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Is the Future Female? A Study on Educational Attainment and Economic Development

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Plain Language Summary

The growing global momentum to educate girls and women raises an important question: how might they shape the economies of tomorrow? This study looks at how female education impacts economic development, which broadly refers to the expansion of a country's economy and the improvement of social welfare. I focus on two levels of education: secondary (high school) and tertiary (college or university). I find that in low-income countries (LICs), girls' secondary education is linked to economic growth. In high-income countries (HICs), it is women's tertiary education that makes a bigger difference. These patterns point to structural transformation, which refers to the idea that the types of jobs in an economy evolve over time. Research shows that this evolution leads to a U-shape in women's labor force participation: it is high in agricultural economies, falls as countries industrialize and shift toward factory work, and then rises again as jobs move into services. These findings suggest that for LICs, policy efforts should focus on enabling girls to advance through their secondary education before turning to broader goals like expanding access to tertiary education. Future research could examine how barriers in the job markets of HICs may limit the full economic returns to women's educational gains.

Abstract

This paper studies the impact of women's secondary and tertiary level educational attainment on economic growth. I regress GDP per capita growth on female and male educational attainment as well as a set of control variables across 141 countries, in 5 year-time periods, from the years 1965 to 2010. Each country in the dataset is classified as low-income, lower middle-income, higher middle-income, and high-income based on their GNP. My results suggest that female secondary education has a positive and significant effect on GDP per capita growth after 1985. When regressing GDP per capita separately on each income group category, I find this effect only present for low-income countries. No significant effect was found for middle- or high-income countries. Additionally, my results report that female tertiary education has a positive and significant impact on GDP per capita growth for high-income countries. I reference the U-Shape hypothesis, which suggests that female labor force participation first declines then rises as economies develop, to provide a potential explanation for those results. I conclude that these results offer an optimistic outlook for low-income countries; secondary education currently drives growth, and returns to tertiary education are expected to follow as development progresses.

Publication Category

Independent Student Research

Academic Context

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Introduction

Many countries around the world have been recognizing the social and economic value of educating young girls and are prioritizing closing the gender gap in education. Lorgelly and Owen (1999) suggest that female education can be socially beneficial by "reducing infant mortality and improving health through increasing the quantity and quality of children's educational attainment" (p.

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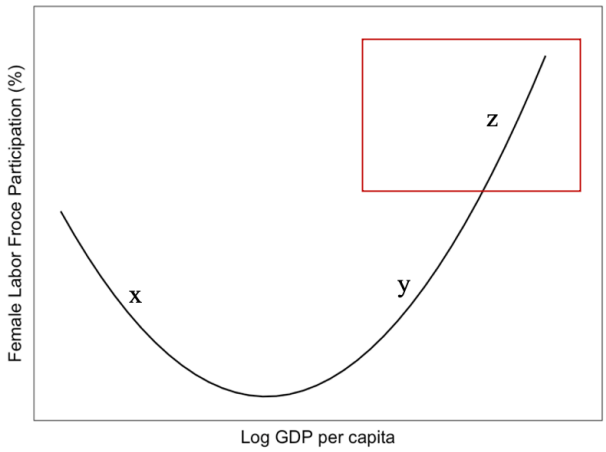
119). Subbarao and Raney (1995) also suggests that female education reduces poverty by increasing labor productivity as well as wages, leading to a consequential increase in household incomes. Nonetheless, the World Bank suggests that limited educational opportunities for young girls hinder economic development and could cost nations between 15 to 30 trillion (USD) in lost lifetime productivity and earnings (Montenegro et al., 2018). With growing interest in the gender gap in education, studies in the late 90s to early 2000s suggest that girls below the age of 16 have gained equal if not greater schooling progress than boys of the same age in many developing countries (Grant & Behrman, 2010). A prominent debate in the 90s focused on the impact of women's education on economic development (e.g., Barro & Lee, 1994; Hill & King, 1995; Lorgelly & Owen, 1999, Stokey, 1994).

This paper builds on that literature by exploring the impact of women's secondary and tertiary education on economic growth. I study this impact over 5 decades, in 5-year time periods, from 1965 to 2010 for countries in four different income group categories. Results suggest that when including all countries, for years after 1985, growth in female secondary education has a positive impact on the GDP (gross domestic product) per capita growth. Interestingly, when splitting my regression based on different income group categories, I find this effect only present for low-income countries. On the other hand, when studying this effect at the tertiary level, I find that on the contrary, female tertiary education only has a positive and significant impact on GDP per capita growth for high-income countries after 1985. Both results seem to fit well with the U-Shape hypothesis,[1] which I reference to provide a potential explanation for the female education coefficients across the different specifications. I plot this curve in Figure 1.

I divide the U-Shape curve in Figure 1 into three segments, each indicated by letters *x*, *y*, and *z*. The U-Shape hypothesis (Boserup, 1970; Durand & Lambert, 1975; Goldin, 1995; Psacharopoulos & Tzannatos, 1989) suggests that women's participation in the labor force is high when GDP per capita is low. Goldin (1995) explains "when incomes are extremely low, and when certain types of agriculture dominate (for example, poultry, dairy, rice, cotton), women are in the labor force to a great extent" (p.63). She states that women in these countries often work on family farms and that they rarely receive monetary compensation for their labor. As countries progress from agricultural to industrialized societies, women's participation in the labor force declines. This is represented in the first segment of the U-Shape curve, indicated by the letter *x* in Figure 1. Goldin (1995) explains that this decline is attributed to a reduction in home-produced goods and therefore leads to a lower demand for women's labor in agriculture. As countries continue to develop and their economies become increasingly dependent on service labor, female labor force participation increases. Ngai and Petrongolo (2017) state that women are more likely to be employed in the service sector, where they are perceived to have

FIGURE 1. FEMALE LABOR FORCE PARTICIPATION. U-Shape Curve demonstrating the trend of female participation rate in the labor force as GDP increases (GDP per capita).



a comparative advantage. This transition helps explain the upward trend in the later stages of the U-shape. This is represented in the second segment of the U-Shape curve, indicated on Figure 1 by the letter *y*. This rise is largely due to a combination of an improvement in education, as well as greater accessibility and opportunities for women in white collar professions (Goldin, 1995). I extend the U-Shape curve and hypothesize that countries with high GDP per capita are now progressing on an extended upward segment of the U-Shape curve, where female labor force participation is high. I represent this by the letter *z* in Figure 1. I classify low-income countries (i.e. those with low gross national income per capita) as those situated

[1] As economies move from agriculture to manufacturing and then to services, the types of jobs available shift, and women are more likely to enter the labor force. Education is one channel through which participation may rise, but this relationship depends on broader labor market conditions and social context.

in segment *x*, and high-income countries (i.e. those with high gross national income per capita) as those situated in segment *z* of the U-Shape curve. Distinguishing these three segments are important to note as they explain my empirical findings.

This paper is organized as follows: Section 2 provides an overview of the existing literature; Section 3 identifies metrics in the dataset, as well as trends across the independent variables of interest; Section 4 presents the models, findings, and robustness checks; Section 5 concludes this paper.

Literature Review

Education is deemed fundamental to economic growth and development by governments and organizations around the world. In the introduction to *The Wealth of Nations*, Adam Smith (1776) states that for an optimal proportion between produce and the number of people who consume it, there needs to be regulation through "the skill, dexterity, and judgment with which its labor is generally applied" (p. 1). Interest in development economics literature peaked in the 1990s when multiple studies analyzed the impact of education, amongst other variables, on economic development. Since then, discussions around women's education and its benefits have been gaining recognition as topics of importance. Governments around the world have been increasingly encouraging and motivating female educational attainment due to its potential to transform countries. Organizations such as the World Bank place great importance on girls' education. The President of the World Bank, James Wolfensohn, quoted an African proverb in 1995: "If we educate a girl, we educate a family—and a whole nation."

A notable study on the determinants of economic development which helped to begin a broad debate on the role of female education on economic growth was Barro and Lee (1994). They gathered data on educational attainment estimates from the years 1950 to 2010 for 146 countries.[2] One reported result from their analysis indicates that there is a negative relationship between female secondary education and GDP growth. They explain that they do not have a convincing story for these findings which reports a negative coefficient on the growth of female secondary education and a positive coefficient on the growth of male secondary education on GDP growth.

Following Barro and Lee's (1994) study, multiple researchers have tried to challenge the negative female education coefficient by presenting potential explanations for the reported result. These findings speak to a wider debate on the role of education in growth. Mankiw et al. (1992) bring human capital into neoclassical growth models and show that differences in its accumulation help explain income gaps across countries. Pritchett (2001), however, questions this view, noting that although educational attainment has risen in many places, it has not always translated into higher growth, often due to issues like education quality and labor market frictions. Taken together, these perspectives point to a more nuanced relationship between education and development.

Stokey (1994) presents an explanation for the negative value on the growth of the female secondary education coefficient found by Barro and Lee (1994). She suggests that this result is associated with four outlier countries (Singapore, Hong Kong, Taiwan and South Korea) having low levels of female school attainment[3] and very high economic growth. She states that the most extreme outlier from Barro and Lee's (1994) sample is Taiwan, a country where the male secondary enrollment rate in 1965 was 93%, while the female rate was only 21%. Stokey (1994) argues that removing the female education variables from Barro and Lee's (1994) models would weaken the significance of the male secondary education coefficient. Lorgelly and Owen (1999) later use Stokey's comments and present a paper in which they remove the four outlier countries to examine if this would alter Barro and Lee's (1994) reported coefficients. They find that, although still negative, the coefficient on the growth of female secondary education is no longer statistically significant even at the 10% level (Lorgelly & Owen., 1999).

Knowles et al. (2002) express a divergent view from that of Barro and Lee (1994). They study the role of gender gaps in education on economic development through measuring its effect on labor productivity. They estimate "the cross-section average long-run effect of female and male education on output per worker" (p.142). Contrary to Barro and Lee's (1994) findings, Knowles et al. (2002) report that female education has a statistically significant positive effect on labor productivity. They explain the difference between their results and Barro and Lee's (1994) is due to their use of base-period values of human capital stock

[2] Barro and Lee frequently update their dataset on educational attainment measures roughly every 10 years.

[3] Hill and King (1995) explain that "this gender gap is defined as the ratio of female-to-male enrollment at the primary or secondary level, whichever ratio is smaller [that is, whichever gender gap is larger]" (p. 27).

measures. Similarly, Hill and King (1995) study the economic implications of the gender gap in education through regressing gross national product (GNP) on the gender gap and female secondary school attainment. Their results report a positive and significant effect of female education on GNP, and they argue that "large gender disparities in educational attainment are associated with lower levels of GNP" (p. 29).

A counterargument to the debate on education and economic growth is Easterly's (2001) critique that there is no correlation between countries increasing the level of education amongst the population and increased GDP. Easterly (2001) states that "education is another magic formula that failed us in our quest for growth" (p. 78). His argument is that although education in developing countries is growing exponentially, the labor market is not mature enough to accommodate those acquired skills. As a result, he argues that growth in educational attainment does not drive economic growth and thus should not be pushed for by organizations such as the World Bank and similar institutions. This concern aligns with Bils and Klenow (2000), who argue that rising education levels may reflect expectations of higher future growth, suggesting reverse causality. Rossi (2020) builds on this debate by reviewing a broader set of human capital measures beyond attainment alone and examining how human capital may contribute to growth through technology adoption and productivity gains. Donaldson and Duflo (2009) argue against this conclusion and suggest that an alternative explanation as to why education does not increase GDP is that the rapid growth of education in some countries may have impacted the quality of education received. Moreover, they explain that some countries which experienced rapid growth in education likewise experienced political conflicts that may have hindered their development.

More recently, papers have studied the impact of gender inequality in both education as well as employment on economic growth. Klasen and Lamanna (2008) find, through an analysis on the Middle East and North Africa region from 1960 to 2000, that gender gaps in education and employment significantly reduce economic growth. Esteve-Volart (2004) reports that for regions in India, the complete exclusion of females from the labor market implies a reduction in GDP per capita. Other work, such as Ngai and Petrongolo (2017), explores how structural transformation shapes female employment patterns across sectors. Hsieh et al.'s (2019) findings suggest that when women are excluded from higher productivity occupations despite having the skills, talent is not being used efficiently, leading to misallocation of talent. A study on the impact of gender inequality in education at the primary and secondary level reports that gender inequality in education has a negative and statistically significant effect on income per capita in North African and Middle Eastern countries (Baliamoune–Lutz & McGillivray, 2015). Taken together, these findings reflect a growing emphasis on how gender inequality in education and employment can hinder economic growth by limiting the full use of talent and reducing productivity.

In this paper, I revisit Barro and Lee (1994) and investigate the impact of female education on economic growth using a cross-country analysis. Barro and Lee (1994) included data from 1965 to 1985, whereas in this paper I examine this impact using 30 years more of data. This is crucial because, as will be seen, growth in female secondary education increased in the years after 1985. While extending the time frame, I also build on their framework by incorporating fixed effects by income group and additional controls to strengthen the empirical approach.[4] This paper intends to fill this gap by exploring the impact of both secondary and tertiary level education on economic growth across countries in different income groups.

Data

The analysis was conducted using Barro and Lee's (2013) public dataset, which includes educational attainment estimates across 141 countries. These estimates are reported across 5-year intervals from 1965 to 2010[5]. This data provides aggregate complete educational attainment measures for people of all ages between 15 to 64. It captures the percentage of the population who have primary, secondary and tertiary schooling attained and completed in each country.[6] I used the World Bank GDP per capita data (current USD) as measure of economic growth. Countries are classified based on their GNP as low-income countries (LICs), lower-middle income countries (LMICs), upper-middle income countries (UMICs) and high-

[4] In doing so, I build on Barro and Lee's original framework and strengthens the empirical approach by incorporating additional controls, using fixed effects by income group, and testing for robustness using lagged variables and female labor force participation.

[5] The earliest GDP per capita data I was able to obtain was in 1965, for a total of 141 countries. My study therefore does not use the complete Barro-Lee dataset, which consists of 146 countries.

[6] The analysis relies on a measure of completed secondary and tertiary schooling attained in the population for each country, in each given year.

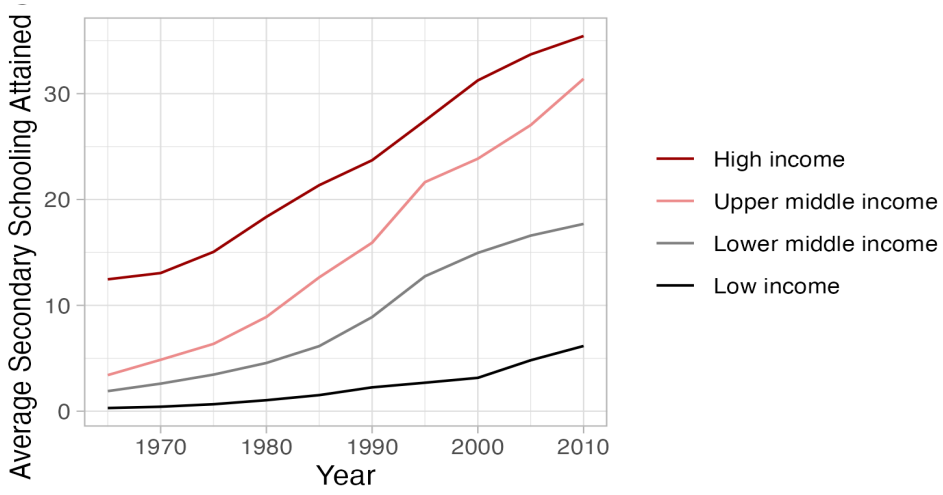
income countries (HICs).[7] Similarly, I obtained necessary data for the control variables through the World Bank. These variables[8] include foreign direct investment (FDI) as a percentage of GDP per capita, unemployment as a percentage of the total labor force, research and development expenditure as a percentage of GDP per capita, as well as a measure of female labor force participation rate[9] (number of women in the labor force over the female population above the age of 15).

A summary statistic of each of the variables in my analysis is provided in Table A1 in the appendix. Table A1 reports the average of each variable in the dataset as well as its standard deviation. As can be seen in Table A1, even though female secondary education is higher in HICs when compared to LICs, the average growth of female secondary education in LICs is almost six times that of HICs. Within LICs, the average growth of female secondary education is almost three times that of male secondary education. Moreover, as illustrated in Table A1, the difference between the female and male growth of average secondary education is much smaller in HICs. Recall the different segments of the U-Shape curve introduced in Figure 1. From Table A1, I see that the average growth of female labor force participation is a negative 1.001p.p. for LICs. It is important to note that unlike for LICs, the average growth of female labor force participation is positive for all other income groups. As will be seen, this is in line with the argument that LICs are situated on the falling segment of the U-Shape curve, with low female labor force participation rate. These comparisons are of importance to my hypothesis as it suggests that female secondary education is contributing to the economic growth of LICs but has become of less significance in HICs.[10]

To further understand the data, I examined different trends amongst my independent variables of interest. I took the average of female secondary and tertiary education in LICs from 1965 to 2010. For comparison purposes, I graph this against all other income groups (HIC, UMIC and LMIC).

Figure 2 shows that average female secondary education attained demonstrates a similar upward growth trend in LICs when compared to HICs after 1985. The difference in the growth of female secondary education pre-1985 (1965-1985) and post-1985 (1990-2010) is 2.69p.p. in LICs, and 2.84p.p. in HICs. I observe a predictable level difference in female secondary education attained in LICs and HICs. In Figure 3, I will see that this difference is more significant at the tertiary level.

FIGURE 2. Female Secondary Education Attained. Percentage of average complete female secondary schooling attained in the population across high-income and LICs from time periods 1965-2010.



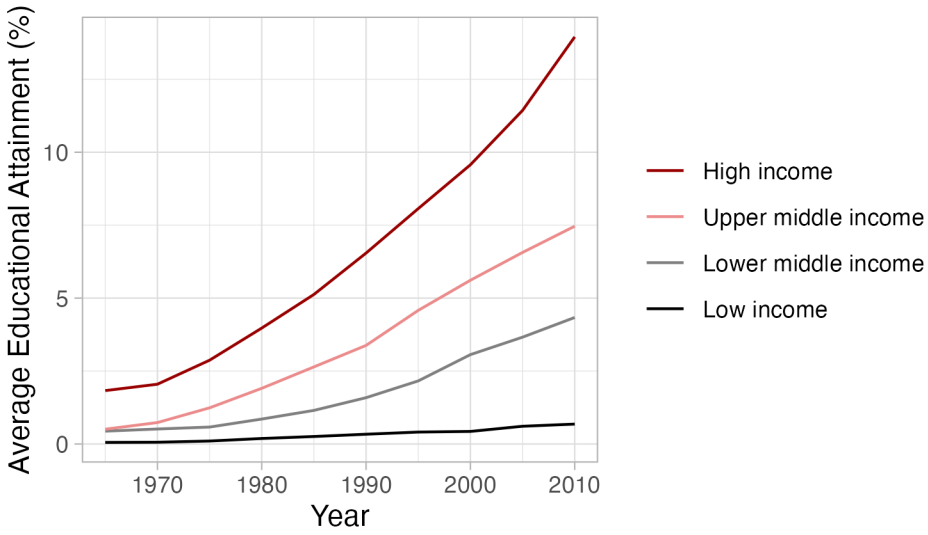
[7] I use the World Bank's latest categorization to indicate each country's income group. The World Bank classifies each country's income group using "gross national income (GNI) per capita valued annually in US dollars using a three-year average exchange rate" (World Bank, 1989).

[8] These controls help isolate the relationship between women's education and growth by accounting for key economic conditions and labor market structures that may vary by countries with varying income groups.

[9] I only include female labor force participation in a robustness specification, not in the main regression. I do this to verify the relationship between women's education and growth is not driven by contemporaneous changes in labor market participation.

[10] Hill and King (1995) argue that women's education can enhance productivity within the home and generate social benefits not always captured by labor market statistics. They suggest that education improves other outcomes such as health or household productivity, which may support growth through broader demographic and social changes.

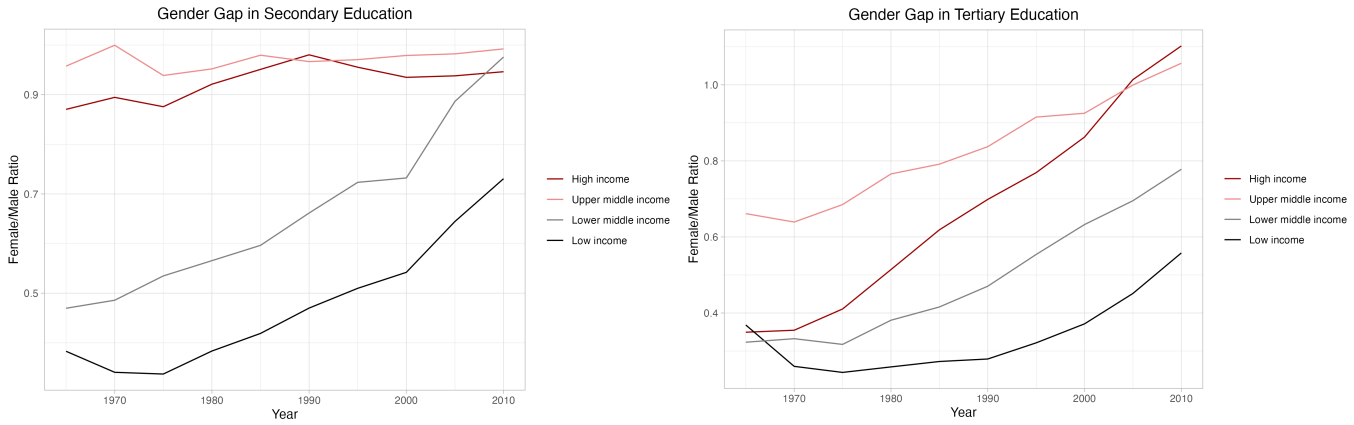
FIGURE 3. Average Female Tertiary Education Attained. Percentage of average complete female tertiary schooling attained in the population across high-income and LICs from time periods 1965-2010.



At the tertiary level, average female education in LICs and HICs demonstrates a different trend than that at the secondary level. Figure 3 shows that there has been a steeper increase in female tertiary education when compared to secondary education in HICs after 1985. The difference in the growth of female tertiary education between pre-1985 and post-1985 is 0.15p.p. in LICs and 4.11p.p. in HICs. This difference in the average growth is much larger at the tertiary level than it is at the secondary level. This suggests that LICs have been catching up to HICs in increasing female educational attainment at the secondary level.

At the tertiary level however, the difference in the growth rate between pre-1985 and post-1985 is much higher in HICs than it is in LICs. This suggests a potential for HICs in terms of the benefit that more women completing tertiary level education could have on economic growth[11]. This comparison is essential to aiding the argument that HICs have transitioned along the U-Shape curve and are now at

FIGURE 4. Female-to-Male Ratio in Secondary and Tertiary Education. Female-to-male ratio is calculated as the percentage of women with complete education at each level divided by the percentage of men, across income groups from 1965 to 2010.



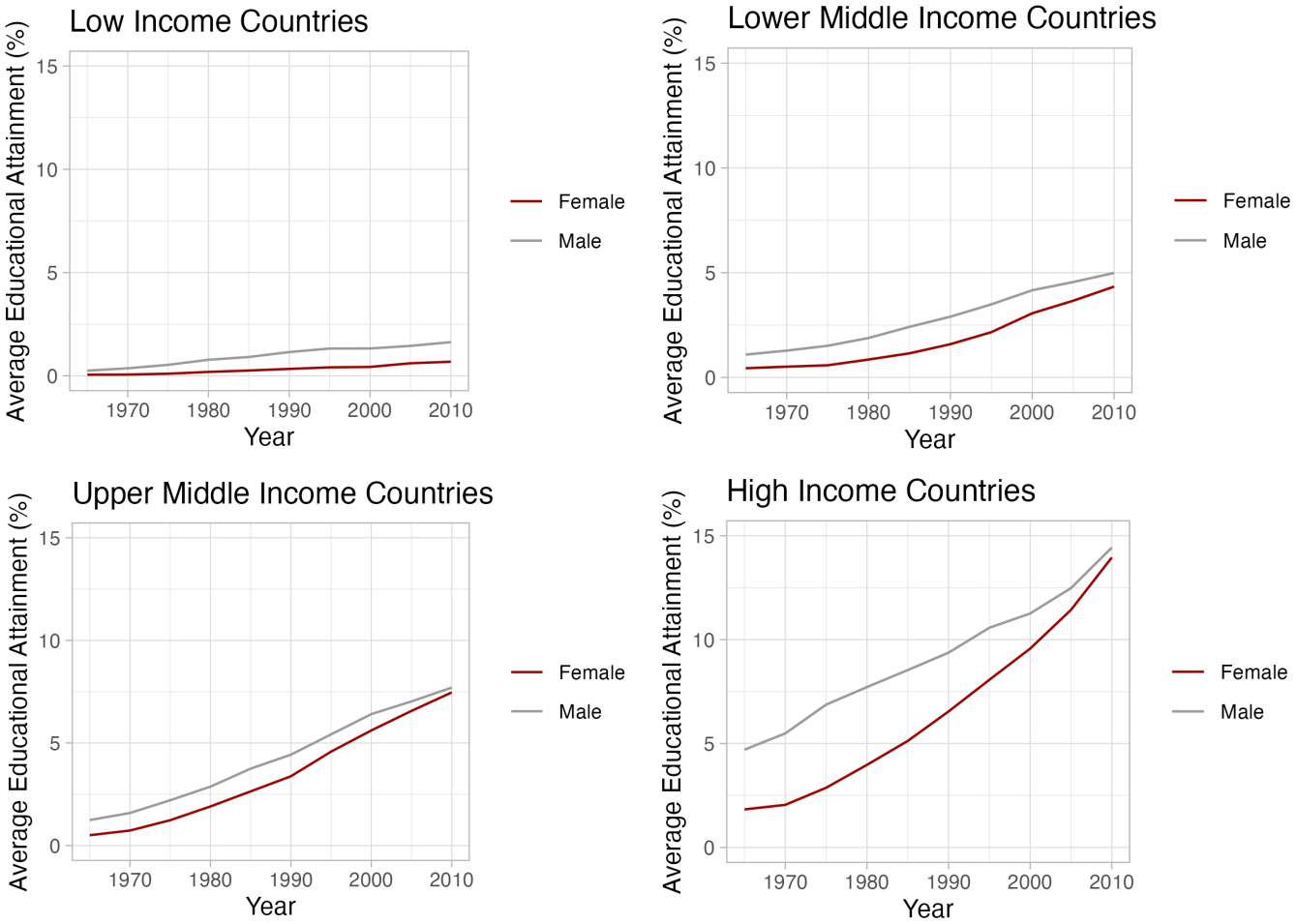
[11] One possible reason is that in HICs, women who complete tertiary education may be more likely to enter higher productivity sectors, which could help explain the potential growth effects.

a level where tertiary education is of great importance. While secondary level schooling has likely played a foundational role in earlier stages of development, HICs today seem to be at a point where gains from tertiary education are more pronounced[12]. HICs today are moving closer toward digital transformation and emphasis on technology has grown exponentially.

Furthermore, I am interested in comparing educational attainment trends across gender at both the secondary and tertiary level for each of income group category. Figure 4 above illustrates that although there exists a level difference in educational attainment across gender, the female-to-male ratio seems to be narrowing. For secondary education, the ratio has steadily increased in LMICs and LICs. At the tertiary level, I observe that in HICs and UMICs, women have surpassed men in attainment, with the ratio rising above one in recent years. Referring back to the U-Shape hypothesis, this parallel movement between the secondary education of the female and male population in LICs may be capturing early signs of structural transformation. Rising levels of female education have been associated with increased labor force participation in many contexts, though this relationship depends on broader labor market conditions.[13]

Figure 5 shows this trend across gender at the tertiary education level. The gender gap in tertiary education seems to be closing for all income group categories except in LICs. This aids in explaining results which suggest that,

FIGURE 5. Average Female and Male Tertiary Education. Percentage of average complete tertiary schooling attained in the population across income group from time periods 1965-2010.



[12] Tertiary education may still matter in other contexts, but in many cases, barriers to access may limit its potential impact.

[13] Figure A1 in the appendix shows the average female and male educational attainment separately over time across income groups.

unlike HICs, LICs are not yet at the stage where their economies reward women for tertiary level educational attainment.[14] Instead, there might still be gains to be made from growing secondary education amongst the female population in LICs. This observation is important in explaining my empirical results as will be seen in section 4.

Models and Results

Main Specifications

I study the effect of female and male education on GDP per capita growth, whilst controlling for different variables that could also help explain my dependent variable. In their study of sources of economic growth, Barro and Lee (1994) examine the effect of a set of explanatory variables that impact economic growth. In the first model, I adopt a model similar to Barro and Lee's (1994) reported model 7 (p.15) [15]. The model is represented as follows:

$$\Delta \mathrm{GDP}_{jt} = \beta_0 + \beta_1 \log(\mathrm{GDP}_{jt}) + \beta_2\, \mathrm{SecondaryFemale}_{jt} + \beta_3 \Delta \mathrm{SecondaryFemale}_{jt} + \beta_4 \mathrm{SecondaryMale}_{jt} + \beta_5 \Delta \mathrm{SecondaryMale}_{jt} + \beta_6 \mathrm{Investment}_{jt} + \varepsilon_{jt} \quad (1)$$

where $\Delta \mathrm{GDP}_{jt}$ represents the growth of average GDP per capita over 5 years for country j, in time period *t*. This average is taken across 5 years due to Barro and Lee's education dataset reporting estimates across 5-year intervals. I add $\log(\mathrm{GDP}_{jt})$ [16] to the model which denotes the observation of GDP per capita for country j, in time period *t*. (Barro & Lee, 1994, p.14). $\mathrm{SecondaryFemale}_{jt}$ and $\mathrm{SecondaryMale}_{jt}$ are the percentages of complete secondary education attained in the population for country j, in time period *t*, for both the female and male population respectively. I add a measure of growth over 5 years for secondary education represented by $\Delta \mathrm{SecondaryFemale}_{jt}$ and $\Delta \mathrm{SecondaryMale}_{jt}$[17]. $\mathrm{Investment}_{jt}$ represents net inflows of FDI as a percentage of GDP per capita for country j in time period *t*.

A troubling result from Barro and Lee (1994) reports a negative and significant coefficient on the growth of female secondary level educational attainment. Barro and Lee (1994) explain that they do not have a story to explain this seemingly negative effect (p.22).[18] Barro and Lee's (1994) study examined years from 1965 to 1985. In my analysis, I split the data into two time-series: the years pre-1985 (1965 to 1985), and those post-1985 (1990 to 2010). In an attempt to compare results from my model to those of Barro and Lee (1994), I run the models for the years pre-1985, and expand the analysis to include the years post-1985. This is essential to understanding how countries have progressed since the 1980s and consequently helps map their position along the U-Shape curve.

When running equation 1 on all time-periods, I find the coefficient on female education to be -0.003 (s.e=0.003). Although negative, the results presented below in Table 1 column 1 indicate that there is no statistically significant impact of female education on GDP per capita growth. As previously mentioned, Barro and Lee (1994) report a statistically significant negative coefficient on the growth of female secondary educational attainment in the years 1965 to 1985 (p.22). When running the regression on the years pre-1985 in column 2, I obtain qualitatively the same results. Female secondary education seems to have a statistically significant negative effect on GDP per capita growth with a coefficient of -0.020 (s.e=0.007), whereas male secondary education appears to have a positive and significant effect. Obtaining qualitatively the same results as Barro and Lee (1994) gives me confidence in my results as I extend their model in several other dimensions.

I extend this analysis and run a regression on the years after 1985 in column 3. I find that the negative effect of female secondary education on GDP per capita growth disappears. From this model, I report that female secondary education is now positive with a coefficient of 0.004 (s.e=0.003); however, it is no longer significant. To provide a potential explanation for these results, I ref-erence the U-Shape hypothesis. Recall that the U-Shape hypothesis suggests that as countries move from agri-cultural to more industrialized societies, and thus GDP per capita consequently increases, female participation rates decline. Goldin (1995) explains that is largely due to "an income

[14] One possible explanation is that LICs are still undergoing structural transformation, and the types of jobs being created may not equally reward men and women. Sectoral shifts, from agriculture to manufacturing, in the economy could result in labor market opportunities that are more accessible to men, limiting the returns to higher education for women even as attainment increases.

[15] It is important to note that the model does not replicate that of Barro and Lee 1994 due to inaccessibility to variables. Furthermore, I do not include a measure of life-expectancy as Barro (1996) note that "'if a measure of health status, such as life expectancy, is included in the regression, then it seems to proxy for the level of human capital. The level of educational attainment then has no additional explanatory power for growth" (p.6).

[16] I follow Barro and Lee (1994) and use the log of GDP per capita from the first year of each 5-year period (for example, 1965 for the 1965–1970 window). This helps account for convergence effects.

[17] I include both the level and the rate of change to capture the level of education in a country as well as more short-term changes in educational attainment.

[18] Barro and Lee have since updated the dataset they used to measure sources of economic growth from 1965-1985. In my analysis, I use the updated dataset published in 2013.

TABLE 1: The Effect of Secondary Education on Economic Growth. I split model 1 into 3 sub-models based on time period categorization. The first model labeled 'All' runs the regression on the years 1965 to 2010 from the dataset. Model 'Pre-1985' only considers the time periods 1965-1985. Model 'Post-1985' considers the time periods 1990-2010. The dependent variable of all models is GDP per capita growth. I control for a measure of FDI in all three models. Standard errors in parentheses. ***p< 0.01, **p<0.05, *p<0.1.

	Model 1		
	(1)	(2)	(3)
	All	Pre-1985	Post-1985
log(GDP)	0.039***	0.128***	0.024*
	(0.012)	(0.027)	(0.012)
Female:			
Secondary Educ	-0.003	-0.020***	0.004
	(0.003)	(0.007)	(0.003)
Growth of Secondary Educ	-0.007	0.055	-0.003
	(0.007)	(0.074)	(0.006)
Male:			
Secondary Educ	0.003	0.011*	0.001
	(0.003)	(0.007)	(0.003)
Growth of Secondary Educ	0.039	-0.027	-0.021
	(0.031)	(0.077)	(0.033)
Investment	✓	✓	✓
Adjusted R^2	*0.014*	*0.089*	*0.084*
Number of Observations	*873*	*265*	*601*

effect, but it may be reinforced by a reduction in the relative price of home-produced goods and by a decrease in the demand for women's labor in agriculture" (p. 62).

I report that this result is possibly due to more countries being in developing stages in the early 1980s, and thus the labor market may not have been rewarding women for attaining secondary education. Hence, this could explain the negative effect found when I run the model only on the years pre-1985 in column 2. The same model on the years after 1985 minimized this effect, implying that although the labor market was still not rewarding women for secondary education, the negative effect of their education on GDP growth was no longer present over the progression of time. I extended Barro and Lee's (1994) analysis in time by running the models on the years after 1985. In model 2, I extend it further and examine if those results are impacted by differences in unemployment rates across different income group categories.

The next subset of models control for the effect of unemployment on GDP per capita growth.[19] Unemployment_{jt} is the total percentage of unemployment in the labor force in country j in time period *t*. Including a measure of unemployment in the model is important as it allows me to control for differences in the labor market at the country level, which could have an impact on the level of female labor force participation. This is important to consider as men tend to have priority in the labor market since they are often responsible for the primary income source in a household. Moreover, I control for income group fixed effects as unemployment rates differ across the different categories.

$$\Delta\text{GDP}_{jt} = \beta_0 + \beta_1 \log(\text{GDP}_{jt}) + \beta_2\, \text{SecondaryFemale}_{jt} + \beta_3 \Delta\text{SecondaryFemale}_{jt} + \beta_4 \text{SecondaryMale}_{jt} + + \beta_5 \Delta\text{SecondaryMale}_{jt} + \beta_6 \text{Investment}_{jt} + \beta_7 \text{Unemployment}_{jt} + \beta_8 \text{IncomeGroup}_{jt} + \varepsilon_{jt} \quad (2)$$

Table 2 reports results from model 2 across the different specifications. When controlling for the effect of unemployment on GDP per capita growth, I find that the coefficient on female secondary education is positive and statistically significant. Column 1 reports the coefficient on female secondary education to be 0.008 (s.e=0.004). A potential explanation could be the disparities in unemployment within different countries across income groups.

As an example, according to the International Labor Organization, the employee-population weighted unem-

[19] The earliest time-period with reported unemployment data I could find is 1995, which aggregates the years from 1991-1995.

TABLE 2: The Effect of Secondary Education on Economic Growth Across Income Groups. Columns 1 through 6 control for unemployment as well as FDI. Column 2 controls for income group fixed effects to capture differences income group may have on GDP per capita growth. I replicate column 1 for each income group category separately and report results in columns 3 to 6. Standard errors in parentheses. ***p< 0.01, **p<0.05, *p<0.1

	Model 2					
	(1)	(2)	(3)	(4)	(5)	(6)
			Low income	Lower Middle Income	Upper Middle Income	High Income
log(GDP)	0.016	0.110***	0.245**	0.178***	0.204***	-0.078**
	(0.014)	(0.028)	(0.114)	(0.063)	(0.059)	(0.034)
Female:						
Secondary Educ	0.008**	0.006	0.045**	0.003	0.006	-0.002
	(0.004)	(0.004)	(0.022)	(0.007)	(0.009)	(0.005)
Growth of Secondary Educ	0.044	0.083	0.227	0.076	0.130	0.004
	(0.074)	(0.074)	(0.198)	(0.155)	(0.286)	(0.222)
Male:						
Secondary Educ	-0.002	0.001	-0.015	<-0.001	0.003	0.006
	(0.004)	(0.003)	(0.014)	(0.007)	(0.008)	(0.004)
Growth of Secondary Educ	-0.082	-0.136	-0.150	-0.127	-0.239	0.023
	(0.107)	(0.107)	(0.346)	(0.244)	(0.264)	(0.193)
Investment	✓	✓	✓	✓	✓	✓
Unemployment	✓	✓	✓	✓	✓	✓
Income group		✓				
Adjusted R^2	*0.06*	*0.10*	*0.30*	*0.16*	*0.17*	*0.04*
Number of Observations	*492*	*488*	*49*	*128*	*125*	*162*

TABLE 3: The Effect of Tertiary Education on Economic Growth Across Income Groups. Model 3 introduces tertiary level education by gender to the regression. Similar to model 2, I control for FDI as well as unemployment. Column 2 controls for research and development (R&D), however does not control country income group fixed effects. I replicate model 3 for each income group category separately and report results in columns 3 to 6. Standard errors in parentheses. ***p< 0.01, **p<0.05, *p<0.1

	Model 3					
	(1)	(3)	(4)	(5)	(6)	(7)
			Low income	Lower Middle Income	Upper Middle Income	High Income
log(GDP)	0.025	-0.004	0.301**	0.166**	0.249***	-0.062*
	(0.016)	(0.031)	(0.122)	(0.068)	(0.063)	(0.036)
Female						
Secondary Educ	0.005	0.008	0.051*	0.001	0.010	-0.001
	(0.004)	(0.007)	(0.023)	(0.007)	(0.009)	(0.005)
Growth of Secondary Educ	0.065	0.237	0.321	0.027	-0.073	0.261
	(0.074)	(0.248)	(0.222)	(0.159)	(0.300)	(0.217)
Tertiary Educ	0.017*	0.026*	0.051	0.007	-0.042**	0.026***
	(0.008)	(0.012)	(0.228)	(0.026)	(0.019)	(0.007)
Growth of Tertiary Educ	-0.124**	-0.138	-0.111	-0.153*	-0.024	-0.053
	(0.044)	(0.192)	(0.078)	(0.087)	(0.157)	(0.085)
Male						
Secondary Educ	<0.001	0.002	-0.012	<-0.001	<-0.001	0.006
	(0.004)	(0.006)	(0.014)	(0.007)	(0.009)	(0.004)
Growth of Secondary Educ	-0.117**	-0.395	-0.335	-0.063	-0.225	-0.293
	(0.107)	(0.242)	(0.365)	(0.248)	(0.233)	(0.188)
Tertiary Educ	-0.021**	-0.016	-0.107	0.007	0.028*	-0.027***
	(0.008)	(0.013)	(0.076)	(0.026)	(0.017)	(0.009)
Growth of Tertiary Educ	0.255**	0.121	0.226	0.314*	0.135	0.415***
	(0.081)	(0.258)	(0.191)	(0.169)	(0.216)	(0.102)
Investment	✓	✓	✓	✓	✓	✓
Unemployment	✓	✓	✓	✓	✓	✓
R&D		✓				
Adjusted R^2	*0.08*	*0.23*	*0.33*	*0.16*	*0.18*	*0.20*
Number of Observations	*488*	*139*	*45*	*124*	*121*	*158*

ployment rate from 2011-2019 in LICs is 33.7% whereas that of HICs is 15% (International Labor Organization, 2022). Referring back to the U-Shape hypothesis, when unemployment rates are high, the labor market is likely rewarding the male adult population for attaining education since, as mentioned previously, men are commonly the primary income source in a household. Additionally, I control for income group fixed effects[20] and find that the positive and significant effect of female secondary education is no longer present. [21] This is likely due to the differences both in the average secondary education attained across countries in different income groups, as well as the previously mentioned disparities in unemployment rates. Moreover, I regress GDP per capita growth on the education explanatory variables separately for each income group category and find that female secondary education is only positive and significant for LICs. I do not find any significant effect for HICs, UMICs or LMICs. I hypothesize that LICs appear to be progressing along the U-Shape curve, and thus female secondary education has the potential to play a significant role in aiding an upward movement along the U-Shape curve in LICs.[22]

Given what I previously saw in the Data section with regards to the high growth of female tertiary education in HICs, my third and preferred model explores the effect of female tertiary education on GDP per capita growth.

$$\Delta \text{GDP}_{jt} = \beta_0 + \beta_1 \log(\text{GDP}_{jt}) + \beta_2\, \text{SecondaryFemale}_{jt} + \beta_3 \Delta \text{SecondaryFemale}_{jt} + \beta_4 \text{TertiaryFemale}_{jt} + \beta_5 \Delta \text{TertiaryFemale}_{jt} + \beta_6 \text{SecondaryMale}_{jt} + \beta_7 \Delta \text{SecondaryMale}_{jt} + \beta_8 \text{TertiaryMale}_{jt} + \beta_9 \Delta \text{TertiaryMale}_{jt} + \beta_{10} \text{Investment}_{jt} + \beta_{11} \text{Unemployment}_{jt} + \beta_{12} \text{RD}_{jt} + \varepsilon_{jt} \quad (3)$$

RD_{jt} denotes research and development expenditure as a percentage of GDP per capita for country j, in time period *t*.[23] Model 3 is an extension of model 2 in which I include tertiary level education as an explanatory variable. Typically, studies within the literature have used secondary educational attainment to measure the impact of education on economic growth. Barro and Lee (1994) give an argument against[24] including tertiary education in growth models.[25] The results from model 3 are in Table 3.

Interestingly, column 1 in Table 3 reports the coefficient on female tertiary education as a positive and significant 0.017 (s.e=0.008). Growth in female tertiary education as reported in column 1 appears to have a negative and significant effect of -0.124 (s.e=0.044) on GDP per capita growth. This result is likely driven by the negative growth of female tertiary education in LICs, LMICs and UMICs. I find in column 7 that tertiary education has a positive and significant effect of 0.026 (s.e=0.007) on GDP per capita growth in HICs. No significant effect was found for LICs and LMICs. Surprisingly, the results suggest that for UMICs female tertiary level education has a negative impact on GDP per capita growth. When aggregating UMICs and LMICs, this effect is no longer present. I am uncertain of the reason(s) behind those results; however, I anticipate further research could lead to a potential explanation.[26] The positive and significant impact of female tertiary education on GDP per capita growth in HICs is specifically interesting due to the link between technological innovation and economic growth. As previously mentioned, countries across different income groups are located on different segments of the U-Shape curve. This further supports my hypothesis that HICs have greatly progressed along the U-Shape curve and are now reaping the benefits of highly mature economics. As for LICs, there are still economic gains to be made from encouraging female secondary educational attainment. This can be seen in column 4 of Table 3, where the coefficient on female secondary education from model 2 remained consistently positive and significant only for LICs across all models.

Robustness Check

Table A2 in the Appendix reports results from the robustness checks. To test my assumptions, I run the models using lagged values for education measures including all countries in column 1, as well as including only LICs in column 2 of Table A2 below. In doing so, I investigate the effect of last year's GDP per capita growth on today's educational attainment measure. Including lagged education helps reduce concerns that GDP and education are moving together in the same year. While this does not fully establish causality, it helps clarify the

[20] Once income group fixed effects are included in column 2, the effect is no longer significant. This is expected given the fixed effects absorb key differences across countries. To better understand this variation, I report separate estimates by income group in columns 3 to 6.

[21] It is important to control for different income groups here, as unemployment differs across countries with high income and low income.

[22] I argue concerns of endogeneity may be less relevant in this context as in many LICs, increases in women's education are likely to reflect more policy shifts or broader social change rather than household decisions based on expected returns from education. This makes it less likely that growth is driving education.

[23] Due to unavailability of data, I only have R&D data for 2000-2010.

[24] They explain that tertiary education is not of high importance for most countries who tend to adopt technology rather than invent it (p. 22).

[25] While tertiary education is more common today, its contribution to growth may still vary across countries. In many LICs, secondary education continues to play a more central role, while returns to tertiary education are likely higher in HICs with more developed labor markets.

[26] Some of the coefficients for male tertiary education turn significant in this model, though the signs vary. It is unclear why that is, however, it may reflect mismatches between education and labor market demands.

direction of the relationship. In addition to lagging education, I add a control of female participation rate (FPR) in model 3 and include all countries in column 3 and only HICs in column 4. FPR is the female labor force participation rate of each country in each year as a percentage of the female population above the age of 15.

I find that lagging education marginally changes the significance of results from model 2. The coefficient on female secondary education in column 1 of Table A2 is 0.007 (s.e=0.004) and statistically significant at a p-value of 0.1. In my original model, the reported coefficient is 0.008 (s.e=0.004) and significant at the 0.05 p-value level. Furthermore, I investigate the effect of controlling for FPR. Heath and Jayachandran (2016) introduce a central theme in the relationship between education and women's participation in the labor force. They suggest that "as increases in education have prompted more women to enter the labor force, improved labor market opportunities have also prompted increases in female education" (p. 2). Thus, to address the potential of reverse causality, I control for female participation rate (FPR) of all women above the age of 15 in model 3.

I find that this has no qualitative difference from my originally reported results. Column 3 shows that the coefficient on female tertiary education is 0.034 (s.e=0.015) and significant at the 0.05 p-value level. When running model 3 independently for HICs, I also obtain qualitatively the same results as those reported in Table 3. The results from the robustness checks are consistent with previous results that female secondary and tertiary level education seem to have a positive and significant effect on GDP per capita growth.

Conclusion

In this paper I explore the impact of women's secondary and tertiary education on economic growth across 141 countries from the years 1965 to 2010. It is important to consider some of the factors that may have influenced my reported results. Although I control for various variables that could affect GDP per capita growth, there may have been some that I could not consider due to unavailability of data, specifically for LICs.[27] Furthermore, it is important to recognize that I do not have information on whether the differences in schooling systems were considered in Barro and Lee's (2013) dataset.[28] In addition, given that I only have information on educational attainment and no method to measure human capital, I am unable to know what quality of education, although complete, was acquired in each country. Lastly, data availability for some of independent variables posed a limitation in my ability to run the preferred models on the pre-1985 years.

Despite these limitations, my results present a promising opportunity for the economic growth of LICs through female education. Referencing the U-Shape hypothesis provides a potential explanation for my empirical findings. LICs are still in the developing stages of their economies where female labor force participation is low and are thus situated on the falling segment of the U-Shape curve, represented by the letter *x* in Figure 1. As female education improves however, women move back into the labor market and their work gains value, increasing their time spent in the labor force (Goldin, 1995). This indicates that there are still economic gains to be made from educating women at the secondary level in LICs. As for HICs, my results report that only tertiary education has a positive and significant effect on GDP per capita growth. HICs have advanced since the 1980s, and their economies have become heavily dependent on digital and technological innovations, contributing to their high GDP per capita. I hypothesize that HICs have exhausted all economic gains from women's secondary education and are now progressing on an extended upward segment of the U-Shape curve. This extension is my contribution to the U-Shape hypothesis and is represented by the letter *z* in Figure 1. My proposed contribution to the U-Shape hypothesis is of value as I saw in section 3, average female tertiary education has grown exponentially over the last few decades in HICs.

The results report that female secondary education has had a negative and significant impact on economic growth pre-1985. I hypothesize that many countries in the 1980s were still in the early developing stages of their economies and thus were moving down along the U-Shape curve. Potentially this negative coefficient I find, and that reported by Barro and Lee (1994), is due to women not being rewarded by the labor market for attaining secondary education in the 1980s. I obtain different results when comparing the years after 1985 and for countries across different income groups. Furthermore, those results suggest that female tertiary education has a positive and significant impact on GDP per capita growth within HICs

[27] I was unable to include some variables used in related studies, such as health indicators or governance quality, as they were not consistently available for the countries and years covered in this dataset.

[28] As Schoellman (2012) points out, differences in education quality across countries can be just as important as differences in years of schooling when explaining economic outcomes.

who have been moving towards more technologically and digitally reliant economies. I hypothesize that HICs have depleted the economic benefits of women's secondary education and are now moving up an extended segment of the U-Shape curve, reaping the benefits of women's tertiary level education. Although there has been great progress in encouraging women to advance in their education across HICs, structural inequalities still hinder women's participation in the labor market. Future research can investigate potential causes of this, such as labor discrimination or the glass ceiling hindering women's advancement in the labor market.

My paper focuses particularly on the economic development of LICs. When regressing GDP per capita growth on female education, I find that at the secondary level, female education has a positive and significant effect on GDP per capita growth for LICs. This result highlights great opportunity for economic growth through the means of female education, as LICs progress towards the upward segment of the U-Shape curve. No positive or significant effect was found for LICs of female education at the tertiary level. Recall Easterly's (2001) argument that there is no correlation between an increase in the level of education and increased GDP. Perhaps there is some merit to this argument in that a rapid increase in education may overwhelm the economy of LICs with skills that they are not ready yet to accommodate. The takeaway could be identifying where each country stands with regards to the U-Shape curve and recognizing that LICs are currently on the declining segment. Knowing this helps predict their potential transition towards the rising segment, represented by the letter *y* in Figure 1, of the curve in the coming decades. To support this transition, greater importance needs be placed on motivating, encouraging and empowering young girls to continue in their education. This is only possible if I address both the quality of education received, as well as the issues that lead to young girls not being unable to attend school, for example when they spend hours walking to collect water (UNICEF, 2016). The United Nations (UN) (2022) has dedicated specific sustainable goals to support economic development. The fourth and fifth goals target equity in the quality of education received, as well as achieving gender equality and empower women and girls. Due to such initiatives, many LICs have made substantial progress in educating young girls and have been moving closer towards closing the gender gap in education. I find that this is contributing positively[29] to their economic growth and it is my belief that economic returns from female tertiary education are forthcoming for LICs who tend to be followers of HICs.

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[29] My analysis explores the impact of women's education on economic growth from 1965-2010. With more data beyond 2010, perhaps I might find a different result for female tertiary education across income groups.

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Appendix

TABLE A1: Summary Statistics. Note: Reports the means and standard deviations in parenthesis of each variable in the dataset. This is split for the time periods pre-1985 (1965-1985) and post-1985 (1990-2010), as well as for each income group classification. Percentage points are represented by (p.p.). (NOTE: GDP per capita growth is measured as the growth of GDP per capita for each country over 5 years. Some values are missing in Table A1, as data for unemployment, research & development, and female participation rate are unavailable before 1985.)

	All	Pre-1985	Post-1985	Low income	Lower Middle Income	Upper Middle Income	High Income
Economic Indicators							
GDP per capita (USD)	7,064.500 (12,850.74)	2,685.048 (4,950.72)	10,342.410 (15,667.19)	363.236 (296.455)	850.946 (788.602)	2,703.067 (2342.164)	18,310.160 (17479.110)
GDP growth (p.p.)	0.420 (0.430)	0.560 (0.440)	0.330 (0.410)	0.262 (0.358)	0.346 (0.417)	0.464 (0.486)	0.508 (0.406)
Foreign Direct Investment (USD)	2.85 (8.99)	0.960 (1.470)	3.72 (10.700)	1.573 (3.374)	1.862 (2.355)	2.464 (2.848)	4.431 (14.777)
Unemployment (p.p.)	7.810 (5.710)		7.810 (5.710)	4.482 (3.221)	8.212 (6.890)	9.608 (6.327)	7.083 (4.035)
Research & Development (% of GDP)	1.080 (0.930)		1.080 (0.930)		0.431 (0.308)	0.510 (0.320)	1.494 (0.981)
Growth of Female Participation Rate (p.p.)	0.015 (0.055)		0.019 (0.062)	-0.010 (0.057)	0.007 (0.045)	0.017 (0.071)	0.029 (0.044)
Educational Attainment Measures							
Female:							
Primary Educ (%)	17.000 (12.420)	17.510 (15.040)	16.620 (10.010)	7.255 (6.728)	14.239 (11.465)	17.566 (9.386)	22.361 (14.112)
Growth of Primary Educ (p.p.)	0.095 (0.470)	0.190 (0.490)	0.027 (0.440)	0.363 (0.539)	0.205 (0.487)	0.063 (0.483)	-0.067 (0.329)
Secondary Educ (%)	15.894 (14.307)	8.440 (9.170)	21.470 (14.915)	2.459 (2.516)	9.651 (12.109)	17.525 (13.176)	24.851 (13.187)
Growth of Secondary Educ (p.p.)	0.374 (2.026)	0.422 (0.554)	0.339 (2.637)	1.002 (5.538)	0.415 (1.0153)	0.278 (0.389)	0.188 (0.278)
Tertiary Educ (%)	4.067 (5.063)	1.677 (2.354)	5.856 (5.763)	0.331 (0.394)	1.993 (3.433)	3.942 (4.232)	7.327 (5.836)
Growth of Tertiary Educ (p.p.)	0.442 (0.927)	0.616 (1.151)	0.311 (0.688)	0.558 (1.544)	0.505 (1.087)	0.390 (0.695)	0.390 (0.596)
Male:							
Primary Educ (%)	18.633 (11.768)	19.956 (13.108)	17.644 (10.559)	13.182 (7.506)	17.771 (11.666)	18.716 (10.166)	21.210 (13.533)
Growth of Primary Educ (p.p.)	0.032 (0.376)	0.107 (0.423)	-0.023 (0.326)	0.186 (0.331)	0.121 (0.466)	0.012 (0.312)	-0.083 (0.315)
Secondary Educ (%)	18.151 (15.060)	10.318 (9.530)	24.013 (15.764)	4.715 (4.269)	12.620 (12.289)	18.883 (14.156)	27.294 (14.717)
Growth of Secondary Educ (p.p.)	0.258 (0.551)	0.370 (0.618)	0.174 (0.477)	0.366 (0.478)	0.324 (0.855)	0.254 (0.380)	0.164 (0.307)
Tertiary Educ (%)	5.424 (5.531)	3.368 (3.835)	6.964 (6.081)	1.008 (1.055)	2.988 (3.412)	4.717 (4.601)	9.734 (5.865)
Growth of Tertiary Educ (p.p.)	0.231 (0.466)	0.343 (0.544)	0.148 (0.377)	0.384 0.783	0.256 (0.510)	0.219 (0.410)	0.170 (0.264)
Number of observations	*1147*	*491*	*656*	*139*	*314*	*304*	*378*
Years	*(1965-2010)*	*(1965-1985)*	*(1990-2010)*	*(1965-2010)*	*(1965-2010)*	*(1965-2010)*	*(1965-2010)*

FIGURE A1: Average Female and Male Secondary Education. Percentage of average complete secondary schooling attained in the population across income groups from time periods 1965-2010.

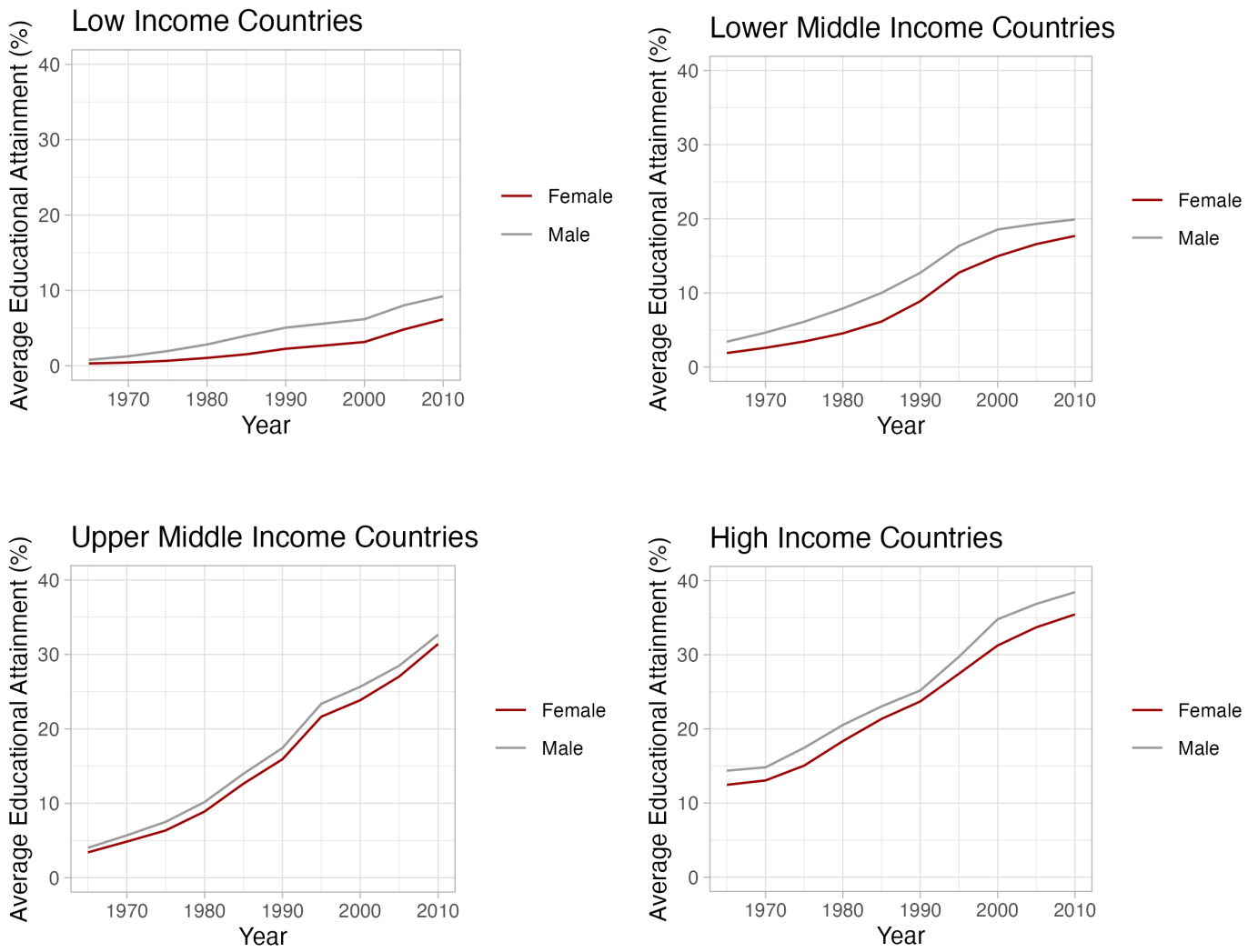

TABLE A2: Robustness Checks. I repeat model 2(a) and lag each of the education variables. Model 3(b) similarly lags the education independent variables as well as adds a measure of female participation rate in the labor market (FPR). Standard errors in parentheses. ***p< 0.01, **p<0.05, *p<0.1"

	Model 2		Model 3	
	(1)	(2)	(3)	(4)
		Low income		High income
log(GDP)	0.017	0.017	0.001	0.056
	(0.014)	(0.0137)	(0.031)	(0.05)
Female				
Lag(Secondary Educ)	0.007*	0.007*	0.009	0.006
	(0.004)	(0.004)	(0.007)	(0.007)
Growth of Secondary Educ	0.016	0.318	0.328	-0.096
	(0.075)	(0.196)	(0.262)	(0.306)
Lag(Tertiary Educ)			0.034**	0.050***
			(0.015)	(0.012)
Growth of Tertiary Educ			0.035	0.302*
			(0.198)	(0.167)
Male				
Lag(Secondary Educ)	-0.001	-0.021	0.002	0.003
	(0.004)	(0.017)	(0.006)	(0.006)
Growth of Secondary Educ	-0.021	-0.192	-0.353	0.135
	(0.109)	(0.347)	(0.258)	(0.262)
Lag(Tertiary Educ)			-0.023	-0.042***
			(0.015)	(0.011)
Growth of Tertiary Educ			-0.043	-0.208
			(0.250)	(0.217)
Investment	✓	✓	✓	✓
Unemployment	✓	✓	✓	✓
R&D			✓	✓
FPR			✓	✓
Adjusted R^2	*0.06*	*0.30*	*0.24*	*0.49*
Number of Observations	*492*	*49*	*138*	*77*