee (2013) data set
MMYS	4.73	6.13	>>

The symbols in the table stand for
TFR : Fertility,
FMYS : Female mean years of schooling
MMYS: Male mean years of schooling

Lee (2013) dataset[11].

By putting together all the parameters obtained out of the model (literature and normalization), ϕ, β and wage gap, and the ones solved within the model by estimation of the wage functions, σ_f and σ_m, we calibrate for the remaining three parameters using the three equations representing fertility, the education of girls and the education of boys. The calibration results are provided in Table 4.3 [12].

As shown in the calibration results table, the preference for the quality of girls, γ_f, is less than unity in both countries. Given the fact that we have normalized the preference to the quality of boys to 1, these results in Table 4.3 show the disparity in terms of parental preference for the quality of girls and boys. Having pinned down all the model parameters, now, we can generate the benchmark economies using these results.

Table 4.4 is the benchmark model for each economy. No disparity between data and model exists. Hence, they are both reported in one column.

4.3.3 Counter− factual experiment

How much do parental gender preference bias in education and differences in the rate of return to education explain the variations in fertility and gender gap in education as implied by the model? To answer this question, we conduct a counter− factual exercise using the benchmark economies. Two exercises are conducted. First, we remove the disparity in the parental preference for quality between girls and boys that exists in the baseline economy as shown in the magnitudes for the parental child quality preference parameters by keeping other parameters fixed. Hence, we increase, γ_f to 1 so that parental preference to the quality of children is identical which, in this scenario, means parents attach equal weight to the quality of girls and boys. This comes by increasing the preference to the quality of girls. The gender gap in education that remains after the bias removal is explained by the different levels of rates of return to schooling for girls and boys since the sex composition of siblings is assumed to be equal. In the first exercise, the rates of return to schooling and preference to the quantity of children parameter values are kept unchanged from their baseline values. Only the bias against the education of girls declines.

Second, we remove the disparity in the return to education between girls and boys that exists in the benchmark by increasing the level of returns to the schooling of girls to the level of that of boys while keeping other parameters fixed. Gender equalization in the rate of returns to schooling can come either by increasing the level of returns to the

[11]The average years of education are divided by the model period, 25. $e_t^g = FMYS/25$, $e_t^b = MMYS/25$.

[12]The calibration is conducted using MATLAB software

Table 4.3: Calibration results

Parameters	Benin	Pakistan
γ	1.7737	1.9896
γ_f	0.8310	0.7588
Ψ	0.7335	0.9616

The parameter γ denotes the weight attached to the quantity of children, whereas γ_f stands for the parental preference for the quality of girls. The last parameter, Ψ represents the education cost per child per unit of time in the model.

Table 4.4: Benchmark model.

Variable	Benin	Pakistan
	Benchmark	Benchmark
TFR	5.36	3.95
FMYS	2.26	2.96
MMYS	4.73	6.13
FMSR	0.48	0.48

The symbols in the table stand for
TFR : Fertility,
FMYS : Female mean years of schooling
MMYS : male mean years of schooling and finally
FMSR : female to male mean years of schooling ratio

schooling of females to the level of that of males or by reducing the return to the schooling of males to the level of females. Here, schooling return to females is increased to the return level of males in the benchmark. While doing this, other parameters including preference bias and weight to the quantity of children are kept to their benchmark level. Hence, now $\sigma_f^{\text{new}} = \sigma_m^{\text{benchmark}}$, girls and boys do get the same return for every unit of time spent in schooling. In this case, the remaining gender disparity in education is explained by the parental gender preference bias. These exercises are done for both economies. From (4.8) and (4.11), one can see the relationship between the preference and schooling returns parameters in one hand, and fertility and gender gap in education on the other. The results of the counter−factual experiment are presented in Table 4.5.

The first row in each economy, Benin and Pakistan, in Table 4.5 represents the benchmark values of fertility (TFR), female mean years of schooling (FMYS), male mean years of schooling (MMYS) and finally female to male mean years of schooling ratio (FMSR). The second row contains the respective results for these variables after removing the gender disparity in parental preference for the quality of children that is derived by increasing the preference to the quality of girls to the level of that of boys while other parameters are kept unchanged. In this case, fertility falls, both the education of girls and boys rise. But the rise in the education of girls is larger. Thus, gender gap in education narrows compared to the benchmark. In the third row, the gender disparity in the rates of return to schooling is eliminated by increasing female returns to schooling to the level of male returns to schooling in the benchmark while other parameters are kept unchanged. The changes in row three are similar to that of row two in terms of direction. However, the magnitudes of departure from the benchmark are more pronounced in the latter.

Table 4.5 shows that changes in preference bias for quality of girls vis−a−vis boys explains large fraction of the variation in fertility, education attainment levels and gender gap in education as implied by the model compared to the benchmark values. The second row, $\gamma_f = 1$, shows this fact. The decrease in preference bias to the quality of girls reduces gender gap in education as the education of girls is affected both via the direct and indirect channels and its increase is larger than that of boys. The latter is affected only indirectly through the quantity−quality tradeoff when the bias against girls declines. Similarly, a narrowing of the difference in the exogenous rate of return to education of girls and boys as shown by row three, $\sigma_f^{\text{new}} = \sigma_m^{\text{benchmark}}$, results in reduced fertility, increases education levels of girls directly and indirectly, boosts boys' education through the quantity− quality tradeoff which is the indirect channel. Here too, since the education of girls is affected both via the direct and indirect channels, the education increase for a girl is larger than that of a boy. Thus, the gender gap in education narrows because the increase in the education of girls due to the above two changes is higher than that of boys.

Table 4.5: Counter− factual experiment: Results

	TFR	FMYS	MMYS	FMSR
Baseline(Benin)	5.36	2.26	4.73	0.48
$\gamma_f = 1$	4.66	3.13	5.45	0.58
$\sigma_f = 0.80 = \sigma_m$	2.80	7.53	9.06	0.83
Baseline(Pakistan)	3.95	2.96	6.13	0.48
$\gamma_f = 1$	2.80	5.50	8.65	0.64
$\sigma_f = 0.99 = \sigma_m$	1.88	9.77	12.87	0.76

The parameters γ_f and σ_f denote preference to the quality of girls and rate of return to schooling for girls respectively. The corresponding parameters for boys are represented by 1 and σ_m. The symbols in the table, here too, stand for Fertility (TFR), female mean years of schooling (FMYS), male mean years of schooling (MMYS) and finally female to male mean years of schooling ratio (FMSR).

4.4 Discussion

Having gone through all these stages of this paper, now we are able to clearly address the question we paused at the beginning about what the possible explanation behind the correlation between fertility and gender equality in education is. In our model, parental gender preference bias provides a sound explanation for why gender gap in education exists and how fertility and gender gap in education are inter−woven. Gender differential in the rate of returns to schooling also provides similar explanation.

When parents attach high weight to the quality of their daughters as manifested in their education expenditure compared to the quality of their sons but still the latter having more weight, they incur more average education spending per child. This makes children relatively dearer in terms of education cost which leads parents to have a lower fertility. The reduction in bias against the education of girls not only raises their education but also increases the education of boys. However, the rise in the latter's education is not as pronounced as that of the former. This is due to both the direct impact through bias reduction and the indirect impact through reduced fertility increasing the education of girls. Whereas, the education of boys rises via the indirect channel only − a rise in a girl's education making the number of kids lower and thereby boosting the per child education expenditure. Besides to this parental preference bias against the education of girls which is the main explanation in the model, the counter−factual experiment shows that gender differential in the rate of return to schooling matters for gender gap in education and also for how it is related to fertility decisions. If the market provides different level of return for every unit of schooling for girls and boys, it affects education and fertility decisions. The higher the return on education, parents will prefer to have fewer kids and provide them with more education. Although increase in the rate of return to education of either gender results in reduced fertility, gender gap narrows only for the cases where returns to the schooling of girls increases by a larger proportion than that of boys or the latter's decreases by a larger proportion than the former.

4.5 Conclusion

Previous studies of fertility and education behavior of households show an inverse relationship between these two which is usually expressed as child quantity− quality tradeoff. In this chapter, we extend the existing literature with gender heterogeneity and by introducing gender specific parental preference to the quality of children− usually manifested as pro− boy bias in education expenditure. Moreover, in the current chapter we also account for gender differentials in the rate of return to schooling in order to explain the empirical association between gender equality in education and fertility.

When parents are biased against the education of daughters, they spend less on education per child. This low average expenditure on education in turn serves as an incentive for parents to have more children. Hence, the quantity− quality tradeoff emerges. It is important to note that this tradeoff in the current study is triggered by the preference bias to the education of girls. Earlier studies treat children as monolith, gender−wise, in terms of resources allocation by their parents for education. Our investigation shows that the larger the preference bias against the education of girls, the higher will be the fertility and the lower will be the education levels, especially that of girls. Thus, gender gap in education becomes wider. On the contrary, when there is parity in parental gender preference for the quality of children, average education expenditure rises. The quality of children as measured by their schooling levels becomes higher, but parents cannot afford high quality for many children, hence, quantity− quality tradeoff kicks in. Therefore, fertility has to decline in the latter case. Moreover, the model also accounts for how exogenous factors such as gender differential in the rate of return to schooling play a part in explaining the observed relationship between gender gap in education and fertility. However, the gender differential in the rate of return is beyond the household's control. To quantify these model results we conduct a quantitative experiment.

The quantitative exercise using Beninese and Pakistani economies shows that a change in parental preference bias for the quality of girls explains large fraction of the variation in fertility, education attainment levels of females and males and more importantly educational gender gap. For instance, due to the decline in parental gender preference bias, in Benin, fertility declines by about one child and gender gap in education falls by 19%. And in Pakistan, fertility declines by about one child and gender gap in education falls by 31%.

Similarly, the exercise shows that a narrowing of the exogenous difference in the rate of return to education of girls and boys by raising the former's to that of the latter reduces fertility, increases education levels and reduces the gender gap in education. Hence, the quantitative exercise corroborates the relationships illustrated by the model. In Benin, fertility declines by about three children and gender gap in education falls by 67%. And in Pakistan, fertility declines by about two children and gender gap in education falls by 54%.

Chapter 5

Child Labor, Gender Equality in Education and Fertility

5.1 Introduction

Child labor practices or lack thereof have important implications for fertility and education. Doepke (2004) points out that child labor restriction policies affect the opportunity cost of education which in turn has an effect on fertility. He finds that child labor ban reduces the opportunity cost of education thereby boosts education and reduces fertility which is in line with the child quantity− quality tradeoff. And these outcomes of the policy in turn are found to have a positive effect on growth in GDP per capita due to the associated increase in skill. However, in this and other similar studies, children are treated as monolith in terms of gender which may lead to the overlooking of some important aspects of child labor such as gender−based division of labor.

Then, what will happen to the above results in Doepke (2004) if we consider gender role? In other words, what are the consequences of child labor restriction policies on fertility and the education of boys and girls in an environment where gender role is an important driver of household division of labor? The existing literature shows that child labor restriction policies are successful in increasing education thereby reducing fertility. In the current chapter, we examine the impact of child labor bans by focusing on the importance of treating differently the child labor experiences of girls and boys in contexts where traditional gender norms influence the household division of labor to take a non−egalitarian arrangement: female homemakers and male bread winners[1]. The question is important for at least three reasons: first, child labor definitions do not usually include unpaid domestic works such as household chores. Second, child labor banning policies target work by children outside of home which may include

[1]Davis et al. (2007) note how crucial gender ideology is in determining which gender does what and where.

employment or child labor on family farm or business though no direct payment is paid in the case of the latter two. This is true both from the visibility of the work of children in family farm(business) and the fact that works in this domain are considered as economic activities by national accounts. Third and most importantly, girls are disproportionately engaged in unpaid own household work like meal preparation, dish washing, laundry, house cleaning and other related activities. Thus, an introduction of child labor ban with these realities in place is less likely to result in equal outcomes for girls and boys− say in terms of education attainment. This point is relevant as our world continues to witness a widespread child labor incidence.

In 2016, one in ten children are engaged in child labor, worldwide, according to ILO (2017). This rampant child labor practice or lack thereof has important implications for various individual, family and societal level outcomes. It is more likely to affect the education level of children, gender gap in education and fertility among other things. Especially, in an environment where beliefs and attitudes continue to shape the role of women and men both within the household domain and in societal life, child labor may perpetuate gender roles by introducing daughters and sons differently to various sets of activities. This in turn is more likely to affect gender gap in education when policies prohibiting child labor are introduced.

Thus, to investigate the real impact of child labor or its counter− measures, it is necessary not to overlook unpaid child work within own household. Its exclusion results in two important problems. First, it results in underestimation of the overall child work incidence as activities such as household chores do not qualify as child labor. Second, since girls are overrepresented in unpaid domestic work activities, this problem makes the work that girls do less visible and consequently not targeted by policy makers[2]. To enrich the perspectives surrounding this disproportionate role by girls in own domestic work, the inclusion of unpaid child work in a systematic examination of child labor is key. Especially, when household gender division of labor is driven by traditional gender role attitudes in which case, both mothers and daughters are overrepresented in unpaid household chores. Therefore, if the aim of child labor banning is intended to bring about some desired economic or social outcomes such as raising gender parity in education, overlooking the own household unpaid child work, as it is usually the case, is more likely to contribute to girls lagging behind in terms of average education attainment compared to boys. This in turn has effects on fertility behavior. Given this problem regarding the gender differences in child labor experience, this study will contribute in designing a mechanism to examine the consequences of child labor restriction policies in an environment where gender role is a key driver of household division of labor.

For the purpose of this study, as it is the case in other studies including Doepke (2004), child labor means the part of work by children for which they are paid for. The second category of child work in this study is unpaid domestic work. In practice, there

[2]Basu & Tzannatos (2003) observe that the existing approach results in undercounting of children in labor in general and girls' work in particular.

are child works outside home such as on family farm or family business in which children are not directly paid for, but which are included in child labor measurement. This way children can boost the household's income if the product is marketable or increase the household's own consumption, otherwise. However, in this study, we abstract from this intermediate part and treat it as child employment so that all child work lies on the two main categories of child work: the one which children are paid for and unpaid domestic child work. This definition is similar to the one provided by the International Labor Organization. ILO defines child labor as any work by a child that is mentally, physically, socially or morally dangerous and harmful to children between the ages of five and fourteen which includes employment in the market and some non− market activities like agricultural produce for own use ILO (2017). However, not all work by children is considered as child labor according to this definition. Household chores undertaken by children do not count as child labor or economic activity following the UN's system of national accounts (UNSNA) UN (2008). Since the main focus in this chapter of the dissertation is to examine how child labor ban affects gender gap in education, any child work related activity that crowds out schooling time is accounted for− unpaid domestic work is included in the model.

By introducing a home production sector, we will examine how unpaid work by children within own household setting, in which girls have disproportionately high engagement, contributes to gender gap in education when child labor restriction policies are legislated. The argument, here, is that the introduction of such policies will not directly affect unpaid domestic production which can be explained partly by the very nature of these works−not included in the national accounts and partly due to the relative difficulty of enforceability. When it comes to child work in outside settings including family farm and business, it is relatively easier to measure and more visible in terms of enforcing bans on.

In this study, we develop an overlapping generations model following that of Doepke (2004) which we extend by including a gender dimension and home production. Thereby, we examine the consequences of child labor restriction policies mainly on gender gap in education. By using an altruistic overlapping generations model with child labor and home production, we investigate how policy introduction affects the education of girls and boys differently or otherwise. The inclusion of the gender−based division of household labor, especially for children and that of home production undertaken by female members of the family to the existing literature brings additional insight on the relationship of child labor restriction policies, gender gap in education and consequently education levels and fertility as the latter two are joint household decisions. Since child labor bans don't take unpaid domestic works into account, there always arises the potential for an unequal impact of such regulations for girls − who are more likely to engage in domestic production vis−vis− boys. In settings where girls home production time is large enough, a ban on child labor makes the opportunity cost of boys' education lower as their alternative time use, child labor, is outlawed. For girls, they still have an alternative time use in home production due to the division of labor based on gender norms. Thus, child labor prohibiting policies in such environments result in unequal outcomes for girls and boys.

In order to clearly show the mechanism how this gender inequality in education comes about following a child labor ban, we perform two main tasks. First, we present the gender gap in education before child labor restriction that arises due to the difference in preference to the quality of children in a similar way to the one illustrated in chapter four of this dissertation. Other things being equal, if parents give different weight to the quality of girls and boys, there will be gender gap in education in the pre−policy regime. Given the benchmark gender gap in education, the second task is to address the question "what happens to this gap once the child labor restriction policy is implemented?". The outcomes of the policy depend on a combination of factors such as initial conditions/benchmark values of education level and home production time for girls and education level for boys. Given these conditions, the way households make choices under child labor ban regarding education levels of boys and girls and home production time of girls is key to the narrowing, widening or continuity of the existing gender gap in education. In line with this, the model identifies three cases: the first case is where the ban is non−binding for girls and binding for boys. Second, binding for girls and non−binding for boys. And the last case is binding for both[3]. The fact that there is an observed gender gap in education as shown in chapter three and from the argument that girls have disproportionately high role in unpaid domestic work, the first case is an ideal condition to show how child labor ban can exacerbate gender gap in education.

The results from the benchmark model show that child labor increases fertility, reduces education levels but doesn't affect gender gap in education. In the model with child labor prohibition, while it is true that child labor restriction policies increase education and reduce fertility−consistent with previous studies, there are cases in which such policies result in an increased gender gap in education. Among the three cases discussed in this study, we find that, in the first case where child labor ban is non−binding for girls and binding for boys the policy widens gender gap in education and reduces fertility compared to the benchmark[4]. This happens as the opportunity cost of education of a boy declines when child labor is prohibited. But for girls, there is

[3]The fourth case is where child labor restriction is non−binding for both. However, this results in the same outcome as in the pre−policy regime. In reality, countries with higher level of average education attainment, hence low child labor, can have such policies in place. Though this will not have direct immediate impact on the education of girls and boys, it can serve as a preventative approach as opposed to the curative measure where education levels are low and child labor practice is rampant.

[4]When a child labor ban in the form of minimum working age requirement is introduced(say, age 15), the level of education of boys may be lower than what can be achieved within the ages of children outlawed from work. This case is binding for boys. Similarly, when the level of education of girls plus their home production time lies below the period in which the law prohibits child labor, it is binding for girls. To make age and schooling level go hand in hand, in the model, grade repetition is ruled out.

no direct impact from the policy as they have additional alternative time use −home production which is not accounted by the ban. In all cases, where the policy is binding for one or both, the primary effect of the ban is to increase education levels and reduce fertility as children become more of a liability due to lost child labor income. But, the secondary effect through a requirement for home production time of girls, fertility tends to rise and education falls. The primary effect dominates the secondary effect as the latter always applies through a girl's home production time only.

The remainder of this chapter is organized as follows. In section 5.2, we develop an altruistic model with child labor and home production sector undertaken by female members of the family. Section 5.3 introduces child labor restriction policies in the form of minimum working age requirement. And in section 5.4, we conduct a numerical exercise to check the quantitative importance of the model. In section 5.5, we present a discussion on the results of the model. The final section concludes the chapter.

5.2 Model

In this section, we focus on developing an altruistic OLG model with child labor and a home production sector undertaken by female members of the household. As in chapter four, parents in this model have different preference for the quality of girls and boys which serves as a potential explanation for the observed gender gap in education and its correlation with fertility. This model with child labor is similar to that of Doepke (2004) with a especial emphasis, here, on parents differently treating the labor of girls and boys which in turn affects the consequences of child labor restriction policies such as gender gap in education. Hence, introducing the gender element and the accompanying home production sector undertaken by female members of the family are key departures of the current study. In contrast to the previous paper, the current study clearly links gender, child labor restriction, education and fertility. The inclusion of the gender component is important due to the existence of different attitudes towards the roles of men and women in society which has crucial economic and social implications as in gender gap in education and fertility. Thus, the societal preferences to assign home production for a particular gender, say to female members of the household, is one such a factor in this model[5]. However, we don't attempt to explain the cultural environment giving rise to the parental gender bias in education investment.

[5]Charmes (2019) in a recent paper provides a worldwide compilation of unpaid work share by each gender. The documentation clearly shows that women have significantly higher share in unpaid homework. For example, in Rep.Korea women's share is 82.8 % while men's is 17.2%. In Cambodia, women's share is 91.3 % while men's is 8.7%. And in Mali women's share in unpaid work is 92 % while men's is 8%. One precautionary note here is that unlike in the aforementioned study, we don't include childcare with unpaid home production. We treat it differently− only the mother takes care of a child as will be shown soon.

The main framework is an overlapping generations model with three periods: childhood, adulthood and old age. Decisions are made during adulthood. They include current and future consumption, saving, time allocation of a mother between home production and market labor, time allocation of boys between schooling and child labor, and time allocation of girls between schooling, child labor and home production. Similar to the preceding chapter, in this model, fertility is endogenous but no control on what sex a child is. Besides, by choosing the number of children, parents decide the amount of time allocated for childcare− undertaken by the mother. When parents decide to have a certain number of children, there is a probability p^f with which they get a baby girl and with $(1 - p^f)$ a baby boy.

5.2.1 A child's time endowment

Each child is endowed with a unit of time. And this time is composed of two main parts which add up to one: $e_0 + \tau = 1$. Where e_0 denotes the period before school entrance age when children are too young to go to school and too young to work. The second period, τ, is the time that can be devoted either to schooling or work. It is the active childhood phase. This time can be devoted either to schooling or child labor for boys and schooling, home production, and child labor for girls. For a boy, the child labor time is given by the difference between the active childhood period (τ) and his schooling time (e_t^b). Hence, child labor time of a boy can be expressed as $\tau - e_t^b$. And for a girl, her child labor time is given by subtracting her schooling time (e_t^g) and home production time(Ω_t^g) from the active childhood time endowment τ. This can be expressed as $\tau - e_t^g - \Omega_t^g$. This child labor time for boys and girls includes time devoted to employment or activities such as family farm or family business in which children may or may not be paid directly. In the model, children in child labor are assumed to be paid following a similar approach to Doepke (2004). Whereas, home production is mainly used to refer to within home activities such as cooking, dish washing, laundry, house cleaning and related activities.

The inclusion of the home production time for a girl (Ω_t^g) is key in the current study as it helps explain the unequal impacts of child labor restriction policies on girls and boys. This happens because girls tend to do more unpaid domestic work than boys[6]. In contrast, boys are more active in outside home activities which is relatively easier to observe and enforce child labor bans compared to the context in which girls are operating.

A clear distinction between what is meant by home production and what activities qualify as child labor in the model are outlined as follows. Work by children in family farm (business), where most child labor takes place, are counted as child labor and

[6] The disproportionate engagement of girls in unpaid own homework is noted by Fares & Raju (2007) and Basu & Tzannatos (2003).

excluded from the household work. This is in line with approaches in the literature. For instance, Basu & Tzannatos (2003) present three categories of child work: household work, agricultural and non−agricultural. Only in the latter two categories is a child work considered child labor. Whereas, household work, in which girls disproportionately do more work according to the authors, is not counted as child labor. They also point out that ILO "ignores the unpaid and not-for-market work that is done in the household, such as household chores". The "household production "in chapter five is similar to what these authors present as "household work ". It may include activities such as cooking, serving meals, dish washing, house cleaning, water fetching and related domestic chores. In Ngai & Petrongolo (2017) the home production includes childcare, cleaning, food preparation and other services that have close substitute in the market (following the Bureau of Economic Analysis)[7]. Neither family farm nor family businesses are mentioned as part of household sector in their study. ILO too, clearly states the exclusion of household chores from standard child labor measurement and the fact that girls shoulder disproportionately higher responsibility in these activities ILO (2017). Thus, the household production in chapter five is used in a similar sense as "housework"in Basu & Tzannatos (2003), "household chores"in ILO (2017) and "household production "in Ngai & Petrongolo (2017). It doesn't include agricultural activities where about two-thirds of child labor takes place.

5.2.2 The household's preference

Next, we formulate the household's preference function, state the resource constraints it faces and derive the closed form solutions for the variables of interest− consumption, saving, home production time of a mother and a daughter, education levels for girls and boys and fertility. The child labor time of girls and boys are also derived from the education results.

The altruistic household has the following preference formulation which satisfies all the properties of standard utility function. As (5.1) shows, the household's utility at time t is a function of current and discounted future consumption, the quantity of children, the quality of girls and boys.

$$u_t = ln(C_t) + \beta ln(C_{t+1}) + \gamma ln(n_t) + \gamma_f ln(w^f_{t+1}) + ln(w^m_{t+1}) \tag{5.1}$$

The parameter β denotes the discount factor of future consumption of a couple. And $\gamma > 0$ represents the altruism of parents to quantity of children, n, whereas $1 \geq \gamma_f \geq 0$ is parental preference to the quality of girls. The last parameter captures

[7]In the current study, care for other members of the family can be included in the home production of services where mothers and daughters jointly work, childcare is undertaken by the mother alone. This was done purposely to avoid young children caring for other children. However, it does not create any problem if it is treated with family member care activities

the presence of parental preference gender bias as we have normalized the preference to the quality of boys to 1. The consumption in this model is a combination of market and home produced. In equation (5.1), C_t and C_{t+1} stand for current and future consumption while w^f_{t+1} and w^m_{t+1} represent next period wage levels of a daughter and a son respectively. Since parents are altruistic, the future wages of children enter into their preference with different weights attached for the quality of girls and boys.

5.2.3 Home production

The combination of consumption at period t is such that part of the it is produced in market ($c_{m,t}$) and the rest at home ($c_{h,t}$). The consumption of the household at time t is given by a Cobb− Douglas combination of the market and the domestically produced.

$$C_t = c^{\rho}_{m,t} c^{(1-\rho)}_{h,t} \tag{5.2}$$

Where ρ denotes the share of market produced portion of current consumption and $(1-\rho)$ stands for the share of home produced consumption. As pointed out earlier, social norms and attitudes influence the household division of labor. Following that, in the current model, home production is undertaken by female members of the household. A mother utilizes a fraction, Ω^f_t, of her time endowment for home production while the other fractions are her labor market time and childcaring time. We treat childcaring as a separate activity from other home production tasks. And a girl's fraction of time, Ω^g_t, is combined with the mother's time to produce the domestic consumption, $c_{h,t}$. Thus, the home production function is given as follows: -

$$c_{h,t} = (\Omega^f_t)^{(1-\chi)} (\Omega^g_t p^f n_t)^{\chi} \tag{5.3}$$

Since there are n_t children at time t out of which $p^f n_t$ are female, the total time supplied for home production by girls is $\Omega^g_t p^f n_t$. In (5.3), χ represents the share of girls in the home production function while $(1-\chi\ )$ denotes a mother's share.

At $t+1$, this home production is undertaken by the older generation. Since an agent doesn't work in the labor market during the third period− old age, home production during $t+1$ is performed by combining a unit of time of a female and that of male. To put it in general form we have the following home production function in (5.4). A female devotes a time Ω^f_{t+1} and that of a male Ω^m_{t+1} where δ is a female's share in the production and $(1-\delta)$ that of a male.

$$c_{h,t+1} = (\Omega^f_{t+1})^{\delta} (\Omega^m_{t+1})^{(1-\delta)} = 1 \tag{5.4}$$

This time, home produced consumption may include leisure too.

5.2.4 The household's problem: Constraints with child labor

Given the preference and home production, a couple faces a resource constraint. The household's income at time t is allocated for current consumption, saving and children's schooling. The parents work in the market only when they are adults and consume from their savings and next period's home production at old age. Each adult has one unit of time endowment. This time endowment is apportioned between labor market, home production and childcaring by the female. And the male's time is devoted to market labor only during adulthood. For simplicity, we assume that only mothers spend time for childcare. And home production requires a fraction of the time of female members of the household: $0 < \Omega_t^f < 1$ by the mother and $0 < \Omega_t^g < 1$ by each daughter.

In addition to adults, children also work and earn income. The third and fourth terms in the right−hand side expression of (5.5) represent income from girls and boys respectively. What a child labor restriction policy does is reducing the time that children work for earning thereby affecting the overall household income as will be illustrated in section 5.3.

The household spends its income on current market consumption ($c_{m,t}$), saves a fraction of it (s_t) and spends the rest on the schooling of children($(p^f e_t^g + (1-p^f)e_t^b)n_t\Psi$).

With these features in mind, the household's budget constraint can be formulated as follows.

$$\begin{aligned} c_{m,t} + s_t + (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi &= w_t^m + w_t^f(1-\phi n_t - \Omega_t^f) \\ &+ (\tau - e_t^g - \Omega_t^g)p^f n_t \phi_c \bar{w}_t + (\tau - e_t^b)(1-p^f)n_t\phi_c\bar{w}_t \end{aligned} \quad (5.5)$$

Where e_t^g and e_t^b are education levels of girls and boys respectively. Ψ is education cost per child per unit of time. Ψe_t^g andΨe_t^b are total education costs per girl and per boy at period t, respectively. The $\bar{w}_t$ in the last two terms of the right−hand side of the equation is average adult wage. And ϕ_c is a fraction of this average wage which working children are paid. A mother spends a fraction ϕ of her time to take care of a child. Depending on her market wage, the couple can adjust the number of children in order to be able to optimize childcaring time. Since she is endowed with one unit of time, her labor supply is given by subtracting her childcaring time and home production time from her total time endowment: $1 - \phi n_t - \Omega_t^f$.

5.2.5 Children's future wage

Since parents are altruistic to the quality of their children, they gain utility from the future welfare of their kids. The welfare is a function of future income of children. The wage income for girls in the next period, w_{t+1}^f, is a function of their schooling time, e_t^g, whose return is governed by σ_f. There is an exogenous productivity parameter, α_f

for a female. Similarly, a boy's future wage income, w^m_{t+1}, is a function of his schooling level, e^b_t whose return is governed by σ_m. There is an exogenous male productivity parameter, α_m for a male. The only factor that parents have control over is the level of schooling expenditure through which they determine e^g_t and e^b_t. Given these features the wage functions are given in (5.6) and (5.7), similar to the ones in chapter four.

The wage for girls is:$w^f_{t+1} = w(e^g_t)$; and for boys it is $w^m_{t+1} = w(e^b_t)$. More specifically, they are provided as follows.

$$w^f_{t+1} = \alpha_f (e^g_t)^{\sigma_f} \tag{5.6}$$
$$w^m_{t+1} = \alpha_m (e^b_t)^{\sigma_m} \tag{5.7}$$

Similar to chapter four, here too, parents are altruistic both to the quantity and quality of their children. Their care for the quality of children means that they value the future income of their children that depends on current education expenditure. It is here that parents can show whether they have equal preference for the quality girls and boys or not. More importantly, parents also demonstrate whether they value income from child labor and also services from unpaid domestic work by children compared to the schooling time of boys and girls which will determine their respective future welfare.

5.2.6 Closed form solutions

Given the household's preference, home production, its resource constraints and children's earnings functions, we derive the closed form solutions for all the decision variables in the model: consumption −current and future in one hand, and market and home on the other, a mother's home production time, a girl's home production time, saving, fertility and the education of boys and girls. From the latter two, we are able to derive the gender gap in education in the model which will be used later to compare the consequences of child labor restriction policies against the benchmark values. These results are derived using equations (5.1), (5.5) (5.6)and (5.7). And the detailed derivations are given in Appendix(B).

The following are the closed form solutions for consumption and saving where $R_{t+1} > 1$ is the gross return on saving.

$$c_{m,t} = \frac{\rho(w^m_t + w^f_t)}{[1 + \rho\beta + \gamma]} \tag{5.8}$$

$$c_{m,t+1} = R_{t+1} s_t = R_{t+1} \beta c_{m,t} = \frac{R_{t+1}\beta\rho(w^m_t + w^f_t)}{[1 + \rho\beta + \gamma]} \tag{5.9}$$

For the current adults, current market consumption(5.8) is a direct function of income and the share of market produced goods while it is decreasing in the future consumption discount factor. In addition to these elements, the future consumption, (5.9) is affected by gross return R_{t+1} on saving. The higher the gross return, other things being equal, the couple will have higher future consumption.

The mother's home production time(Ω_t^f) is given by (5.10).

$$\Omega_t^f = \frac{(1-\rho)(1-\chi)(w_t^m + w_t^f)}{[1+\rho\beta+\gamma]w_t^f} \tag{5.10}$$

When it comes to a mother's home production time, as shown in(5.10), it depends directly on the share of home produced consumption $(1-\rho)$ and the share of the mother in this production $(1-\chi)$ and it is decreasing in the female market wage (w_t^f). Hence, when market wage increases, a mother has to substitute her home production time by labor market time as the increase in the latter makes the opportunity cost of a unit of home production higher.

Similarly, a girl's home production time as shown in (5.11) depends directly on the share of home produced consumption $(1-\rho)$ and the share of a girl in this production (χ). A girl's home production time is negatively related to the children's labor income $(\phi_c \bar{w}_t)$.

$$\Omega_t^g = \frac{(1-\rho)\chi(w_t^f\phi - \tau\phi_c\bar{w}_t)}{p^f\phi_c\bar{w}_t[\gamma-(\gamma_f\sigma_f+\sigma_m)]} \tag{5.11}$$

The three remaining variables in the household's optimization are fertility, the education of girls and the education level of boys. They are given as follows:

$$n_t = \frac{(w_t^m + w_t^f)[\gamma-(\gamma_f\sigma_f+\sigma_m)]}{[1+\rho\beta+\gamma](w_t^f\phi - \tau\phi_c\bar{w}_t)} \quad \rightarrow \text{Fertility rate.} \tag{5.12}$$

$$e_t^g = \frac{\gamma_f\sigma_f(w_t^f\phi - \tau\phi_c\bar{w}_t)}{(\phi_c\bar{w}_t+\Psi)p^f[\gamma-(\gamma_f\sigma_f+\sigma_m)]} \quad \rightarrow \text{Girls' education.} \tag{5.13}$$

$$e_t^b = \frac{\sigma_m(w_t^f\phi - \tau\phi_c\bar{w}_t)}{(\phi_c\bar{w}_t+\Psi)(1-p^f)[\gamma-(\gamma_f\sigma_f+\sigma_m)]} \quad \rightarrow \text{Boys' education.} \tag{5.14}$$

For equations (5.12), (5.13)and (5.14) to hold, the non $-$ negativity constraints , $\gamma-(\gamma_f\sigma_f+\sigma_m) > 0$ and $w_t^f\phi - \tau\phi_c\bar{w}_t > 0$ must be satisfied or both are negative at the same time. Now child labor supply by a girl and boy can be expressed as $\tau - e_t^g - \Omega_t^g$ and $\tau - e_t^b$ respectively.

As shown in (5.12), child labor increases fertility. This effect is captured by the fraction of average adult income($\phi_c \bar{w}_t$)that a child in labor earns. The higher this child labor income, the stronger is the incentive for parents to have more children. Moreover, fertility will be lower the higher the fraction of consumption good produced in the market. On the contrary, child labor reduces both the education of girls (5.13) and the education of boys (5.14). This happens due to the opportunity cost of education for a child being higher when income from child labor is relatively larger. If this income approaches to zero, fertility will decline and education levels rise. When it comes to the gender gap in education, child labor doesn't seem to play a role at this stage as it will be clearly shown in (5.15).

The gender gap in education in this model which is the ratio of a girl's education level to the education level of a boy, is calculated by dividing (5.13) by (5.14). This female to male schooling ratio can be simplified as follows: -

$$\frac{e_t^g}{e_t^b} = \frac{\left(\frac{\gamma_f \sigma_f (w_t^f \phi - \tau \phi_c \bar{w}_t)}{(\phi_c \bar{w}_t + \Psi) p^f [\gamma - (\gamma_f \sigma_f + \sigma_m)]}\right)}{\left(\frac{\sigma_m (w_t^f \phi - \tau \phi_c \bar{w}_t)}{(\phi_c \bar{w}_t + \Psi)(1 - p^f)[\gamma - (\gamma_f \sigma_f + \sigma_m)]}\right)} = \frac{\gamma_f \sigma_f (1 - p^f)}{\sigma_m p^f} \tag{5.15}$$

Equation (5.15) is the gender gap in education in the benchmark model. Here, the child labor parameters do not seem to affect the gender gap in education as they do not appear in the ratio. This can be explained using the fact that, in the presence of child labor, there will not be strong economic rational to spend more on the education of boys than girls given the level of parental preference bias. Only the parental preference parameters to the quality girls and boys, the gender specific rates of return to education and the gender composition of siblings are what remain in the female to male education ratio. Then, given the influence of gender norms and the subsequent household division of labor where girls disproportionately engage in unpaid domestic work, how do government policies aiming to restrict child labor practices affect this gender gap in education in (5.15)?

The main task in this chapter is to outline a clear mechanism relating child labor restriction policies and gender gap in education. This emanates from the fact that girls work in home production sector and policies are not effected in this domain of work while boys are active in outside home labor which can easily be affected by the policy directly compared to the context of girls. The next section examines the potential consequences of a child labor banning policy introduced in the form of minimum working age requirement in an environment with such household gender division of labor.

5.3 Child Labor Regulation

The main argument in this study is that norms and attitudes about gender role affect the household division of labor and this in turn has far reaching implication for outcomes such as gender gap in education when child labor is outlawed. Traditional gender norm dictates that mothers and daughters will be the main actors in household works. An introduction of child labor ban in this environment will affect those children who are engaged in outside home activities more− boys. Hence, girls will have to continue to contribute to the production of home consumption even after the introduction of child labor ban as unpaid domestic work does not qualify as child labor. This is more likely to create a wedge between girls and boys in terms of education even if, generally, the policy results in an increase in the education level of both.

A child labor regulation in this model comes in the form of minimum working age requirement. Thus, policy makers ban children from labor that otherwise could be working until a certain age specified by law. For instance, a law may require children to be 15 years of age or above to engage in work. Such policies affect both education and fertility outcomes by changing the opportunity cost of education and the incentive to have an additional child. For instance, before the ban, if boys go to school until age 10 and devote the remaining childhood period for work, after a child labor ban, they cannot work until they are 15. As a result, the opportunity cost of their education declines. However, if girls were going to school until age 10 and engage in home production until age 15, after the ban, they will continue to work at home which means there is no change in their opportunity cost of education.

Thus, the outcomes of the policy depend on a combination of factors such as benchmark values of education level and home production time for girls and education level for boys compared to the minimum working age required by the law. Given these conditions, the way households make choices under child labor ban regarding education levels of boys and girls and home production time of the latter is key to the narrowing, widening or continuity of the existing gender gap in education. In line with this, the model identifies three cases: the first case is where the ban is non−binding for girls and binding for boys. Second, binding for girls and non−binding for boys. And the last case is binding for both. The way this policy affects the opportunity cost of education depends on whether the benchmark education of boys is above or below the period during which children are prohibited from work. Let this period during which children are banned from work be denoted by $\bar{e}$ which is a fraction of the active childhood period, τ. Since there is an early childhood period when kids are too young to work or to go to school (e_0), the minimum working age requirement is set at the sum of this early childhood period and the period during which children are banned from work : $e_0 + \bar{e}$[8].

[8]We can compare $e_0 + \bar{e}$ with the sum of a girl's education, home production time and the early childhood period ($e_0 + e_t^g + \Omega_t^g$) and with a boy's early childhood period plus his education($e_0 + e_t^b$). For instance, if children start schooling at age 7 and the law says "children in the age range 7−14

By the time the policy is introduced, the conditions may vary from economy to economy. Some economies may be having higher average years of schooling such that the policy doesn't have a curative effect but preventative one. Others can have higher average schooling for one of the genders; and even other economies can be in a condition where both genders have extremely low schooling levels compared to the period the policy wants to prohibit child employment. Hence, the consequences of any child labor restriction policy depend on how high girls' home production time plus their schooling is located compared to the period during which child labor is outlawed and how far the education level of boys is further from this threshold period. Given these realities, it is possible to outline initial states that correspond to benchmark values of a model economy. Depending on the benchmark education and home production time (of girls) compared to the fraction of active childhood period τ that is banned from work, $\bar{e}$, there are four initial conditions. The four cases are provided as follows: -

1. Child labor restriction policy: Non$-$ binding for girls and binding for boys.

$$e^{g}_{t,BM} + \Omega^{g}_{t,BM} \geq \bar{e} \geq e^{b}_{t,BM}$$

Where, the subscript *BM* denotes *benchmark*. This is the main case as far as the core of this study's effort is concerned. Girls' home production time is high which makes its sum with their schooling above the period during which child labor is prohibited. One expects that parents don't have to maneuver the education of girls to the same degree as boys after the policy introduction if home produced consumption is important to the household and the role of girls in its production is vital. The fact that the child labor ban is non$-$ binding for girls and binding for boys doesn't emanate from relatively high schooling level of girls compared to boys. Boys always have an education level that is greater than or equal to girls. This is true both by construction(model) and also empirical observation as illustrated in chapter three. Hence, in case 1, it can be said that girls have relatively considerable role in home production which is invisible to policy makers aiming to eliminate child labor.

2. Child labor restriction policy: Binding for girls and non$-$ binding for boys.

cannot work", $e_0 = 6$ and $\bar{e} = 8$. Assuming no grade repetition, when comparing schooling levels plus home production time for girls with the duration in which children are prohibited from work, the early childhood period (e_0) can be dropped as it appears on both sides. Similarly, for boys the comparison is between their education (e^b_t) and the period prohibited from work ($\bar{e}$). This way it is possible to identify if the policy is binding for boys only, binding for both or binding for girls only. Since childhood in the model is equivalent to 1 unit of time, the total period that children can use for work, school or both is given by $\tau = 1 - e_0$. It is a fraction of this active childhood period (τ) that a policy prohibits from work($\bar{e}$)

$$e^g_{t,BM} + \Omega^g_{t,BM} \leq \bar{e} \leq e^b_{t,BM}$$

This case is possible when both or one of the two variables, e^g_t and Ω^g_t are relatively low. Even though it is treated as one possibility it doesn't supply enough story as much as the earlier case does to the kind of question posed at the beginning of this chapter "how does child labor restriction policy affect the education of girls and boys in an environment where gender role is prevalent and girls disproportionately engage in unpaid domestic work?". The fact that the minimum working age policy is not binding for girls indicates that their role in home production or the home produced consumption has lower share compared to the market produced.

3. Child labor restriction policy: Binding for both girls and boys.

$$e^g_{t,BM} + \Omega^g_{t,BM} \leq \bar{e} \text{ and } e^b_{t,BM} \leq \bar{e}$$

At the benchmark, both boys and girls can have lower level of education attainment and also girls home production time is low to a degree its sum with schooling is smaller than the period during which children are not allowed to work by law($\bar{e}$).

4. Child labor restriction policy: Non$-$ binding for both.

$$e^g_{t,BM} + \Omega^g_{t,BM} \geq \bar{e} \text{ and } e^b_{t,BM} \geq \bar{e}$$

In the last case, education levels of boys and the sum of education and home production time of girls are high enough that the policy doesn't have a direct effect. However, countries with high level of schooling can still have child labor restrictions in place as a preventative approach as opposed to the curative child labor bans in low education attainment cases.

Since case 4 is similar to the benchmark, the focus will be on the remaining three, especially on the first one. After the policy introduction, various scenarios arise depending on how the agents react to it and adjust their decisions. Again, depending on how agents react to the policy, given the above benchmark scenarios, we have the following possible outcomes.

1. Non$-$ binding for girls and binding for boys.

1.1 $e^g_t + \Omega^g_t \geq \bar{e}$ and $e^b_t < \bar{e}$

1.2 $e_t^g + \Omega_t^g \geq \bar{e}$ and $e_t^b = \bar{e}$

Parents can choose a level of education for boys in which they can have some idle time or at the corner.

2. Binding for girls and non− binding for boys.

2.1 $e_t^g + \Omega_t^g \leq \bar{e}$ and $e_t^b \geq \bar{e}$

2.2 $e_t^g + \Omega_t^g = \bar{e}$ and $e_t^b \geq \bar{e}$

For girls the binding case will always have a corner solution as their idle time can be used for home production with zero opportunity cost.

3. Binding for both girls and boys

3.1 $e_t^g + \Omega_t^g = \bar{e}$ and $e_t^b < \bar{e}$

3.2 $e_t^g + \Omega_t^g = \bar{e}$ and $e_t^b = \bar{e}$

Similar to case 1, parents can choose a level of education for boys that is either combined with idleness or at the corner. And in the same way as in case 2, for girls the binding case will always have a corner solution as their idle time can be used for home production with zero opportunity cost of an additional unit of time as there is no child labor income.

The policy affects gender gap in education by disproportionately affecting girls' and boys' opportunity cost of education due to the presence of female run home production sector that is not directly targeted by child labor restriction policy makers. Now, we can rewrite the budget constraint as follows.

$$\begin{aligned} c_{m,t} + s_t + (p^f e_t^g + (1-p^f) e_t^b) n_t \Psi &= w_t^m + w_t^f (1 - \phi n_t - \Omega_t^f) \\ &+ (\tau - \max(e_t^g + \Omega_t^g, \bar{e})) p^f n_t \phi_c \bar{w}_t + (\tau - \max(e_t^b, \bar{e}))(1-p^f) n_t \phi_c \bar{w}_t \end{aligned} \quad (5.16)$$

After the child labor ban, it doesn't matter which of the three main cases the initial condition of an economy was, fertility is expected to decline via the primary effect due to lack of child labor income, education levels of girls and boys rise. And the direction of gender gap in education depends on the particular scenario− it might not be affected, might increase or decrease depending on the initial condition and how the agents react. Next, we solve the household's problem after the policy introduction and compare it with the benchmark values of home production time, fertility, education levels, and most importantly gender gap in education.

5.3.1 Case 1: Initial condition: binding for boys non− binding for girls

Although all the initial conditions are possible, the main focus of this study is to show how girls' disproportionate engagement in domestic production makes the consequences of child labor restriction policies different for them and boys − gender gap in education. For the rest of the cases, the policy is either binding for both or for girls only which implies their home production time is lower or not that significant when compared to the period during which child labor is banned. That is closer to the cases where there is no gender−based division of labor. Thus, case 1 is the main scenario that captures the problem this study wants to address since girls' home production time plus their education is higher than the period during which child labor is banned while boys' education is below this policy threshold period.

Case 1 in turn is sub− divided into two as agents can choose an education level for a boy that is below the the policy cut− off, $e_t^b < \bar{e}$ which means there is an idle time for a boy but its opportunity cost is zero as far as current child labor income is concerned. The second choice being the corner case where $e_t^b = \bar{e}$. However, if one considers forgone human capital accumulation due to idleness that will be a different line of argument.

Next, we derive the closed form solutions for each sub−case and compare them with the benchmark value.

Case 1.1: Non− binding for girls and binding for boys

Given the condition $e_t^g + \Omega_t^g \geq \bar{e}$ and $e_t^b < \bar{e}$, we can rewrite the household's budget constraint in (5.16) as: -

$$\begin{aligned} c_{m,t} + s_t + (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi = w_t^m + w_t^f(1-\phi n_t - \Omega_t^f) \\ + (\tau - e_t^g - \Omega_t^g)p^f n_t \phi_c \bar{w}_t + (\tau - \bar{e})(1-p^f)n_t\phi_c\bar{w}_t \end{aligned} \quad (5.17)$$

Using the preference, home production function, children's earning equation from section 5.2 and the new budget constraint we can solve for fertility, education of boys and girls, home production time of girls and the gender gap in education. In this case, the fertility is given by (5.18). To make the comparison easier, we also write the benchmark fertility expression below it. The detailed derivations are provided in Appendix(C)

$$n_t = \frac{(w_t^m + w_t^f)[\gamma - (\gamma_f \sigma_f + \sigma_m)]}{[1+\rho\beta+\gamma](w_t^f \phi - (\tau - \bar{e}(1-p^f))\phi_c \bar{w}_t)} \tag{5.18}$$

$$n_t = \frac{(w_t^m + w_t^f)[\gamma - (\gamma_f \sigma_f + \sigma_m)]}{[1+\rho\beta+\gamma](w_t^f \phi - \tau\phi_c \bar{w}_t)} \qquad \rightarrow \text{Benchmark}$$

Compared to the benchmark, fertility now, with the child labor restriction policy, is clearly lower. One can easily notice that the child labor income expression in the denominator for the (5.18) is higher due to the period corresponding to child labor prohibition: $(\tau\phi_c\bar{w}_t)^{\text{Benchmark}} \geq ((\tau - \bar{e}(1-p^f))\phi_c\bar{w}_t)^{\text{Policy}}$. The reduction in fertility can be explained by the rise in the opportunity cost of having an additional child with no prospect of income from that particular child's employment and costs associated with an increase in education. In the same way, we derive the home production time of girls under the policy regime and compare it with its benchmark counterpart. This equation is given by (5.19).

$$\Omega_t^g = \frac{(1-\rho)\chi(w_t^f \phi - (\tau - \bar{e}(1-p^f))\phi_c \bar{w}_t)}{p^f \phi_c \bar{w}_t(\gamma - (\gamma_f \sigma_f + \sigma_m))} \tag{5.19}$$

$$\Omega_t^g = \frac{(1-\rho)\chi(w_t^f \phi - \tau\phi_c \bar{w}_t)}{p^f \phi_c \bar{w}_t[\gamma - (\gamma_f \sigma_f + \sigma_m)]} \qquad \rightarrow \text{Benchmark}$$

Compared to the benchmark, the home production time of girls now, with the child labor restriction policy, is clearly higher. One can easily notice that the numerator for the (5.19) is higher due to the period corresponding to child labor prohibition($\bar{e}$). The economic intuition behind this rise in home production time of girls is that because of the fall in fertility, parents have to resort to existing girls by demanding them to work more− intensive margin. Here too, the decline in income from child labor is the factor that makes the benchmark home production time lower lower: $(\tau\phi_c\bar{w}_t)^{\text{Benchmark}} \geq ((\tau - \bar{e}(1-p^f))\phi_c\bar{w}_t)^{\text{Policy}}$.

The remaining two variables are the education of girls (5.20) and boys (5.21) given below followed by their respective benchmark values.

$$e_t^g = \frac{\gamma_f \sigma_f (w_t^f \phi - (\tau - \bar{e}(1-p^f))\phi_c \bar{w}_t)}{(\phi_c \bar{w}_t + \Psi)p^f)[\gamma - (\gamma_f \sigma_f + \sigma_m)]} \tag{5.20}$$

$$e_t^g = \frac{\gamma_f \sigma_f (w_t^f \phi - \tau\phi_c \bar{w}_t)}{(\phi_c \bar{w}_t + \Psi)p^f[\gamma - (\gamma_f \sigma_f + \sigma_m)]} \qquad \rightarrow \text{Benchmark}$$

The education of girls also rises due to the indirect effect of the ban on child labor though they continue to work at home. However, since boys have to quit working, parents will need to have fewer children due to the primary effect of the policy and it becomes less costly to send an additional child to school. This child quantity− quality tradeoff spills over to help raise the education of girls. Therefore, while the education of boys increases due to both the direct impact of the policy− removing one of the competing time allocation alternatives which is child employment for wage and through the indirect effect via child quantity− quality tradeoff. However, girls experience a rise in their education via the latter channel only. This indirect effect occurs due to parents having fewer children as a result of which they can afford more for each child's education, relative to the pre−policy.

$$e_t^b = \frac{\sigma_m(w_t^f\phi - (\tau - \bar{e}(1-p^f))\phi_c\bar{w}_t)}{\Psi(1-p^f)[\gamma - (\gamma_f\sigma_f + \sigma_m)]} \tag{5.21}$$

$$e_t^b = \frac{\sigma_m(w_t^f\phi - \tau\phi_c\bar{w}_t)}{(\phi_c\bar{w}_t + \Psi)(1-p^f)[\gamma - (\gamma_f\sigma_f + \sigma_m)]} \qquad \rightarrow \text{Benchmark}$$

Even though both boys and girls experience a rise in their education levels following the child labor ban, the increase for girls is less than that of boys− due to the former's role in the home production which is not directly affected by child labor ban. The next equation provides the gender gap in education in the policy regime. It is derived by dividing (5.20) by (5.21).

$$FMSR \approx \frac{e_t^g}{e_t^b} = \frac{\left(\frac{\gamma_f\sigma_f(w_t^f\phi - (\tau - \bar{e}(1-p^f))\phi_c\bar{w}_t)}{(\phi_c\bar{w}_t+\Psi)p^f)[\gamma-(\gamma_f\sigma_f+\sigma_m)]}\right)}{\left(\frac{\sigma_m(w_t^f\phi - (\tau - \bar{e}(1-p^f))\phi_c\bar{w}_t)}{\Psi(1-p^f)[\gamma-(\gamma_f\sigma_f+\sigma_m)]}\right)} = \frac{\gamma_f\sigma_f(1-p^f)\Psi}{\sigma_m p^f(\phi_c\bar{w}_t + \Psi)} \tag{5.22}$$

The comparison between gender gaps in education using (5.15), for the pre−policy / benchmark, and (5.22) for the post−policy introduction clearly shows that gender gap in education has widened due to the policy in this particular case.

$$[\frac{e_t^g}{e_t^b}]^{Before} = \frac{\gamma_f\sigma_f(1-p^f)}{\sigma_m p^f} > \frac{\gamma_f\sigma_f(1-p^f)\Psi}{\sigma_m p^f(\phi_c\bar{w}_t + \Psi)} = [\frac{e_t^g}{e_t^b}]^{After}$$

The gender gap in education after the introduction of the child labor ban is higher compared to the benchmark as the female to male education ratio has declined.

5.3.2 Case 1.2: Non− binding for girls and corner solution for boys

The other sub− case here is that parents choose a level of education for boys that is exactly equal to the child work prohibition period − corner solution($e_t^b = \bar{e}$). Compared to the earlier sub− case, here, we expect fertility to be even lower and education levels even higher and the gender gap in education even wider compared to the benchmark. Given the condition $e_t^g + \Omega_t^g \geq \bar{e}$ and $e_t^b = \bar{e}$, we can rewrite the budget constraint as: -

$$\begin{aligned} c_{m,t} + s_t + (p^f e_t^g + (1-p^f)\bar{e})n_t\Psi = w_t^m + w_t^f(1 - \phi n_t - \Omega_t^f) \\ + (\tau - e_t^g - \Omega_t^g)p^f n_t \phi_c \bar{w}_t + (\tau - \bar{e})(1-p^f)n_t\phi_c\bar{w}_t \end{aligned} \quad (5.23)$$

Fertility for case 1.2 is given as in(5.24). The higher the fraction of boys and the larger the forgone child labor income, the decline in fertility will be higher.

$$n_t = \frac{(w_t^m + w_t^f)[\gamma - \gamma_f\sigma_f]}{[1+\rho\beta+\gamma](w_t^f\phi + (1-p^f)\bar{e}(\phi_c\bar{w}_t + \Psi) - \tau\phi_c\bar{w}_t)} \quad (5.24)$$

$$n_t = \frac{(w_t^m + w_t^f)[\gamma - (\gamma_f\sigma_f + \sigma_m)]}{[1+\rho\beta+\gamma](w_t^f\phi - \tau\phi_c\bar{w}_t)} \rightarrow \qquad \rightarrow \text{benchmark}$$

For similar reason as in case 1.1, the home production time of girls rises. Fewer girls, given their home production share and the share of home produced consumption implies that more time is needed from each girl due to the decline in the number of children.

$$\Omega_t^g = \frac{(1-\rho)\chi(w_t^f\phi + (1-p^f)\bar{e}(\phi_c\bar{w}_t + \Psi) - \tau\phi_c\bar{w}_t)}{p^f\phi_c\bar{w}_t(\gamma - \gamma_f\sigma_f)} \quad (5.25)$$

$$\Omega_t^g = \frac{(1-\rho)\chi(w_t^f\phi - \tau\phi_c\bar{w}_t)}{p^f\phi_c\bar{w}_t[\gamma - (\gamma_f\sigma_f + \sigma_m)]} \qquad \rightarrow \text{benchmark}$$

When it comes to education, in contrast to fertility, for case 1.2, the higher the fraction of boys in children's composition and the larger the forgone child labor income, the larger the rise in girls' education. This is due to the fact that fertility has fallen and parents can afford for more education of the few children they have. The education of girls is affected through this indirect channel: quantity− quality tradeoff due to the fact that parents having fewer children.

$$e_t^g = \frac{\gamma_f \sigma_f (w_t^f \phi + (1-p^f)\bar{e}(\phi_c \bar{w}_t + \Psi) - \tau \phi_c \bar{w}_t)}{(\phi_c + \Psi) p^f \bar{w}_t [\gamma - \gamma_f \sigma_f]} \tag{5.26}$$

$$e_t^g = \frac{\gamma_f \sigma_f (w_t^f \phi - \tau \phi_c \bar{w}_t)}{(\phi_c \bar{w}_t + \Psi) p^f [\gamma - (\gamma_f \sigma_f + \sigma_m)]} \qquad \rightarrow \text{benchmark}$$

When it comes to the remaining cases (case 2 & 3), their closed form solutions cannot be recovered. However, it is possible to point out the impact of child labor restriction policies given these initial conditions and the agents possible reactions.

5.3.3 Case 2: Binding for girls and non− binding for boys.

Since parents can increase the home production time of girls, Ω_t^g, with zero opportunity cost, the case now can be written as: - $e_t^g + \Omega_t^g = \bar{e}$ and $e_t^b \geq \bar{e}$. And the budget constraint of the household can be adjusted as follows.

$$c_{m,t} + s_t + (p^f e_t^g + (1-p^f) e_t^b) n_t \Psi = w_t^m + w_t^f (1 - \phi n_t - \Omega_t^f) + (\tau - \bar{e}) p^f n_t \phi_c \bar{w}_t + (\tau - e_t^b)(1-p^f) n_t \phi_c \bar{w}_t \tag{5.27}$$

and

$$\Omega_t^g = \bar{e} - e_t^g$$

Since this case is not binding for boys, the policy affects the education of boys only indirectly through the increase in the education of girls or increased home production time of girls or both. There will be a disproportionate impact on girls if parents decide to invest more on their education. One possibility is an increase in the education of girls, e_t^g, to $\bar{e} - \Omega_{t,BM}^g$ or an increase in home production time of girls, Ω_t^g to $\bar{e} - e_{t,BM}^g$ or both can rise slightly. Where the subscript BM denotes *benchmark*. In case 2, fertility decreases due to the primary effect and it tends to rise via the secondary effect (if the home production time of girls is important and parents want more of it). When it comes to the gender gap in education, there is a possibility for it to decrease due to a faster increase in e_t^g to $\bar{e} - \Omega_{t,BM}$ or remain constant if parents choose to increase only home production time of girls following the child labor ban: an increase in Ω_t^g to $\bar{e} - e_{t,BM}^g$.

5.3.4 Case 3: Binding for both.

$e_t^g + \Omega_t^g = \bar{e}$ and $e_t^b \leq \bar{e}$.

The are two budget constraints depending on whether parents choose corner case for education of boys or there is some idle time for boys.

$$c_{m,t} + s_t + (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi = w_t^m + w_t^f(1-\phi n_t - \Omega_t^f) \\ + (\tau - \bar{e})p^f n_t \phi_c \bar{w}_t + (\tau - \bar{e})(1-p^f)n_t\phi_c\bar{w}_t \quad \text{The case where } e_t^b < \bar{e} \quad (5.28)$$

$$c_{m,t} + s_t + (p^f e_t^g + (1-p^f)\bar{e})n_t\Psi = w_t^m + w_t^f(1-\phi n_t - \Omega_t^f) \\ + (\tau - \bar{e})p^f n_t \phi_c \bar{w}_t + (\tau - \bar{e})(1-p^f)n_t\phi_c\bar{w}_t \quad \text{The case where } e_t^b = \bar{e} \quad (5.29)$$

and the additional constraint

$$\Omega_t^g = \bar{e} - e_t^g$$

When the policy is binding for both, the primary effect through reduced child labor income results in reduced fertility rate as boys certainly have to stop working until the minimum working age required by law. Girls too will stop working for income. This makes children more of a liability leading to reduced fertility. However, depending on the share of home produced consumption and girls' role in that production, parents may want to have more children as about half of the children will be females (secondary effect− which is lower than the primary effect as the latter affects both genders). The gender gap in education in this case can remain the same or deteriorate as the increase in the education of boys is greater than or equal to the rise in the education of girls. This happens because parents have zero opportunity cost of raising a girl's home production time by one more unit until the sum of it with a girl's education is exactly equal to the child labor threshold period ($\bar{e}$).

In case 3, parents can choose a non− corner level of schooling for boys− with some idle time. However, for the girls there is always a corner solution as far as the sum of their home production time and education is concerned.

Next, we perform a numerical exercise to visualize the results both in the benchmark model and the impact of the child labor restriction policy.

5.4 Numerical Exercise

The results from the model with child labor restriction policy regime as in case 1 show that fertility declines due to forgone child labor income and rising opportunity cost of having an additional child absent child labor. Both education levels of girls and boys rise. However, boys' education rises by larger proportion as their time now is allocated between idleness or schooling, whereas girls have two competing requirements: home production time and schooling. This creates disparity in their education gain following the policy implementation. To quantify these developments following the policy, we conduct a computational exercise. The purpose of this exercise is to show the numerical importance of the model by quantifying the potential consequences of child labor restriction policy in the form of minimum age requirement mainly on gender gap in education and also on fertility and education attainment of both genders. For this exercise, we use the main closed form solution after the policy introduction, case 1, which captures the essence of the problem statement explained in the beginning in combination with the benchmark model. This way, we will be able to see how the outcomes of interest depart from the benchmark due to the child employment restriction say, minimum working age of 15. Assume that schooling and child labor start at age 7. Hence, the policy bans children from working for 8 years, 7−14. This is the period when schooling and employment compete for boys. And schooling, employment and home production time of girls compete.

Thus, this numerical exercise helps visualize how the introduction of child labor restriction policy in the form of minimum working age requirement affects home production time of girls, gender gap in education, fertility rate and education levels for both genders. Here, there is no endeavor to pin down the parameter values by targeting moments from a particular economy. Rather, we set the values of the parameters for some by adopting from literature and others are set by assuming a reasonable range− using economic intuition. Table5.1 provides the symbol, description and value of model parameters.

By using the parameter values in Table 5.1, we generate the benchmark values for fertility, education of boys and education and home production time for girls. Then, by introducing a child labor restriction policy in the form of minimum age requirement ($\geq$ 15), we calculate the values for the variables and compare them with their benchmark counterparts. The gender gap in education values follow from the values in the levels of education for girls and boys. The results from the numerical exercise ar provided in Table 5.2

In comparison with the benchmark model, the child labor restriction policy introduced in the form of a minimum working age requirement of 15 results in increased education levels for both girls and boys. It also results in reduced fertility rate as shown in Table 5.2. However, the gender gap in education widens. This happens for the simple reason that the ban reduces the opportunity cost of education for boys by removing one of the competing time allocation alternatives− child employment. On the contrary, even though girls too stop working in outside employment, due to the prevalence of gender−based household division of labor, they have to continue shouldering the brunt of home production. This makes their education attainment to increase by a lower proportion compared to boys. When it comes to home production time of girls, the value after the policy is larger than the benchmark. This can be explained in terms

Table 5.1: Parameter choice

Parameter	Description	Value
β	Discount factor	0.98^{25}
ϕ	A fraction of time spent on childcare	0.26
ρ	Share of market produced consumption	0.70
χ	Share of a girl in home production	0.46
τ	Time endowment for children	19/25
w_t^m	Normalized male wage	1.00
w_t^f/w_t^m	Gender wage gap	0.70
$\bar{e}$	Outlawed child labor period(7−14)	8/25
σ_f	Return to the schooling of girls	0.52
σ_m	Return to the schooling of boys	0.65
γ	Weight to the quantity of children	1.47
γ_f	Weight to the quality of girls	0.95
Ψ	Education cost parameter	0.96
ϕ_c	Fraction of average wage a child gets	0.21
p^f	Probability of having a female baby	0.50

Table 5.2: Numerical Example:Results

Variables	Benchmark (Before the policy)	After policy (A ban until age 14)	% change Due to policy
Fertility	4.00	2.51	↓ 37.25
Girls' education	3.20	5.10	↑ 59.37
Boys' education	4.20	7.92	↑ 88.57
Schooling Ratio(F/M)	**0.76**	**0.64**	**↓ 18.40**
Ω_t/ Girl's home production time	5.80	9.22	↑ 58.97

of reduced fertility which results in more pressure on the existing girls with an increase in per girl home production time. This is true as there are fewer children now which implies fewer girls in absolute numbers given their relative composition. Thus, per girl home production time increases−intensity of a girl's homework rises.

The key channel contributing to this widening in gender gap in education is the gender−based division of household labor resulting in a female run home production sector. The home production time of girls in turn is a function of the share of girls in the production(χ) and the share of home produced consumption($1-\rho$). These two weights are important underlying parameters governing how the education of girls differently responds from that of boys when child labor is banned. The higher the share of girls in the home production(χ) and the larger the share of home produced consumption($1-\rho$), the policy is more likely to be non−binding for girls and binding for boys.

From the findings of the model and what the numerical exercise demonstrates it is possible to point out what type of policy interventions will be desirable in situations where girls are more active in home production than boys. Conventional child labor restriction policies do not directly target unpaid home production and even the definitions of child labor do not apply to it. Thus, child labor bans are less likely to narrow the gender gap in education. This is due to lack of measurement and policy enforcement mechanisms in unpaid domestic work. Therefore, governments can devise various indirect mechanisms to address these gender gap problems. The remedial measures may include compulsory education, female specific education subsidy, tuition reduction / exemption targeting girls, school meal programs and other similar measures. In fact, some countries have gender specific education support programs in place. For instance, Raynor et al. (2006) document how a combination of free and compulsory primary education policy and free tuition for girls in classes 6−8 introduced in 1990 helped bring about gender parity in education in Bangladesh. Besides, a nationwide female stipend program (FSP) was introduced in 1994. The authors note how the combination of these measures boosted girls' secondary school enrollment and retention[9].

5.5 Discussion

The existing literature shows that child labor restriction policies are successful in increasing education thereby reducing fertility. However, these studies treat children as monolith in terms of gender. This has far− reaching implications, especially, when household gender division of labor is driven by traditional gender role attitudes in which case, both mothers and daughters are overrepresented in unpaid household chores. Therefore, if the aim of child labor banning is intended to bring about some desired economic or social outcomes such as raising gender parity in education, overlooking the own household unpaid child work, as it is usually the case, is more likely to contribute to girls lagging behind in terms of average education attainment compared to boys. This in turn has effects on fertility behavior. Given this problem regarding the gender differences in child labor experience, this study contributes in designing a mechanism to examine the consequences of child labor restriction policies in an environment where gender role is a key driver of household division of labor.

In the current chapter, we examine the impact of child labor bans by focusing on the importance of treating differently the child labor experiences of girls and boys in contexts where traditional gender norms influence the household division of labor to take a non−egalitarian arrangement: female homemakers and male bread winners. This distinction of child labor experience by gender is important for at least three reasons: first, child labor definitions do not usually include unpaid domestic works. Second, child labor banning policies target work by children outside of home. Third, girls are disproportionately engaged in unpaid own household work. Thus, an introduction of child labor ban with these realities in place is less likely to result in equal outcomes for girls and boys− say in terms of education attainment. To this end we employ a macroeconomic framework which is similar to Doepke (2004) where he examines how child labor restriction policies account for variations in education and fertility

[9]As stated by Raynor et al. (2006), the objectives of the program include enrollment and retention parity, delayed marriage and fertility control, employment/empowerment, equality. Girls' disproportionate engagement in unpaid domestic work, as emphasized in this chapter, doesn't seem to be directly targeted.

outcomes. The author finds that when child labor is restricted, education rises and fertility declines rapidly. However, this and other similar investigations on the impact of child labor restriction policies on fertility and education do not examine gender differential impacts which are important in settings where norms and attitudes govern the household division of labor. In such an environment girls and boys will not have the same experience both in child labor and in the outcomes of its outlawing.

In order to clearly show the mechanism how this gender inequality in education changes following a child labor ban, we perform two main tasks. First, using a model with home production sector we present the gender gap in education before child labor restriction is introduced. Given the benchmark gender gap in education, the second task is to address the question "what happens to this gap once child labor restriction policy is implemented?". The outcomes of the policy depend on a combination of factors such as benchmark values of education level and home production time for girls and education level for boys compared to the period during which children cannot participate in child labor. In line with this, the model identifies three cases: the first case is where the ban is non−binding for girls and binding for boys. Second, binding for girls and non−binding for boys. And the last case is binding for both.

The results from the benchmark model show that child labor increases fertility, reduces education levels but doesn't affect gender gap in education. In the model with child labor prohibition in the form of minimum working age requirement of 15 or above, the results show that while it is true that child labor restriction policies increase education and reduce fertility which is consistent with previous studies, there are cases in which such policies result in an increased gender gap in education. In a similar case, home production time of girls also increases for the reason that there are fewer children following the child labor ban leading to fewer girls in the household.

5.6 Conclusion

Findings from previous studies show that child labor regulations do lower the opportunity cost of education and result in a rise of schooling and a fall in fertility. The results of the current model show that although child labor ban, indeed, increases education and reduces fertility in general, gender gap in education may become worse in some cases. In this chapter, we examine the potential consequences of child labor restriction policies on gender equality in education in an environment where gender role is a key driver of household labor division. To this end, we use an altruistic model similar to previous studies but with child labor and a home production sector undertaken by female members of the household.

By introducing a child labor restriction policy in the form of a minimum working age requirement, we are able to show that although child labor ban increases education and reduces fertility in general, gender gap in education may become worse in some scenarios like the first case. And home production time of girls rises when there are fewer children(girls) in the household− in the same case. The numerical exercise also demonstrates that the results from the model are quantitatively important. There are also a couple of other cases in which gender gap in education may widen, remain at the same level as the benchmark or narrow following a child labor prohibition.

The policy implication is that governments should devise gender specific education incentives in an environment where girls are more likely to engage in unpaid domestic production which cannot be directly affected by policies such as minimum working age requirement. This way, the disproportionately higher opportunity cost of education that girls face can be minimized.

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Appendix A

Appendix for Chapter Four

A.1 Appendix for Chapter Four: Main Version

Parental Gender Preference Bias in Human Capital Investment, Gender Gap in Education and Fertility

Using equations (4.1), (4.2), (4.3) and (4.4), the Lagrange formulation takes the following form.

$$ln(c_t) + \beta ln(c_{t+1}) + \gamma ln(n_t) + \gamma_f ln(w^w_{t+1}) + ln(w^m_{t+1}) + \lambda_1[w^m_t + w^f_t(1 - \phi n_t) - c_t - s_t - (p^f e^g_t + (1 - p^f)e^b_t)n_t\Psi] + \lambda_2(\alpha_f(e^g_t)^{\sigma_f} - w^f_{t+1}) + \lambda_3(\alpha_m(e^b_t)^{\sigma_m} - w^m_{t+1}) \quad (A.1)$$

Next, the first order conditions are derived with respect to current consumption, c_t, future consumption c_{t+1}, future female wage , w^f_{t+1}, future male wage w^m_{t+1} , the educations of girls, e^g_t and that of boys e^b_t.

$$L_{c_t} : \frac{1}{c_t} - \lambda_1 = 0 \quad (A.2)$$

$$L_{c_{t+1}} : \beta\frac{1}{c_{t+1}} - \frac{\lambda_1}{R_{t+1}} = 0 \quad (A.3)$$

$$L_{n_t} : \frac{\gamma}{n_t} - \lambda_1(w^f_t\phi + (p^f e^g_t + (1 - p^f)e^b_t)\Psi) = 0 \quad (A.4)$$

$$L_{w^f_{t+1}} : \frac{\gamma_f}{w^f_{t+1}} - \lambda_2 = 0 \quad (A.5)$$

$$L_{w^m_{t+1}} : \frac{1}{w^m_{t+1}} - \lambda_3 = 0 \quad (A.6)$$

$$L_{e^g_t} : -\lambda_1 p^f n_t\Psi + \lambda_2\sigma_f\alpha_f(e^g_t)^{\sigma_f - 1} = 0 \quad (A.7)$$

$$L_{e^b_t} : -\lambda_1(1 - p^f)n_t\Psi + \lambda_3\sigma_m\alpha_m(e^b_t)^{\sigma_m - 1} = 0 \quad (A.8)$$

Where, $s_t = \frac{c_{t+1}}{R_{t+1}}$ and
$w^f_{t+1} = \alpha_f (e^g_t)^{\sigma_f}; w^m_{t+1} = \alpha_m (e^b_t)^{\sigma_m}$

Using (A.2),(A.5) and (A.7) the expression for the education of girls can be simplified as follows.

$$e^g_t = \frac{\gamma_f \sigma_f c_t}{\Psi p^f n_t} \tag{A.9}$$

And by using (A.2), (A.6) and (A.8), the expression for the education of boys can be simplified as follows.

$$e^b_t = \frac{\sigma_m c_t}{\Psi (1-p^f) n_t} \tag{A.10}$$

By combining (A.2) and (A.4) , the expression for the utility from having an additional child can be provided.

$$\frac{\gamma}{n_t} = \frac{1}{c_t}(w^f_t \phi + (p^f e^g_t + (1-p^f) e^b_t)\Psi) \tag{A.11}$$

By inserting (A.9) and (A.10) into (A.11), this can further be simplified into: -

$$\frac{\gamma}{n_t} = \frac{1}{c_t}(w^f_t \phi + (\frac{\gamma_f \sigma_f c_t}{n_t} + \frac{\sigma_m c_t}{n_t}) \tag{A.12}$$

This leads to a more simplified expression.

$$\frac{c_t}{n_t} = \frac{w^f_t \phi}{(\gamma - (\gamma_f \sigma_f + \sigma_m))} \tag{A.13}$$

By inserting (A.13) into (A.9) and (A.10), the closed form solutions for education levels of girls and boys can be derived.

$$e^g_t = \frac{\sigma_f \gamma_f w^f_t \phi}{(\gamma - (\gamma_f \sigma_f + \sigma_m)) p^f \Psi} \tag{A.14}$$

$$e^b_t = \frac{\sigma_m w^f_t \phi}{(\gamma - (\gamma_f \sigma_f + \sigma_m))(1-p^f)\Psi} \tag{A.15}$$

From the budget constraint in (4.2),

$c_t + s_t = w^m_t + w^f_t(1 - \phi n_t) - (p^f e^g_t + (1-p^f) e^b_t) n_t \Psi$

Using (A.2),(A.3), this s_t can be expressed in terms of c_t

$s_t = \frac{c_{t+1}}{R_{t+1}} = \beta c_t$

Hence, the above budget constraint can be rewritten as: -

$$(1+\beta)c_t = w_t^m + w_t^f - (w_t^f \phi n_t + (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi) \tag{A.16}$$

The expression containing the third, fourth and fifth terms in the right−hand side of (A.16), $(w_t^f \phi n_t + (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi)$, is equivalent to γc_t using (A.11).

By exploiting this relationship, the closed form solution for current consumption can easily be derived.

$$(1+\beta)c_t = w_t^m + w_t^f - \gamma c_t$$
$$\Rightarrow c_t = \frac{w_t^m + w_t^f}{1+\beta+\gamma} \tag{A.17}$$

Since the relationship between c_t, s_t and c_{t+1} has already been established, saving and future consumption are expressed as follows by using (A.17).

$$s_t = \beta c_t = \frac{\beta(w_t^m + w_t^f)}{1+\beta+\gamma} \tag{A.18}$$
$$c_{t+1} = R_{t+1}s_t = \frac{R_{t+1}\beta(w_t^m + w_t^f)}{1+\beta+\gamma} \tag{A.19}$$

And by combining (A.17) and (A.13), the expression for fertility in the model is given by:-

$$n_t = \frac{c_t(\gamma - (\gamma_f\sigma_f + \sigma_m))}{w_t^f \phi}$$
$$\Rightarrow n_t = \frac{(w_t^m + w_t^f)}{(1+\beta+\gamma)} \frac{(\gamma - (\gamma_f\sigma_f + \sigma_m))}{w_t^f \phi} \tag{A.20}$$

In order to derive the gender gap in education in the model and establish the quantity− quality tradeoff, (A.14), (A.15) and (A.20) are combined .

By dividing (A.14) by (A.15), we have: -

$$\frac{e_t^g}{e_t^b} = \frac{\left(\frac{\sigma_f\gamma_f w_t^f \phi}{(\gamma-(\gamma_f\sigma_f+\sigma_m))p^f\Psi}\right)}{\left(\frac{\sigma_m w_t^f \phi}{(\gamma-(\gamma_f\sigma_f+\sigma_m))(1-p^f)\Psi}\right)} = \frac{\gamma_f\sigma_f(1-p^f)}{\sigma_m p^f} \tag{A.21}$$

In order to establish the quantity− quality tradeoff in the model, (A.20) and (A.21) have to be combined. Hence,

$$n_t = \frac{(w_t^m + w_t^f)}{(1+\beta+\gamma)} \frac{(\gamma - (\frac{p^f e_t^g}{(1-p^f)e_t^b} + 1)\sigma_m)}{w_t^f \phi} \tag{A.22}$$

Now, the relationship between female to male schooling ratio and fertility as provided in (A.22) demonstrates how these two are negatively related.

A.2 Appendix for Chapter four: An alternative wage formulation

In order to check if the results in the main model are robust to various specifications, a linear wage function is used as an alternative.

$$w_{t+1}^f = \alpha_f + \sigma_f e_t^g \tag{A.23}$$

$$w_{t+1}^m = \alpha_m + \sigma_m e_t^b \tag{A.24}$$

Using equations (4.1), (4.2), $(A.23)$ and $(A.24)$, the Lagrange formulation takes the following form.

$$ln(c_t) + \beta ln(c_{t+1}) + \gamma ln(n_t) + \gamma_f ln(w_{t+1}^f) + ln(w_{t+1}^m) + \lambda_1[w_t^m + w_t^f(1-\phi n_t) - c_t - s_t - (p^f e_t^g + (1-p^f)e^b)n_t\Psi] + \lambda_2(\alpha_f + \sigma_f e_t^g - w_{t+1}^f) + \lambda_3(\alpha_m + \sigma_m e_t^b - w_{t+1}^m) \tag{A.25}$$

Next, the first order conditions are derived with respect to current consumption, c_t, future consumption c_{t+1}, future female wage, w_{t+1}^f, future male wage w_{t+1}^m, the educations of girls, e_t^g and that of boys e_t^b.

$$L_{c_t} : \frac{1}{c_t} - \lambda_1 = 0 \tag{A.26}$$

$$L_{c_{t+1}} : \beta\frac{1}{c_{t+1}} - \frac{\lambda_1}{R_{t+1}} = 0 \tag{A.27}$$

$$L_{n_t} : \frac{\gamma}{n_t} - \lambda_1(w_t^f \phi + (p^f e_t^g + (1-p^f)e^b)\Psi) = 0 \tag{A.28}$$

$$L_{w_{t+1}^f} : \frac{\gamma_f}{w_{t+1}^f} - \lambda_2 = 0 \tag{A.29}$$

$$L_{w_{t+1}^m} : \frac{1}{w_{t+1}^m} - \lambda_3 = 0 \tag{A.30}$$

$$L_{e_t^g} : -\lambda_1(p^f n_t \Psi) + \lambda_2\sigma_f = 0 \tag{A.31}$$

$$L_{e_t^b} : -\lambda_1((1-p^f)n_t\Psi) + \lambda_3\sigma_m = 0 \tag{A.32}$$

Where, $s_t = \frac{c_{t+1}}{R_{t+1}}$ and

Using (A.26),(A.29), (A.30), (A.31) and (A.32) the expression for the education of girls and boys can be simplified as follows.

$$e_t^g = \frac{\gamma_f c_t}{\Psi p^f n_t} - \frac{\alpha_f}{\sigma_f} \tag{A.33}$$

$$e_t^b = \frac{c_t}{\Psi(1-p^f)n_t} - \frac{\alpha_m}{\sigma_m} \tag{A.34}$$

By combining (A.26) and (A.28), the expression for the utility from having an additional child can be provided.

$$\frac{\gamma}{n_t} = \frac{1}{c_t}(w_t^f \phi + (p^f e_t^g + (1-p^f)e^b)\Psi) \tag{A.35}$$

By inserting (A.33) and (A.34) into (A.35), this can further be simplified into: -

$$\frac{\gamma}{n_t} = \frac{1}{c_t}(w_t^f \phi + (p^f(\frac{\gamma_f c_t}{\Psi p^f n_t} - \frac{\alpha_f}{\sigma_f}) + (1-p^f)(\frac{c_t}{\Psi(1-p^f)n_t} - \frac{\alpha_m}{\sigma_m}))\Psi) \tag{A.36}$$

This leads to the more simplified expression.

$$\frac{c_t}{n_t} = \frac{w_t^f \phi - (\frac{\alpha_f}{\sigma_f}p^f + \frac{\alpha_m}{\sigma_m}(1-p^f))\Psi}{\gamma - (\gamma_f + 1)} \tag{A.37}$$

By inserting (A.37) into (A.33) and (A.34), the closed form solutions for education levels of girls and boys can be derived.

$$e_t^g = \frac{\gamma_f}{p^f\Psi}\Big[\frac{w_t^f\phi - (\frac{\alpha_f}{\sigma_f}p^f + \frac{\alpha_m}{\sigma_m}(1-p^f))\Psi}{(\gamma-(\gamma_f+1))}\Big] - \frac{\alpha_f}{\sigma_f} \tag{A.38}$$

$$e_t^b = \frac{1}{(1-p^f)\Psi}\Big[\frac{w_t^f\phi - (\frac{\alpha_f}{\sigma_f}p^f + \frac{\alpha_m}{\sigma_m}(1-p^f))\Psi}{(\gamma-(\gamma_f+1))}\Big] - \frac{\alpha_m}{\sigma_m} \tag{A.39}$$

From the budget constraint in (4.2),

$c_t + s_t = w_t^m + w_t^f(1-\phi n_t) - (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi$

Using (A.26),(A.27, this s_t can be expressed in terms of c_t

$s_t = \frac{c_{t+1}}{R_{t+1}} = \beta c_t$

Hence, the above budget constraint can be rewritten as: -

$$(1+\beta)c_t = w_t^m + w_t^f - (w_t^f\phi n_t + (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi) \tag{A.40}$$

The expression containing the third, fourth and fifth terms in the right−hand side of (A.16), $(w_t^f\phi n_t + (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi)$, is equivalent to γc_t using (A.35).

By exploiting this relationship, the closed form solution for current consumption can easily be derived.

$$(1+\beta)c_t = w_t^m + w_t^f - \gamma c_t$$

$$\Rightarrow c_t = \frac{w_t^m + w_t^f}{1+\beta+\gamma} \tag{A.41}$$

Since the relationship between c_t, s_t and c_{t+1} has already been established, saving and future consumption are expressed as follows by using (A.41).

$$s_t = \beta c_t = \frac{\beta(w_t^m + w_t^f)}{1+\beta+\gamma} \tag{A.42}$$

$$c_{t+1} = R_{t+1}s_t = \frac{R_{t+1}\beta(w_t^m + w_t^f)}{1+\beta+\gamma} \tag{A.43}$$

And by combining (A.41) and (A.37), the expression for fertility in the model is given by:-

$$n_t = \frac{c_t(\gamma - (\gamma_f + 1))}{w_t^f \phi - (\frac{\alpha_f}{\sigma_f} p^f + \frac{\alpha_m}{\sigma_m}(1 - p^f))\Psi}$$

$$\Rightarrow n_t = \frac{(w_t^m + w_t^f)}{(1 + \beta + \gamma)} [\frac{(\gamma - (\gamma_f + 1))}{(w_t^f \phi - (\frac{\alpha_f}{\sigma_f} p^f + \frac{\alpha_m}{\sigma_m}(1 - p^f))\Psi)}] \tag{A.44}$$

In order to derive the gender gap in education in the model and establish the quantity− quality tradeoff, (A.38) , (A.39) and (A.44) are combined .

By dividing (A.38) by (A.39), we have: -

$$\frac{e_t^g}{e_t^b} = \frac{\left(\frac{\gamma_f}{p^f \Psi}\left[\frac{w_t^f \phi - (\frac{\alpha_f}{\sigma_f} p^f + \frac{\alpha_m}{\sigma_m}(1-p^f))\Psi}{(\gamma - (\gamma_f + 1))}\right] - \frac{\alpha_f}{\sigma_f}\right)}{\left(\frac{1}{(1-p^f)\Psi}\left[\frac{w_t^f \phi - (\frac{\alpha_f}{\sigma_f} p^f + \frac{\alpha_m}{\sigma_m}(1-p^f))\Psi}{(\gamma - (\gamma_f + 1))}\right] - \frac{\alpha_m}{\sigma_m}\right)} \tag{A.45}$$

In order to establish the quantity− quality tradeoff in the model using (A.44) and (A.45), the same approach can be applied as in AppendixA.1.

Appendix B

Appendix for Chapter Five: Benchmark Model

Model for Child Labor, Gender Equality in Education and Fertility

Household's problem before the child labor ban

Using equations (5.1), (5.5), (5.3) (5.6) and (5.7), the Lagrange formulation takes the following form.

$$\begin{aligned}\rho ln(c_{m,t})+(1-\rho)ln(c_{h,t})+\beta\rho ln(c_{m,t+1})+\beta(1-\rho)ln(c_{h,t+1})+\gamma ln(n_t)+\gamma_f ln(w^w_{t+1})+ln(w^m_{t+1})\\ +\lambda_1[w^m_t+w^f_t(1-\phi n_t)+(\tau-\Omega^g_t-e^g_t)p^f n_t\phi_c\bar{w}_t+(\tau-e^b_t)(1-p^f)n_t\phi_c\bar{w}_t\\ -c_{m,t}-c_{m,t+1}/R_{t+1}-(p^f e^g_t+(1-p^f)e^b_t)n_t\Psi]+\lambda_2(\alpha_f(e^g_t)^{\sigma_f}-w^f_{t+1})\\ +\lambda_3(\alpha_m(e^b_t)^{\sigma_m}-w^m_{t+1})\end{aligned} \quad \text{(B.1)}$$

From this Lagrange formulation the first order conditions with respect to current market consumption, $c_{m,t}$, future market consumption, $c_{m,t+1}$, current home consumption, $c_{h,t}$, number of children, n_t, future female wage, w^f_{t+1}, future male wage, future male wage w^m_{t+1}, home production time of a mother,Ω^f_t, home production time of a daughter, Ω^g_t, the educations of girls, e^g_t and that of boys, e^b_t, are derived.

$$L_{c_{m,t}} : \frac{\rho}{c_{m,t}} - \lambda_1 = 0 \quad \text{(B.2)}$$

$$L_{c_{m,t+1}} : \beta\rho\frac{1}{c_{m,t+1}} - \frac{\lambda_1}{R_{t+1}} = 0 \quad \text{(B.3)}$$

$$L_{n_t}: \frac{(1-\rho)\chi+\gamma}{n_t} - \lambda_1(-((\tau - e_t^g - \Omega_t^g)p^f\phi_c\bar{w}_t + (\tau - e_t^b)(1-p^f)\phi_c\bar{w}_t) + w_t^f\phi + (p^f e_t^g + (1-p^f)e_t^b)\Psi) = 0 \quad (B.4)$$

$$L_{\Omega_t^f}: \frac{(1-\rho)(1-\chi)}{\Omega_t^f} - \lambda_1 w_t^f = 0 \quad (B.5)$$

$$L_{w_{t+1}^f}: \frac{\gamma_f}{w_{t+1}^f} - \lambda_2 = 0 \quad (B.6)$$

$$L_{w_{t+1}^m}: \frac{1}{w_{t+1}^m} - \lambda_3 = 0 \quad (B.7)$$

$$L_{\Omega_t^g}: \frac{(1-\rho)\chi}{\Omega_t^g} - \lambda_1 p^f n_t\phi_c\bar{w}_t = 0 \quad (B.8)$$

$$L_{e_t^g}: -\lambda_1(p^f n_t\phi_c\bar{w}_t + p^f n_t\Psi) + \lambda_2\alpha_f\sigma_f(e_t^g)^{\sigma_f-1} = 0 \quad (B.9)$$

$$L_{e_t^b}: -\lambda_1((1-p^f)n_t\phi_c\bar{w}_t + (1-p^f)n_t\Psi) + \lambda_3\alpha_m\sigma_m(e_t^b)^{\sigma_m-1} = 0 \quad (B.10)$$

Using (B.2),(B.6),(B.7),(B.8),(B.9) and (B.10) the expression for home production time and education of girls and education of boys can be simplified as follows.

$$\Omega_t^g = \frac{(1-\rho)\chi c_{m,t}}{\rho\phi_c\bar{w}_t p^f n_t} \quad (B.11)$$

$$e_t^g = \frac{\gamma_f\sigma_f c_{m,t}}{(\phi_c\bar{w}_t + \Psi)p^f\rho n_t} \quad (B.12)$$

$$e_t^b = \frac{\sigma_m c_{m,t}}{(\phi_c\bar{w}_t + \Psi)(1-p^f)\rho n_t} \quad (B.13)$$

And by combining (B.2),(B.4),(B.11) , (B.12) and (B.13), the expression for the utility from having an additional child can be simplified as follows.

$$\frac{(1-\rho)\chi}{n_t} + \frac{\gamma}{n_t} = \frac{\rho}{c_{m,t}}(w_t^f\phi + (p^f e_t^g + (1-p^f)e_t^b)\Psi - [(\tau - e_t^g - \Omega_t^g)p^f\phi_c\bar{w}_t + (\tau - e_t^b)(1-p^f)\phi_c\bar{w}_t]) \quad (B.14)$$

By replacing for Ω_t^g, e_t^g, e_t^b using equations (B.11) , (B.12) and (B.13), equation (B.14) can be further simplified.

$$\frac{((1-\rho)\chi+\gamma)c_{m,t}}{n_t} = \rho(w_t^f\phi + p^f(\phi_c\bar{w}_t+\Psi)e_t^g + (1-p^f)(\phi_c\bar{w}_t+\Psi)e_t^b$$
$$- [(\tau-\Omega_t^g)p^f\phi_c\bar{w}_t + \tau(1-p^f)\phi_c\bar{w}_t]) \quad \text{(B.15)}$$

$$\Rightarrow \frac{((1-\rho)\chi+\gamma)c_{m,t}}{\rho n_t} = (w_t^f\phi + \frac{\gamma_f\sigma_f c_{m,t}}{\rho n_t} + \frac{\sigma_m c_{m,t}}{\rho n_t} + \frac{(1-\rho)\chi c_{m,t}}{\rho n_t} - \tau\phi_c\bar{w}_t) \quad \text{(B.16)}$$

This leads to a more simplified expression.

$$\frac{c_{m,t}}{n_t} = \frac{\rho(w_t^f\phi - \tau\phi_c\bar{w}_t)}{(\gamma-(\gamma_f\sigma_f+\sigma_m))} \quad \text{(B.17)}$$

By inserting B.17) into B.11), (B.12) and (B.13), the closed form solutions for education levels of girls and boys in the benchmark model of chapter five can be derived.

$$\Omega_t^g = \frac{(1-\rho)\chi(w_t^f\phi - \tau\phi_c\bar{w}_t)}{p^f\phi_c\bar{w}_t[\gamma-(\gamma_f\sigma_f+\sigma_m)]} \quad \text{(B.18)}$$
$$e_t^g = \frac{\gamma_f\sigma_f(w_t^f\phi - \tau\phi_c\bar{w}_t)}{(\phi_c\bar{w}_t+\Psi)p^f[\gamma-(\gamma_f\sigma_f+\sigma_m)]} \quad \text{(B.19)}$$
$$e_t^b = \frac{\sigma_m(w_t^f\phi - \tau\phi_c\bar{w}_t)}{(\phi_c\bar{w}_t+\Psi)(1-p^f)[\gamma-(\gamma_f\sigma_f+\sigma_m)]} \quad \text{(B.20)}$$

And from the budget (5.5) and (B.4), current market consumption can be derived.

$$c_{m,t} + s_t = w_t^m + w_t^f - w_t^f\Omega_t^f - [-(\tau - e_t^g - \Omega_t^g)p^f n_t\phi_c\bar{w}_t - (\tau - e_t^b)(1-p^f)n_t\phi_c\bar{w}_t$$
$$+ (w_t^f\phi n_t + (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi)] \quad \text{(B.21)}$$

Using (B.2),(B.3, s_t can be expressed in terms of $c_{m,t}$

$s_t = \frac{c_{m,t+1}}{R_{t+1}} = \beta c_{m,t}$

Hence, we can rewrite the above budget constraint as follows. The expression in the square bracket in the right side of (B.21)

$$[-(\tau - e_t^g - \Omega_t^g)p^f n_t\phi_c\bar{w}_t - (\tau - e_t^b)(1-p^f)n_t\phi_c\bar{w}_t + (w_t^f\phi n_t + (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi)]$$

is equivalent to

$$((1-\rho)\chi+\gamma)c_{m,t}/\rho$$

by exploiting (B.16) .

Moreover, a mother's home production time can also be simplified using (B.5) and (B.2).

$$\Omega_f = \frac{(1-\rho)(1-\chi)c_{m,t}}{\rho w_t^f} \tag{B.22}$$

Combining these components, we get the simplified form of the budget constraint as

$\Rightarrow (1+\beta)c_{m,t} + ((1-\rho)\chi+\gamma)c_{m,t}/\rho + \frac{(1-\rho)(1-\chi)c_{m,t}}{\rho} = w_t^m + w_t^f$

Therefore,

$$c_{m,t} = \frac{\rho(w_t^m + w_t^f)}{[1+\rho\beta+\gamma]} \tag{B.23}$$

From (B.17) and (B.23) we can solve for fertility.

$$n_t = \frac{(w_t^m + w_t^f)[\gamma - (\gamma_f\sigma_f + \sigma_m)]}{[1+\rho\beta+\gamma](w_t^f\phi - \tau\phi_c\bar{w}_t)} \tag{B.24}$$

And from (B.22 and (B.23) for a mother's home production time.

$$\Omega_t^f = \frac{(1-\rho)(1-\chi)(w_t^m + w_t^f)}{[1+\rho\beta+\gamma]w_t^f} \tag{B.25}$$

In order to derive the gender gap in education in the model and establish the quantity− quality tradeoff, we use (B.19) , (B.20) and (B.24) .

By dividing (B.19) by (B.20), we have the gender gap in education in the benchmark model.

$$\frac{e_t^g}{e_t^b} = \frac{\left(\frac{\gamma_f\sigma_f(w_t^f\phi-\tau\phi_c\bar{w}_t)}{(\phi_c\bar{w}_t+\Psi)p^f[\gamma-(\gamma_f\sigma_f+\sigma_m)]}\right)}{\left(\frac{\sigma_m(w_t^f\phi-\tau\phi_c\bar{w}_t)}{(\phi_c\bar{w}_t+\Psi)(1-p^f)[\gamma-(\gamma_f\sigma_f+\sigma_m)]}\right)} = \frac{\gamma_f\sigma_f(1-p^f)}{\sigma_m p^f} \tag{B.26}$$

In order to establish the quantity− quality tradeoff in the model, in the same fashion as in the appendix A.1, we combine the expressions for fertility (B.24) and gender gap in education in the model (B.26).

$$n_t = \frac{(w_t^m + w_t^f)[\gamma - (\frac{p^f e_t^g}{(1-p^f)e_t^b} + 1)\sigma_m]}{[1 + \rho\beta + \gamma](w_t^f \phi - \tau\phi_c \bar{w}_t)} \tag{B.27}$$

Now, the relationship between female to male schooling ratio and fertility as provided in (B.27) demonstrates how these two are negatively related. This is the quantity−quality tradeoff in this model. More gender equality in education implies less fertility which is the same as in chapter four.

Appendix C

Appendix for Chapter Five: Child Labor Ban

1 Initial case: non− binding for girls and binding for boys.

1.1 Non−binding for girls and binding for boys: $e_t^g + \Omega_t^g \geq \bar{e}$ and $e_t^b < \bar{e}$

Now, the budget constraint in (5.5) can be rewritten as: -

$$c_{m,t} + s_t + (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi = w_t^m + w_t^f(1 - \phi n_t - \Omega_t^f) + (\tau - e_t^g - \Omega_t^g)p^f n_t \phi_c \bar{w}_t + (\tau - \bar{e})(1-p^f)n_t\phi_c\bar{w}_t \quad \text{(C.1)}$$

And the Lagrange formulation of the form

$$\rho ln(c_{m,t}) + (1-\rho)ln(c_{h,t}) + \beta\rho ln(c_{m,t+1}) + \beta(1-\rho)ln(c_{h,t+1}) + \gamma ln(n_t) + \gamma_f ln(w_{t+1}^w) + ln(w_{t+1}^m) + \lambda_1[w_t^m + w_t^f(1-\phi n_t - \Omega_f) + (\tau - \Omega_t^g - e_t^g)p^f n_t\phi_c\bar{w}_t + (\tau - \bar{e})(1-p^f)n_t\phi_c\bar{w}_t - c_{m,t} - c_{m,t+1}/R_{t+1} - (p^f e_t^g + (1-p^f)e_t^b)n_t\Psi] + \lambda_2(\alpha_f(e_t^g)^{\sigma_f} - w_{t+1}^f) + \lambda_3(\alpha_m(e_t^b)^{\sigma_m} - w_{t+1}^m) \quad \text{(C.2)}$$

Next, the first order conditions with respect to current market consumption, $c_{m,t}$, future market consumption, $c_{m,t+1}$, current home goods consumption, $c_{h,t}$, future female wage, w_{t+1}^f, number of children, n_t, future male wage, future male wage w_{t+1}^m, home production time of a mother, Ω_t^f, home production time of a daughter, Ω_t^g, the educations of girls, e_t^g and that of boys, e_t^b, are derived.

$$L_{c_{m,t}} : \frac{\rho}{c_{m,t}} - \lambda_1 = 0 \tag{C.3}$$

$$L_{c_{m,t+1}} : \beta\rho\frac{1}{c_{m,t+1}} - \frac{\lambda_1}{R_{t+1}} = 0 \tag{C.4}$$

$$L_{n_t} : \frac{(1-\rho)\chi + \gamma}{n_t} - \lambda_1(-((\tau - \Omega_t^g - e_t^g)p^f\phi_c\bar{w}_t + (\tau - \bar{e})(1-p^f)\phi_c\bar{w}_t) + w_t^f\phi + (p^f e_t^g + (1-p^f)e_t^b)\Psi) = 0 \tag{C.5}$$

$$L_{\Omega_t^f} : \frac{(1-\rho)(1-\chi)}{\Omega_t^f} - \lambda_1 w_t^f = 0 \tag{C.6}$$

$$L_{w_{t+1}^f} : \frac{\gamma_f}{w_{t+1}^f} - \lambda_2 = 0 \tag{C.7}$$

$$L_{w_{t+1}^m} : \frac{1}{w_{t+1}^m} - \lambda_3 = 0 \tag{C.8}$$

$$L_{\Omega_t^g} : \frac{(1-\rho)\chi}{\Omega_t^g} - \lambda_1 p^f n_t \phi_c \bar{w}_t = 0 \tag{C.9}$$

$$L_{e_t^g} : -\lambda_1(\phi_c p^f n_t \bar{w}_t + p^f n_t \Psi) + \lambda_2 \alpha_f \sigma_f (e_t^g)^{\sigma_f - 1} = 0 \tag{C.10}$$

$$L_{e_t^b} : -\lambda_1 \Psi(1-p^f)n_t + \lambda_3 \alpha_m \sigma_m (e_t^b)^{\sigma_m - 1} = 0 \tag{C.11}$$

By following the same procedure as in Appendix (B): We can simplify the expression in C.9),C.10), and C.11) as follows by using (C.3)

$$\Omega_t^g = \frac{(1-\rho)\chi c_{m,t}}{\rho\phi_c\bar{w}_t p^f n_t} \tag{C.12}$$

$$e_t^g = \frac{\gamma_f \sigma_f c_{m,t}}{(\phi_c\bar{w}_t + \Psi)p^f \rho n_t} \tag{C.13}$$

$$e_t^b = \frac{\sigma_m c_{m,t}}{\Psi(1-p^f)\rho n_t} \tag{C.14}$$

And from (C.3) and (C.5) the FOC for the marginal utility from having a child can be simplified as follows.

$$\frac{(1-\rho)\chi}{n_t}+\frac{\gamma}{n_t}=\frac{\rho}{c_{m,t}}(w_t^f\phi+(p^f e_t^g+(1-p^f)e_t^b)\Psi-[(\tau-e_t^g-\Omega_t^g)p^f\phi_c\bar{w}_t+(\tau-\bar{e})(1-p^f)\phi_c\bar{w}_t]) \tag{C.15}$$

$$\frac{((1-\rho)\chi+\gamma)c_{m,t}}{n_t}=\rho(w_t^f\phi+p^f(\phi_c\bar{w}_t+\Psi)e_t^g+(1-p^f)\Psi e_t^b - [(\tau-\Omega_t^g)p^f\phi_c\bar{w}_t+(\tau-\bar{e})(1-p^f)\phi_c\bar{w}_t]) \tag{C.16}$$

Then, by combining (C.12), (C.13), (C.14) and (C.15)

$$\frac{((1-\rho)\chi+\gamma)c_{m,t}}{\rho n_t}=(w_t^f\phi+\frac{\gamma_f\sigma_f c_{m,t}}{\rho n_t}+\frac{\sigma_m c_{m,t}}{\rho n_t}+\frac{(1-\rho)\chi c_{m,t}}{\rho n_t}-(\tau-\bar{e}(1-p^f))\phi_c\bar{w}_t) \tag{C.17}$$

The expression for the marginal utility from having a child can further be simplified as follows.

$$\frac{c_{m,t}}{n_t}=\frac{\rho(w_t^f\phi-(\tau-\bar{e}(1-p^f))\phi_c\bar{w}_t)}{(\gamma-(\gamma_f\sigma_f+\sigma_m))} \tag{C.18}$$

By inserting (C.18) into (C.12), (C.13), (C.14), the closed form solution for home production time of girls, education levels for both genders can be recovered.

$$\Omega_t^g=\frac{(1-\rho)\chi(w_t^f\phi-(\tau-\bar{e}(1-p^f))\phi_c\bar{w}_t)}{p^f\phi_c\bar{w}_t[\gamma-(\gamma_f\sigma_f+\sigma_m)]} \tag{C.19}$$

$$e_t^g=\frac{\gamma_f\sigma_f(w_t^f\phi-(\tau-\bar{e}(1-p^f))\phi_c\bar{w}_t)}{(\phi_c\bar{w}_t+\Psi)p^f[\gamma-(\gamma_f\sigma_f+\sigma_m)]} \tag{C.20}$$

$$e_t^b=\frac{\sigma_m(w_t^f\phi-(\tau-\bar{e}(1-p^f))\phi_c\bar{w}_t)}{\Psi(1-p^f)[\gamma-(\gamma_f\sigma_f+\sigma_m)]} \tag{C.21}$$

And from the budget (C.1) and (C.5), current market consumption can be derived.

$$(1+\beta)c_{m,t} = w_t^m + w_t^f - w_t^f\Omega_t^f$$
$$-[-(\tau-e_t^g-\Omega_t^g)p^f n_t\phi_c\bar{w}_t-(\tau-\bar{e})(1-p^f)n_t\phi_c\bar{w}_t+(w_t^f\phi n_t+(p^f e_t^g+(1-p^f)e_t^b)n_t\Psi)] \tag{C.22}$$

$\Rightarrow (1+\beta)c_{m,t} + ((1-\rho)\chi+\gamma)c_{m,t}/\rho + \frac{(1-\rho)(1-\chi)c_{m,t}}{\rho} = w_t^m + w_t^f$
Thus, current market consumption is given by: -

$$c_{m,t} = \frac{\rho(w_t^m + w_t^f)}{[1+\rho\beta+\gamma]} \tag{C.23}$$

By combining (C.18) and (C.23), fertility after the policy introduction becomes

$$n_t = \frac{(w_t^m + w_t^f)[\gamma - (\gamma_f\sigma_f + \sigma_m)]}{[1+\rho\beta+\gamma](w_t^f\phi - (\tau - \bar{e}(1-p^f))\phi_c\bar{w}_t)} \tag{C.24}$$

Similarly, by combining (C.3) and (C.6), the home production time of an adult female can described as

$$\Omega_t^f = \frac{(1-\rho)(1-\chi)(w_t^m + w_t^f)}{[1+\rho\beta+\gamma]w_t^f} \tag{C.25}$$

In order to derive the gender gap in education in the model and establish the quantity− quality tradeoff, we use (C.20), (C.21) and (C.24) .
By dividing (C.20) by (C.21), we have the gender gap in education in the benchmark model.

$$\frac{e_t^g}{e_t^b} = \frac{\left(\frac{\gamma_f\sigma_f(w_t^f\phi-(\tau-\bar{e}(1-p^f))\phi_c\bar{w}_t)}{(\phi_c\bar{w}_t+\Psi)p^f[\gamma-(\gamma_f\sigma_f+\sigma_m)]}\right)}{\left(\frac{\sigma_m(w_t^f\phi-(\tau-\bar{e}(1-p^f))\phi_c\bar{w}_t)}{\Psi(1-p^f)[\gamma-(\gamma_f\sigma_f+\sigma_m)]}\right)} = \frac{\gamma_f\sigma_f(1-p^f)}{\sigma_m p^f(\phi_c\bar{w}_t+\Psi)} \tag{C.26}$$

Compared to the benchmark, gender gap in education is wider, now.
And, in order to establish the quantity− quality tradeoff in the model, we combine (B.24) and (B.26).

$$n_t = \frac{(w_t^m + w_t^f)[\gamma - (\frac{p^f(\phi_c\bar{w}_t+\Psi)e_t^g}{(1-p^f)e_t^b} + 1)\sigma_m]}{[1+\rho\beta+\gamma](w_t^f\phi - (\tau - \bar{e}(1-p^f))\phi_c\bar{w}_t)} \tag{C.27}$$

Here too, the relationship between female to male schooling ratio and fertility as provided in (C.27) demonstrates how these two are negatively related.

1.2 **Non−binding for girls and corner for boys**: $e^g_t + \Omega^g_t \geq \bar{e}$ and $e^b_t = \bar{e}$.
If the condition is violated and $e^b_t \geq \bar{e}$, the result will be a corner solution at $e^b_t = \bar{e}$. The, condition becomes $e^g_t + \Omega^g_t \geq \bar{e}$ and $e^b_t = \bar{e}$.
In this case, the constraint the household faces becomes: -

$$c_{m,t}+s_t+(p^f e^g_t+(1-p^f)\bar{e})n_t\Psi = w^m_t+w^f_t(1-\phi n_t-\Omega^f_t)+(\tau-e^g_t-\Omega^g_t)p^f n_t\phi_c\bar{w}_t + (\tau-\bar{e})(1-p^f)n_t\phi_c\bar{w}_t \quad \text{(C.28)}$$

The FOCs are derived in similar fashion as before

$$L_{c_{m,t}} : \frac{\rho}{c_{m,t}} - \lambda_1 = 0 \quad \text{(C.29)}$$

$$L_{c_{m,t+1}} : \beta\rho\frac{1}{c_{m,t+1}} - \frac{\lambda_1}{R_{t+1}} = 0 \quad \text{(C.30)}$$

$$L_{n_t} : \frac{(1-\rho)\chi+\gamma}{n_t} - \lambda_1(-((\tau-\Omega^g_t-e^g_t)p^f\phi_c\bar{w}_t + (\tau-\bar{e})(1-p^f)\phi_c\bar{w}_t) + w^f_t\phi + (p^f e^g_t + (1-p^f)\bar{e})\Psi) = 0 \quad \text{(C.31)}$$

$$L_{\Omega^f_t} : \frac{(1-\rho)(1-\chi)}{\Omega^f_t} - \lambda_1 w^f_t = 0 \quad \text{(C.32)}$$

$$L_{w^f_{t+1}} : \frac{\gamma_f}{w^f_{t+1}} - \lambda_2 = 0 \quad \text{(C.33)}$$

$$L_{\Omega^g_t} : \frac{(1-\rho)\chi}{\Omega^g_t} - \lambda_1 p^f n_t\phi_c\bar{w}_t = 0 \quad \text{(C.34)}$$

$$L_{e^g_t} : -\lambda_1(\phi_c p^f n_t\bar{w}_t + p^f n_t\Psi) + \lambda_2\alpha_f\sigma_f(e^g_t)^{\sigma_f-1} = 0 \quad \text{(C.35)}$$

By following the same procedure as the Case 1.1, we can simplify the expression in C.35) and (C.34) by using (C.29) as follows.

$$\Omega^g_t = \frac{(1-\rho)\chi c_{m,t}}{\rho\phi_c\bar{w}_t p^f n_t} \quad \text{(C.36)}$$

$$e^g_t = \frac{\gamma_f\sigma_f c_{m,t}}{(\phi_c\bar{w}_t+\Psi)p^f\rho n_t} \quad \text{(C.37)}$$

And from (C.29),(C.31), (C.36)and C.37) the FOC for the marginal utility from having a child plus the above two expressions we can derive:

$$\frac{(1-\rho)\chi}{n_t}+\frac{\gamma}{n_t} = \frac{\rho}{c_{m,t}}(w^f_t\phi+(p^f e^g_t+(1-p^f)\bar{e})\Psi-[(\tau-e^g_t-\Omega^g_t)p^f\phi_c\bar{w}_t+(\tau-\bar{e})(1-p^f)\phi_c\bar{w}_t])$$

$$\Rightarrow \frac{((1-\rho)\chi+\gamma)c_{m,t}}{n_t} = \rho(w_t^f\phi + p^f(\phi_c\bar{w}_t+\Psi)e_t^g + \Omega_t^g p^f\phi_c\bar{w}_t + (1-p^f)\Psi\bar{e} + \phi_c(1-p^f)\bar{w}_t\bar{e} - [(\tau p^f\phi_c\bar{w}_t + \tau(1-p^f)\phi_c\bar{w}_t]) \quad \text{(C.38)}$$

Then, by combining (C.36), (C.37) and (C.38)
$\Rightarrow \frac{((1-\rho)\chi+\gamma)c_{m,t}}{\rho n_t} = (w_t^f\phi + \frac{\gamma_f\sigma_f c_{m,t}}{\rho n_t} + \frac{(1-\rho)\chi c_{m,t}}{\rho n_t} + (1-p^f)\bar{e}(\phi_c\bar{w}_t+\Psi) - \tau\phi_c\bar{w}_t$

$$\Rightarrow \frac{c_{m,t}}{n_t} = \frac{\rho(w_t^f\phi + (1-p^f)\bar{e}(\phi_c\bar{w}_t+\Psi) - \tau\phi_c\bar{w}_t)}{(\gamma-\gamma_f\sigma_f)} \quad \text{(C.39)}$$

By inserting (C.39) into (C.36) and (C.37).

$$\Omega_t^g = \frac{(1-\rho)\chi(w_t^f\phi + (1-p^f)\bar{e}(\phi_c\bar{w}_t+\Psi) - \tau\phi_c\bar{w}_t)}{p^f\phi_c\bar{w}_t(\gamma-\gamma_f\sigma_f)}$$
$$e_t^g = \frac{\gamma_f\sigma_f(w_t^f\phi + (1-p^f)\bar{e}(\phi_c\bar{w}_t+\Psi) - \tau\phi_c\bar{w}_t)}{(\phi_c\bar{w}_t+\Psi)p^f)[\gamma-\gamma_f\sigma_f]}$$

And from the budget constraint, current market consumption can be derived as: -

$$(1+\beta)c_{m,t} = w_t^m + w_t^f - w_t^f\Omega_t^f - [-(\tau - e_t^g - \Omega_t^g)p^f n_t\phi_c\bar{w}_t - (\tau-\bar{e})(1-p^f)n_t\phi_c\bar{w}_t + (w_t^f\phi n_t + (p^f e_t^g + (1-p^f)\bar{e})n_t\Psi)] \quad \text{(C.40)}$$

By combining (C.31), (C.33) and (C.40)
$\Rightarrow (1+\beta)c_{m,t} + ((1-\rho)\chi+\gamma)c_{m,t}/\rho + \frac{(1-\rho)(1-\chi)c_{m,t}}{\rho} = w_t^m + w_t^f$
Now, the expressions for $c_{m,t}, n_t, \Omega_t^f$ can be given as follows.

$$c_{m,t} = \frac{\rho(w_t^m + w_t^f)}{[1+\rho\beta+\gamma]}$$ Hence, using (C.39), fertility becomes,
$$n_t = \frac{(w_t^m + w_t^f)[\gamma-\gamma_f\sigma_f]}{[1+\rho\beta+\gamma](w_t^f\phi + (1-p^f)\bar{e}(\phi_c\bar{w}_t+\Psi) - \tau\phi_c\bar{w}_t)}$$
$$\Omega_t^f = \frac{(1-\rho)(1-\chi)(w_t^m + w_t^f)}{[1+\rho\beta+\gamma]w_t^f}$$

2 Initial Case: Non− binding for boys and binding for girls.

2.1 Binding for girls and non− binding for boys: $e_t^g + \Omega_t^g = \bar{e} \le e_t^b$.

In this case, the constraint the household faces becomes: -

$$c_{m,t}+s_t+(p^f e_t^g+(1-p^f)e_t^b)n_t\Psi = w_t^m+w_t^f(1-\phi n_t-\Omega_t^f)+(\tau-\bar{e})p^f n_t\phi_c\bar{w}_t + (\tau - e_t^b)(1-p^f)n_t\phi_c\bar{w}_t \quad (C.41)$$

And

$$\Omega_t^g = \bar{e} - e_t^b$$

The FOC, here too, are derived in a similar as before but using the modified budget constraint.

$$L_{c_{m,t}} : \frac{\rho}{c_{m,t}} - \lambda_1 = 0 \quad (C.42)$$

$$L_{c_{m,t+1}} : \beta\rho\frac{1}{c_{m,t+1}} - \frac{\lambda_1}{R_{t+1}} = 0 \quad (C.43)$$

$$L_{n_t} : \frac{(1-\rho)\chi+\gamma}{n_t} - \lambda_1(-((\tau-\bar{e})p^f\phi_c\bar{w}_t + (\tau - e_t^b)(1-p^f)\phi_c\bar{w}_t) + w_t^f\phi + (p^f e_t^g + (1-p^f)e_t^b)\Psi) = 0 \quad (C.44)$$

$$L_{\Omega_t^f} : \frac{(1-\rho)(1-\chi)}{\Omega_t^f} - \lambda_1 w_t^f = 0 \quad (C.45)$$

$$L_{w_{t+1}^f} : \frac{\gamma_f}{w_{t+1}^f} - \lambda_2 = 0 \quad (C.46)$$

$$L_{w_{t+1}^m} : \frac{1}{w_{t+1}^m} - \lambda_3 = 0 \quad (C.47)$$

$$L_{e_t^g} : -\frac{(1-\rho)\chi}{\bar{e}-e_t^g} - \lambda_1 p^f n_t\Psi + \lambda_2\alpha_f\sigma_f(e_t^g)^{\sigma_f-1} = 0 \quad (C.48)$$

$$L_{e_t^b} : -\lambda_1(\phi_c(1-p^f)n_t\bar{w}_t + \Psi(1-p^f)) + \lambda_3\alpha_m\sigma_m(e_t^b)^{\sigma_m-1} = 0 \quad (C.49)$$

$\Rightarrow$ No closed form solution for n_t, e_t^g, e_t^b and Ω_t^g .

Case 3 **Initial case: Binding for both.**

3.1 **Binding for both**: $\Omega_t^g + e_t^g = \bar{e}$ and $e_t^b < \bar{e}$

Now, the budget constraints are,

$$\begin{aligned} c_{m,t} + s_t + (p^f e_t^g + (1-p^f)e_t^b))n_t\Psi = w_t^m + w_t^f(1 - \phi n_t - \Omega_t^f) \\ + (\tau - \bar{e})p^f n_t \phi_c \bar{w}_t + (\tau - \bar{e})(1-p^f)n_t\phi_c\bar{w}_t \end{aligned} \quad \text{(C.50)}$$

and

$$\Omega_t^g = \bar{e} - e_t^g$$

$$\begin{aligned} L_{c_{m,t}} : \frac{\rho}{c_{m,t}} - \lambda_1 = 0 \\ L_{c_{m,t+1}} : \beta\rho\frac{1}{c_{m,t+1}} - \frac{\lambda_1}{R_{t+1}} = 0 \\ L_{n_t} : \frac{(1-\rho)\chi + \gamma}{n_t} - \lambda_1(-(\tau - \bar{e})\phi_c\bar{w}_t + w_t^f\phi + (e_t^g p^f + (1-p^f)e_t^b)\Psi) = 0 \\ L_{\Omega_t^f} : \frac{(1-\rho)(1-\chi)}{\Omega_t^f} - \lambda_1 w_t^f = 0 \\ L_{w_{t+1}^f} : \frac{\gamma_f}{w_{t+1}^f} - \lambda_2 = 0 \\ L_{w_{t+1}^m} : \frac{1}{w_{t+1}^m} - \lambda_3 = 0 \\ L_{e_t^g} : -\frac{(1-\rho)\chi}{\bar{e} - e_t^g} - \lambda_1 p^f n_t\Psi + \lambda_2\alpha_f\sigma_f(e_t^g)^{\sigma_f - 1} = 0 \\ L_{e_t^b} : -\lambda_1\Psi(1-p^f) + \lambda_3\alpha_m\sigma_m(e_t^b)^{\sigma_m - 1} = 0 \end{aligned}$$

$\Rightarrow$ Here too, $\Rightarrow$ no closed form solution for n_t, e_t^g, e_t^b and Ω_t^g .

3.2 Corner solution for both

In case parents choose the education of boys to be equal to the policy threshold, the condition can be rewritten as
$\Omega_t^g + e_t^g = \bar{e}$ and $e_t^b = \bar{e}$
The budget constraints

$$\begin{aligned} c_{m,t} + s_t + (p^f e_t^g + (1-p^f)\bar{e}))n_t\Psi = w_t^m + w_t^f(1 - \phi n_t - \Omega_t^f) \\ + (\tau - \bar{e})p^f n_t\phi_c\bar{w}_t + (\tau - \bar{e})(1-p^f)n_t\phi_c\bar{w}_t \end{aligned}$$

$$c_{m,t} + s_t + (e_t^g p^f + (1-p^f)\bar{e})n_t\Psi = w_t^m + w_t^f(1 - \phi n_t - \Omega_t^f) + (\tau - \bar{e})n_t\phi_c\bar{w}_t \quad \text{(C.51)}$$

and ,

$\Omega_t^g = \bar{e} - e_t^g$

The Lagrange formulation is: -

$$\rho ln(c_{m,t}) + (1-\rho) ln(c_{h,t}) + \beta\rho ln(c_{m,t+1}) + \beta(1-\rho) ln(c_{h,t+1}) + \gamma ln(n_t) + \gamma_f ln(w_{t+1}^w) + ln(w_{t+1}^m)$$
$$+\lambda_1(w_t^m + w_t^f(1-\phi n_t - \Omega_t^f) + (\tau-\bar{e}) n_t \phi_c \bar{w}_t - c_{m,t} - c_{m,t+1}/R_{t+1} - (p^f e_t^g + (1-p^f)\bar{e}) n_t \Psi)$$
$$+ \lambda_2(\alpha_f (e_t^g)^{\sigma_f} - w_{t+1}^f)$$

Where $c_{h,t} = (\Omega_t^f)^{(1-\chi)} (\Omega_t^g p^f n_t)^\chi = (\Omega_t^f)^{(1-\chi)} ((\bar{e} - e_t^g) p^f n_t)^\chi$
FOC:

$$L_{c_{m,t}} : \frac{\rho}{c_{m,t}} - \lambda_1 = 0$$
$$L_{c_{m,t+1}} : \beta\rho \frac{1}{c_{m,t+1}} - \frac{\lambda_1}{R_{t+1}} = 0$$

$$L_{n_t} : \frac{(1-\rho)\chi + \gamma}{n_t} - \lambda_1(-(\tau - \bar{e})\phi_c \bar{w}_t + w_t^f \phi + (e_t^g p^f + (1-p^f)\bar{e})\Psi) = 0 \quad \text{(C.52)}$$

$$L_{\Omega_t^f} : \frac{(1-\rho)(1-\chi)}{\Omega_t^f} - \lambda_1 w_t^f = 0$$
$$L_{w_{t+1}^f} : \frac{\gamma_f}{w_{t+1}^f} - \lambda_2 = 0$$
$$L_{e_t^g} : -\frac{(1-\rho)\chi}{\bar{e} - e_t^g} - \lambda_1 p^f n_t \Psi + \lambda_2 \alpha_f \sigma_f (e_t^g)^{\sigma_f - 1} = 0$$

$\Rightarrow$ No closed form solutions.

List of Tables

Table C.1: Country classification based on income

Income category	GNI per capita 1980($\approx$ 1987)$	GNI per capita 2010$
Low income	≤ 480	≤ 1005
Lower middle income	$481 - 1,940$	$1,006 - 3,975$
Upper middle income	$1,941 - 6,000$	$3,976 - 12,275$
High income	$> 6,000$	$> 12,275$

Table C.2: Estimation results: Log−linear

Dependent Variable: Log (Fertility)

VARIABLES	(1)	(2)	(3)	(4)
Female to male schooling ratio	-0.299*	-0.259*	-0.235**	-0.228**
	(0.154)	(0.147)	(0.110)	(0.114)
Log (Overall average schooling)	-0.476***	-0.438***	-0.225***	-0.242***
	(0.0414)	(0.0392)	(0.0458)	(0.0460)
Log (GDP per capita)		-0.127***		-0.0594**
		(0.0257)		(0.0286)
Country FE	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes
Constant	2.191***	2.282***	1.835***	1.932***
	(0.0821)	(0.0734)	(0.0979)	(0.111)
Observations	763	763	763	763
R-squared	0.946	0.949	0.953	0.953

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table C.3: List of countries in the data used for regression

Albania	China, Hong Kong SAR	Guyana	Mauritius	Senegal
Algeria	Colombia	Haiti	Mexico	Sierra Leone
Argentina	Congo	Honduras	Morocco	Singapore
Australia	Costa Rica	Iceland	Mozambique	South Africa
Austria	Cote dIvoire	India	Myanmar	Spain
Bahrain	Cuba	Indonesia	Namibia	Sri Lanka
Bangladesh	Cyprus	Iran (Islamic Republic of)	Nepal	Sudan
Barbados	DR Congo	Iraq	Netherlands	Sweden
Belgium	Denmark	Ireland	New Zealand	Switzerland
Belize	Dominican Rep.	Israel	Nicaragua	Thailand
Benin	Ecuador	Italy	Niger	Togo
Bolivia	Egypt	Jamaica	Norway	Trinidad and Tobago
Botswana	El Salvador	Japan	Pakistan	Tunisia
Brazil	Fiji	Jordan	Panama	Turkey
Brunei Darussalam	Finland	Kenya	Papua New Guinea	United Arab Emirates
Bulgaria	France	Lesotho	Paraguay	United Kingdom
Burundi	Gabon	Luxembourg	Peru	Uruguay
Cameroon	Gambia	Malawi	Philippines	USA
Canada	Germany	Malaysia	Portugal	Venezuela
Central African Republic	Ghana	Mali	Republic of Korea	Zambia
Chile	Greece	Malta	Rwanda	Zimbabwe
China	Guatemala	Mauritania	Saudi Arabia	